master of science in digital media
university of bremen, germany
1 april 2004 – 31 march 2005

art and algorithm

a project report

This report concludes the studies during the project «art and algorithm». The project was part of the M.Sc. programme in Digital Media, Fachbereich Mathematik/Informatik, at Universtät Bremen. The project was supervised by Frieder Nake and Susanne Grabowski during the summer term 2004 and winter term 2004/05 (April 1, 2004, through March 31, 2005).

University of Bremen, Germany, April 2005

Enquiries:
Frieder Nake, FB 3, University of Bremen, P.O. Box 330440, D-28334 Bremen, Germany
nake@informatik.uni-bremen.de

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chapter 1

All degree programmes of the computing science department at University of Bremen center around the educational concept of project work. The project here is a form of focusing the activities of a group of students, for one or even two years, around one topic, task, and challenge. In this essay, we describe the idea behind our proposal of a project for the M.Sc. in Digital Media programme.

art and algorithm:

essentials of digital media

Frieder Nake & Susanne Grabowski

Art and Algorithm: Essentials of Digital Media

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All degree programmes of the computing science department at University of Bremen center around the educational concept of project work. The project here is a form of focusing the activities of a group of students, for one or even two years, around one topic, task, and challenge. In this essay, we describe the idea behind our proposal of a project for the M.Sc. in Digital Media programme. We made it to those students who entered their second semester in the summer term, 2004, and finished the project by the end of the winter term, 2004/05. The project's title was «Art and Algorithms», AAA for short. It is an informal rule that projects in Bremen must be identified by some interesting, or funny, acronym.

Algorithms, virtually everyone will agree, are objects of mathematics and computing science. They are well defined, and may largely be equated with the concept of computable functions. In the history of human culture, the concept of „algorithm" belongs to an area of utmost clarity, transparency, and precision. Deduction and proof are its preferred methods although it is clear that to find an algorithm involves a great deal of immediate insight and intuition. The term „algorithm" is so well defined, and accepted by the relevant scientific community, that every student in the field must know one definition with only little varation of description. This is possible only because the community has developed the concept up to a point of broadest agreement. Algorithms are both, text and machine, description and operation, at the same time. We may view them as a new kind of entity: executable text.

What a *work of art* should be is, to the contrary, controversial. Agreement will, perhaps, end after suggesting that it is an object of aesthetics and art history. If it is, as in our case, a visual work of art, it may also be investigated by picture theory. The work of art is ill defined.We are usually convinced that we know quite well what a work of art is until someone asks us to make that explicit. We may not be able to give a sharp definition that identifies the work of art among other works, and that the community of art lovers agree with. Often, the concepts of beauty, or of aesthetics, enter such attempts.
The realm of computable functions is largely characterized by construction. The very idea of a computable function is a constructive one. The realm of aesthetic events, on the other hand, is largely characterized by interpretation. Who ever takes a risk, may in principle enter the discourse. The first area has a tendency towards objective measures, the second towards subjective values.

Algorithms are designed for machines to carry out. Art works are designed for humans to perceive. The two identifying poles of the topic of project AAA, art and algorithm, thus appear as being far apart from each other. This could make the investigation of the relation of art and algorithms a good choice for a study project in digital media. The chance of that choice would be that two types of original interest would be served, controvery could emerge, software could be developed, a lot of material could be studied and discussed, and even some interesting ideas might spring up from such joint work.

In digital media studies, the activity of designing and implementing software meets the activity of designing environments for human communication. The first of these two is tied up with algorithms, the second touches art. In digital media design, cooperation in the borderland between the cultures of construction and of interpretation is mandatory. Successful design of digital media requires the combined capabilities of dealing with rule-based knowledge flowing in from those two origins. Though there are rules in both areas, their types are far apart. For good reasons, strict, and syntactically fixed rules govern the notation of algorithms, whereas vaguly defined, and pragmatically soft rules govern decisions in the course of creating a work of art.

Rules of design for computability appear to be of a general kind; they come as theorems and demand exact obedience. Rules of design for beauty are of a singular kind; they appear in the form of examples and anecdotes demanding a feeling for their applicability.
Collaborators in a digital media design group should be prepared to deal with both kinds of rules. They must also be aware of the two different attitudes their audience and the computer will later, after the design work has been finished, extend towards the medium. What is the difference?
The difference is trivial but decisive. It may sound strange, but we want to formulate it thus: design, in one case, reaches out for humans to carry out, in the other case, however, it is for computers. It is certainly helpful and, perhaps, even correct, to draw such a distinction between design goals: for humans, for computers. But at the very moment we write this down, it sounds ridiculous. Ontologically, humans and computers are so hopelessly different that it is certainly a violation at least of good taste to use the term *attitude* in both cases. The computer can simply not have an attitude. For, if a system can be characterized as having an attitude, it must inherently be capable of taking on a different attitude even if reluctantly. But the computer's behavior is characterized by function, and it always functions one and the same way it is made to function.

It is safe to claim that all the famous, and not so famous, comparisons between computers and humans that put the two, in some respect or other, and the same level, are comparisons of the logical results of functions, not of the dialectical development of processes. Such comparisons reduce the situation to a formal and logical context. They ignore the finite existence and experience of life in time and space, the deep human knowledge of birth and death.

The most famous, and perhaps the earliest one, of those arguments is, of course, by Alan Turing. Cleverly designed, it is a beautiful case of the radically rational reduction in thinking. It resulted in the so-called Turing test, or imitation game. It has ever since fascinated innocent people, as well as not quite so innocent computing experts, who claim to see no real difference between themselves as humans, and the machines they are programming and, perhaps, even using. The scandal may be summarized in the question: Why would anybody hope to be indistiguishable from a computer when he or she is obviously different on all counts?

Despite this abyss, in the case of a subject matter so strongly determined by its semiotic character as the subject matter of . software is, it may be justified to nevertheless talk of the two attitudes that the human participant and the computer medium show in a given situation. As a strong disclaimer, we point out that this can be maintained in only a purely formal way. No similarity in actually carrying out a function is contained. In particular, the word „attitude" here is used in a strictly formal sense only, no psychology or decision making involved.

What is our argument to allow for such a formal comparison, in spite of the strict disclaimer? We observe that both, computer and human, when requested to do something, must check the semiotic elements offered to them. The human in such a case interprets. The computer determines. Interpretation happens by putting signals into contexts, where the choice of context is free and changing. Determination happens by following the path of signals through a given network that constitutes the context.

The essence of the process of interpretation is that it could result in a totally different outcome. There is no true or false interpretation, there are only likely and not quite so likely ones. The essence of the process of determination is that it must repeatably result in one and the same outcome each time it gets applied. Determination is objective and neutral, interpretation is subjective and partial.

The digital medium must, therefore, be constructed as a means for determination, and as an end to interpretation. From a semiotic perspective, considering the formal place of interpretation in semiosis, it shows up at exactly the same place as determination. This formal correspondence of the two operations allows for our comparison.

The concept of algorithmic sign is well suited for this task. Applying it to our current situation, we may say that in *Art And Algorithm* students were asked to design algorithmic signs of some special kind.

Let us move on to a bird's eye view of the project members' work. Considering the topic of the project on the most abstract level, it had engrained into it a deep dialectics. Without escape, the proper treatment of the topic must take into account this state of affairs. The dialectics of art and algorithm was indeed intended to become the common denominator of each of the individual tasks that participants would eventually be working on. We hoped that small groups of students would decide to work on particular aspects of the broad topic. Perhaps, they would approach their special topic from one end of the spectrum and treat it in such a way that light would be shed onto the other end. intended to become the common denominator of each of the individual tasks that participants would eventually be working on. We hoped that small groups of students would decide to work on particular aspects of the broad topic. Perhaps, they would approach their special topic from one end of the spectrum and treat it in such a way that light would be shed onto the other end.

Odd as it may sound, a group might, e.g., raise the question, „Is there a powerful visual form that would convincingly express the concept of computation?" They would have to deeply think about automatic computation, as, e.g., Turing-computability, and try to design forms, colors, animated sequences that would visually express the concept.

To give a second example from the other end, another group might ask, „How does recursion enter into graphic design work?" They would study a good introductory text on the fundamentals of design, or do some interviews with designers, and try to identify recursive parts in their work that might become candidates for a programmed implementation.

We, as proposers and advisors of the project, hoped to find a dozen or so of students who would choose topics from fine art and study them carefully from the perspective of algorithm. Alternatively, they would study a topic from computation but under the unusual perspective of aesthetics. In either case, we requested that students would turn their findings into designs of interactive installations. The collection of case studies should be integrated into a loose combination, which would be presented at some sort of media event. We had no doubts that some groups would see their work rather close to the fine art (or aesthetic) end, whereas others would identify themselves as programmers and algorists. However, the challenge was to open up against one's past and beloved prejudice, and enter the postmodern world of transdisciplinarity, even if reluctantly.

The project started with a group of twelve students. They constituted an interesting mixture of nationalities: one student had come from India, one from China, two from the US, four from Pakistan, and four were Germans. One American and one Pakistani, to our regret, later left the project because their general life circumstances had changed.The remaining ten participants, by a process influenced by discussion, presentation, partial analysis, personal preference, and finally decision, created four topics that they organized into the following subgroups (our naming schema):

–Merzing the Internet (four students from Germany),
–Playing the art Game (three students, one each from China, India, and Pakistan),
–Tiling the Turing machine (two students from Pakistan),
–Insisting on politics (one student from the US).

As announced in the introduction, the following chapters summarize the topics, goals, and achievements of each of these four subtasks. A general conclusion will be drawn at the end of this report. Therefore, we do not further characterize the details of the four tasks.

However, we want to raise the following question: is there a coherent logic in dividing the entire study group into exactly those four? Can an argument be built up, and maintained, that would let the four appear as special cases of some systematic view of the field? At first, our answer is: No, there is no such systematics. The splits just happened because of preferences, priorities, prejudice, inclinations, or other reasons why individuals in a study environment decide to choose something. Such things happen, and that is good as long as there is at least some connection to the overall task.

We could also define criteria or dimensions of relevance to the AAA contradiction, and place the results of subprojects accordingly along such dimensions. Two obvious dimensions were automatically given with the project proposal – (1) art, and (2) algorithm. They could be chosen as the two axes in a planar scatter plot, if scales from low to high appeared to be feasible. An attempt to actually do that failed, and the idea was abandoned. We decided, instead, to very briefly characterize the subprojects calling them as above.

Insisting on politics contributed an important facet insofar as it made all the other participants aware of the basic fact that any art belongs to the superstructure of society. Even though the relation between the economic base and the ideological superstructure is not of the cause-and-effect kind, there are massive problems of oppression, war, and poverty in the world, that appear more pressing than issues of algorithmic influcences on art. A person holding such a position may, of course, still investigate intricacies of algorithmics in art, or vice versa. Inspiration for the project must have come from the miserable condition of large parts of the world population, and use high tech for propaganda. The current contribution produced a great deal of data and animated clips. They were put together in a sort of hypermedium that makes up a documentary.

Tiling the Turing machine is the interesting experiment to use a special kind of tilings, the so-called Wang tilings of the plane, to visually demonstrate the sequence of operations that a Turing machine is performing on a given input string. The potential of this idea could be tremendous: possibly, a way could be found to visualize the execution (and definition) of a Turing machine not in the usual way of table-and-tape but in a dynamic picture to be explored interactively. The current solution is still low on exploiting the interactive potentials. The broad background here is algorithms. There is the rule-based behavior of the Turing machine, as well as the rules of defining the tiles.

Adopting techniques from computer games to let pairs of people cooperate via the Internet in the design of an image is the idea of Playing the artGame. In taking the new art of gaming as the background, the project placed itself right between art and algorithm. When the Turing project had to comply with formal rules, the three students of Playing could design their own set. Repertoires of images from art history, as well as some typical and some not so typical drawing and collaging operations are presented to the two players to choose from. They take turns in working on their combined image. They must evaluate each move, their partner's as well as their own. Depending on how much they agree in the evaluation, they get rewards. The potential here is to learn about and from the other (perhaps anonymous) player in such a way that cooperation towards a common goal increases.

The nonsense word merzing, in Merzing the Internet, refers to Kurt Schwitters' Merzbau and Merz philosophy. This project thus started from a background in art history, and to be more precise, in Dadaism.

Reference

Frieder Nake, Susanne Grabowski: The interface as sign and as aesthetic event. In Paul Fishwick (ed.): Aesthetic computing. Cambridge, MA: MIT Press, to appear

It dwells on the technique of collage, so important to many of the dadaists. But it transfers that idea into current technology. It combines Internet access to text and images (via standard software) and combines the findings in projections onto a cube of canvas. The internet is searched for images that fit the keywords. An algorithmic process causes a newly appearing image to drift on the procted area in such a way that forces of attraction and repulsion between images get balanced in order to determine the image's final location. The group made an effort to build an interactive installation that, at least remotely, reminds of Kurt Schwitters' ideas.

Digital media cannot exist, or function, without an algorithmic foundation. In many cases, this foundation will be taken from application software without special efforts to create proprietory solutions. Creative digital media will, however, need innovative programming beyond pure application.

Digital media can neither exist, or function properly, without an aesthetic appeal. In many cases, the perceivable appearance will be adapted from application software that is often so powerful that the designer is contend with using what he finds. Creative digital media will, however, need aesthetic innovation the same way that typography and page layout have always led to new designs in spite of the hundreds of available fonts. Now, of course, the issue is to design interaction – and that is new.

chapter 2

The interactive software installation megaMERZ refers to the artwork and theories of the German universal artist Kurt Schwitters (1887-1948). In the following text we want to introduce the reader to how we picked up the MERZ idea of Kurt Schwitters for the issue of a dialectic discourse in the field of "art and algorithm".

megaMERZ

Roland Knauff, Hanjo Meyer-Rieke,
Milena Reichel, Bettina Söhle

I Introduction

Figure 6: Basic class diagram and a screen shot from the first prototype running

The dialectics in megaMERZ are given through the existence of aesthetic and algorithmic elements in Schwitters' work. He was working with parody and alienation and at the same time with a high sense of structure. megaMERZ is picking up some algorithmic elements of Schwitters' work without forgetting to take his aesthetic principle into consideration.

MERZ in Schwitters' sense, taken as an artistic process of creating a collage or producing a sculpture from different material, can be seen as an "emotional impressive process". Traditionally an artist's work is seen as cooperation of handicraft technique and artistic design. How does this subjective artistic process fit in the objective and ordered realm of algorithms? Algorithms are based on mathematics, having the goal to "get logical and describable sentences with the goal of unambiguous statements." (Franke, Helbig 1988, p.7) MERZ is not logical and offers a broad range of ambiguity and interpretation.

The group megaMERZ developed algorithms, which are picking up some aspects of Schwitters' work. We faced the question what happens if an algorithm is to perform the artistic MERZ process automatically? Is the result emotionally and aesthetically appropriate? Or does the column loose its artistic character, because it is produced by a machine and not by a human being?

In a digital media context, design has the function to represent information in a way that the information is understandable. It is interesting that a representation of something on a computer display - an image - can be relevant in an aesthetic or an algorithmic way. The image on the display - in our case on the column - has to be seen in its two dimensions: in its beauty and as its pure code. With the following text we want to document our research based on some "art and algorithm" contradictions, which we encountered by reflecting on Schwitters' work from a computer science point of view.
We will start with a short introduction into the main artwork and theories of Kurt Schwitters, pointing out some artistic and algorithmic elements in his work. Then we will give a short summary of our work during the last year and describe the final idea which derived from these investigations and forms the foundation of the media installation megaMERZ. In the end we will document the final installation and give an outline for the future.

2 MERZ

2.1 Kurt Schwitters and MERZ

Kurt Schwitters (1887-1948, German) was a universal artist of Modernity, a representative of many artistic fields. He experimented with typography, sculpture, writing, painting, and architecture - just to mention some disciplines. He was educated as an artist and worked in Germany (Hanover) in the 20s and 30s of the last century. Schwitters invented MERZ - "a vision of the *'Gesamtkunstwerk'* (Braun 1999, p. 31), the total work of art, which was to break down the barriers between art and life." (www.kurt-schwitters.org) Schwitters wrote a lot of statements about MERZ like following: "MERZ means creating relationships, and preferably between all things in the world." (Lach 1981, p. 187)
His lifework was the MERZbau - a kind of interior architectural sculpture, which was permanently growing, always changing and never finished. Like most of his artistic activities, the MERZbau was also based on the "principle of the collage". (Braun 1999, p. 32) With this art technique Kurt Schwitters searched for new forms of expression through modified material during the Weimar Republic. He believed in the autonomous creation of nonsense inside a society in order to produce new signs - MERZ signs. In art history the new aesthetic of the alienation of material through collage technique found its starting point with futurist and Dadaist art. Schwitters can be seen as a precursor of these art movements. (Braun 1999, p. 14)
In the second half of the 1930s Schwitters left Germany under the pressure of the Nazi regime. He fled to Norway where he started a second MERZbau. After the Germans invaded Norway he had to flee to England, where he began his third MERZbau. He never returned to Germany.

Figure 1: The MERZbild gave MERZ its name

The Starting point of the MERZbau, and one of its central and recurring elements, is the column, on which Schwitters noted: *"Ja, was ist die Säule? Sie ist zunächst nur eine von vielen, etwa eine von zehn. Sie heißt Kathedrale des erotischen Elends, oder abgekürzt KdeE, wir leben in der Zeit der Abkürzungen. Außerdem ist sie unfertig, und zwar aus Prinzip."* (Nündel 1999, p. 59) – "Well, what is the column? First of all it is just one of many, of about ten. It is called Cathedral of Erotic Misery, CoEM, we are living in a time of abbreviations. Besides it is unfinished, as a matter of principle." (In the following we will use the German abbreviation *KdeE* for this column.) Furthermore: *"Man könnte sagen, die KdeE ist die Gestaltung aller Dinge, mit einigen Ausnahmen, die in meinem Leben der letzten 7 Jahre entweder wichtig oder unwichtig waren, zu reiner Form, in die sich aber eine gewisse literarische Form* *eingeschlichen hat."*(Nündel 1999, p. 59) – "One might say, the CoEM is the shaping of all things, with some exceptions, that have been relevant or irrelevant in my life during the last 7 years, into pure form, but in which has crept a certain literary form." This "certain literary form" refers (see Nündel 1999, p. 59) to all the semantic interrelations in the MERZbau, e.g. so called caves or grottos that were dedicated to a person or a theme (like Mondrian or Goethe) and not just assembled and arranged because of purely formal, syntactic aspects. This contradiction will be of some interest later on.

2.2 MERZ as a subject of art and algorithm

"The MERZ technique seemed to be made for the Internet. One can find all kinds of different material, which could be reassembled to a giant MERZ collage. The internet like the MERZbau consists of all kind of fragments of what ever origin. Like the MERZbau those things sometimes get obscured by other things and are after while almost not findable anymore even though they are still there."(Group internal paper, July 2004)
This can be described as the starting point of our idea.

To understand MERZ it was necessary to know Schwitters' basic aesthetic principles of design and his rough term of art. His artworks were mostly intuitive and full of contradictions (Schulz 2004). Schwitters expressed this contradiction in his famous statement: "I am a painter and I nail my paintings." (www.kurt-schwitters.org)

Reading this sentence you can feel the ambivalence, the dialectics and the humor of Kurt Schwitters. These three categories were fundamental for his works based on alienation and parody, contradiction and nonsense. (ibid.)

On our first encounter with Kurt Schwitters' art, we were fascinated by this contradictory personality. How could a person that seemed so neat and ordinary create such artworks of chaotic beauty? A dialectics that showed some similarity to the dialectics of our project topic "art and algorithm". Later we discovered neither was the person Kurt Schwitters as neat as it seemed, nor was his art as chaotic as we thought on the first glance. But nevertheless the interest was there, and as our research went on we discovered some aspects in Schwitters' numerous works that led us to the conclusion that his work could be a worthwhile inspiration for works in the field of art and algorithm, as we will describe in the following.

Frieder Nake suggested looking at Schwitters' works on number systems. It seemed to be an interesting starting point to explore the algorithmic components in his works. Numbers are after all the basis of computation. The result of our research was a little disappointing, as we found only one article (see Lach 1981, p. 268) by Schwitters in which he in fact described a number system. Schwitters explanations were as short as they were precise. He had designed a complete duodecimal number system with a complete new set of digits. His focus was hereby on the design of the digits. He designed them in such a way that simply by looking at the digit it was instantly clear by which numbers it could be evenly divided. This result was of little interest for us, but it showed Schwitters' interest in formal systems. In the same year, 1927, he also wrote articles about restructuring the German language to make it more logical. His love for formal systems can also be seen in the design of his "*Systemschrift*" (system script), a system of letters designed to remove all ambivalence from the German language. Each glyph should represent exactly one sound.

During our research we came across a different publication by Schwitters: a little pamphlet he had designed for the potential customers of his advertising agency. This brochure included astonishingly accurate guidelines for the design of print publications. What caught our eye was a paragraph in which Schwitters described the process of assessing elements in design. He implied that he actually used numerical values to assess those elements. Explicitly he only wrote about assigning a zero value to resting elements. He than pointed out the importance of the balance between the relations of all the values.

During his time of typographic work Schwitters followed firm graphic design principles. He wrote the following issues in describing his Gestalt principles in the design of a poster (see Lach 1981, p. 215): the logical and conscious structuring of text and shape, the visible connection between the shapes, creating unity from diversity and using different methods like: choice, restriction, structure, rhythm, balance and system.

In an earlier article Schwitters wrote the following line about art: *"Was Kunst ist, wissen Sie ebenso gut wie ich, es ist nichts weiter als Rhythmus."* – "What art is, you know it as well as I do, it is nothing other than rhythm." (Lach 1981, p. 244) For Schwitters, balance meant the weighing of elements against each other. *"Das Kunstwerk entsteht durch künstlerisches Abwerten seiner Elemente."* (ibid., p. 74) These sentences were important for our further development of a balancing algorithm.

One of Schwitters' ideas he never realized was the *MERZ-Bühne* (MERZ stage). Its description was a very important influence for our final megaMERZ installation and its "demonstration room". At one point for example Schwitters wrote: *"Man kann sich das Bühnenbild etwa in der Art eines Merzbildes vorstellen. Die Teile des Bildes bewegen und verändern sich, und das Bild lebt sich aus."* (Lach 1981, p. 80) – "One can imagine the stage design in a way like a MERZ picture. The parts of the picture move and change, and the picture acts itself out." Just a few lines later Schwitters wrote a lengthy description of a MERZ play, which had some characteristics of an algorithm. (Grawe 1996, p. 74) It is rather untranslatable since it contains a lot of words created by Schwitters himself. Most words where very figurative and described manipulations of surfaces and simple geometric objects that would be impossible to achieve in the real world, but could easily be done with a computer. Based on this first research steps on Schwitters' aesthetic and algorithmic design rules, we started with our first experiments, which are described in detail in the following chapter.

When we look back on our research and working process, different stages can be identified. The first stage was a phase based on research – collecting important information, analyzing MERZ and experimenting around with technical possibilities. The second stage can be seen as the development of the first software prototype. Afterwards in the third stage we decided on the presentation form of megaMERZ and defined ourselves a worst-case scenario with possible extensions. We reached the worst-case state quite early and started to work on extensions. In the fourth stage we concentrated on the actual installation and the balancing algorithm.

3 megaMERZ
first algorithmic-aesthetic stages

3.1 Stage I (April - July 2004)

We formulated our main goal the following way:
“Our main goal is to bring the Merz Idea to the Internet, to find out the algorithm(s), if any, behind Schwitter’s work and to develop an algorithmic look on Merz. Maybe by that we can get a step closer to the *“Gesamtkunstwerk”* Schwitters demanded. We want to reflect on the idea of the Internet resembling a world in ruins consisting of fragmented bits of information, from which a MERZbau is growing, making new use out of the pieces.”

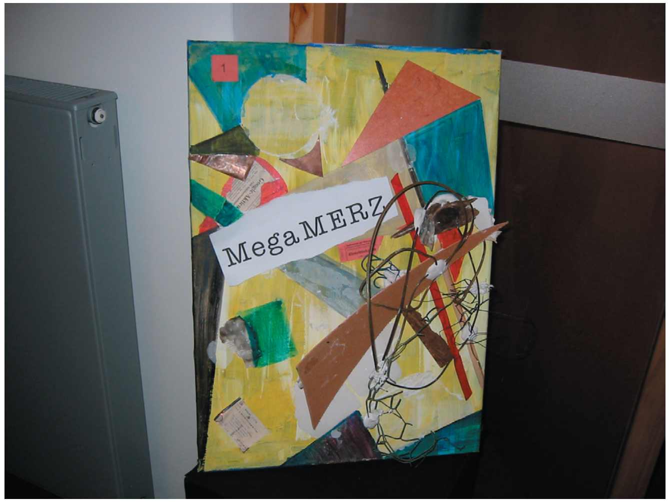


Figure 2: a MERZ picture made by the megaMERZ Group

We started the research work with a trip to Hanover where we visited the *MERZbau* reconstruction and had the opportunity to buy literature about Schwitters and the *MERZbau*. Afterwards we worked independently on several small things. Firstly we conducted further research about the work of Schwitters. We decided to get some hands on action and to create some small independent prototypes. To get an idea of Schwitters’ design rules, we went into his process of MERZing, of adding new material into a MERZ collage. We imitated his principles of composition in reconstructing such a collage by hand. Through this exercise we got a first feeling of Schwitters’ fundamental aesthetic understanding of balance and rhythm in a composition. In parallel we started developing prototypical algorithms for the material collection (using the Google API) as well as for the pre-MERZing material preparation and conditioning.

One small project was to read and to find out what kind of verbs Schwitters used to describe how he worked. The verb list is quite complex and written in German because Schwitters invented his own words which would loose their original meaning through translation. The verb list was a good start to find out what the algorithm of the software has to do. The list contained terms like to nail (*nageln*), to paint (*anmalen*), to connect (*verbinden*), to dissolve (*auflösen*), to electrify (*elektrifizieren*), to destroy (*zerstören*), to balance (*balancieren*) and to distribute (*verteilen*).

The description of the earlier mentioned MERZ stage has itself some algorithmic character and was the inspiration for a short video in which we explored the possibilities of MERZ image manipulation: set surfaces, take them till the thought infinity, put colour on them, move them, make them rough, fold (*zerknicken*) them and make them turbulent, bend (*krümmen*) the pieces of nothing together, stick smooth surfaces, bend (*biegen*) line movements, cross flamed lines, stalked lines, faced lines, let the lines fight with each other and stroke each other in presented tenderness, points should shine like stars, dance and close up as lines, bend (*biegen*) the lines, bend the edges to a whirl point. (see Grawe 1996, p. 74)

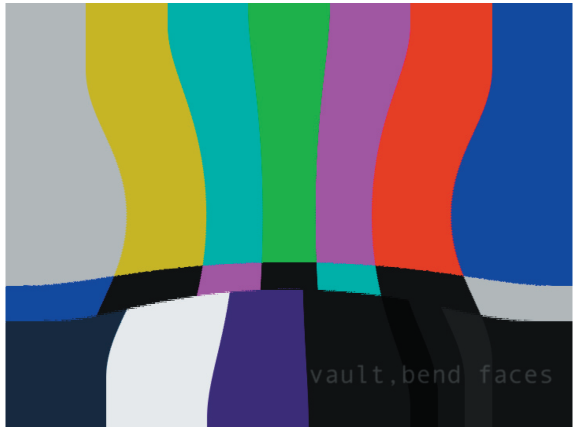


Figure 3: The image shows one screenshot of the movie visualizing the algorithm

Another small project was the modeling of the “Cathedral of Erotic Misery” with the application Maya in order to get a feeling for its structure. We experimented with the possibilities of a generative architecture of the rooms, columns and grottos.

Figure 4: Reconstructed KdeE: Basic MERZ shapes in a 3D program

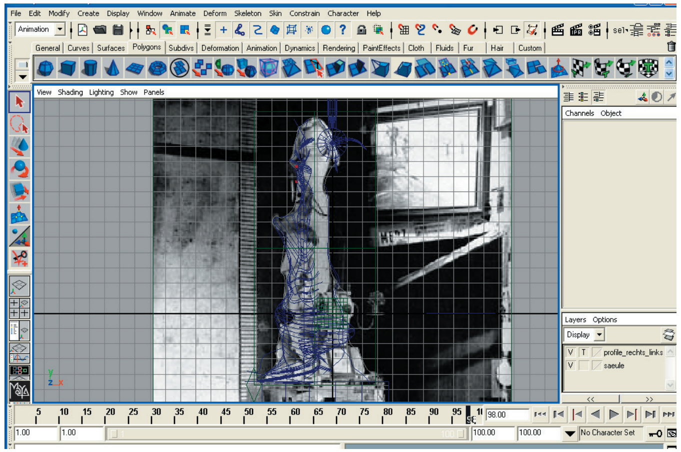
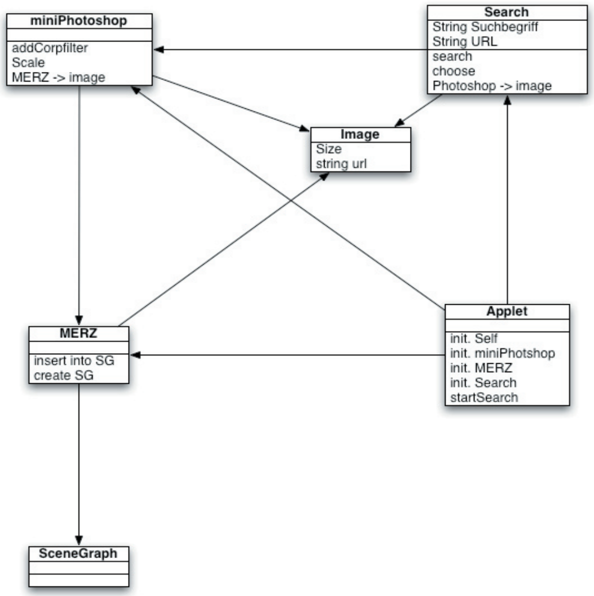


Figure 5: Reconstructed KdeE: The images show results of the modeling of basic shapes

Basic interface prototype

For the very first prototype of the interface two primitive shapes and two algorithms to recognize them were implemented – column and horseshoe. People could build shapes from “pixels” (black boxes with distinguishable patterns on it) which were then interpreted by the computer to create the basic shapes for the 3D scene. To implement this, we used the AR Toolkit software, which can recognize different patterns in an input stream from a camera (e.g. a web cam) and add 3D objects on the pattern positions in real time. We used it to recognize the patterns and then check the positions the patterns had to each other. In case all (three) patterns are on top of each other, the computer draws a column. In case one pixel is in the middle and two are on top of it next to each other it would draw a horseshoe.

We finally decided not to use the interface prototype because our idea shifted towards user interactions as described in stage 2 and 3.



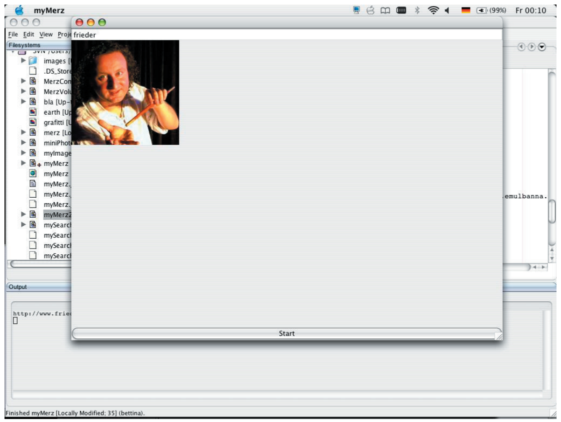


Figure 6: Basic class diagram and a screen shot from the first prototype running

3.2 Stage 2 (August - October 2004)

In stage 2 we concentrated on the first software prototype and the decision which technologies we were going to use. After encountering several problems with OpenGL we switched to Java and the Java3D library. We started with the development of the class diagram (Fig. 6) and then implemented it.

The program therefore consisted of an application (in the diagram called Applet) that started an interface, in which the user can enter a text in a text field and press the start button. The word is then sent to the search module that contacts Google to find an image for the text. This image is sent to the MiniPhotoshop module that allows to crop and change the image and finally hands it over to the MERZ module. This part of the program inserts the modified image into the Scene graph that is displayed by the Java3d rederer.

3.3 Stage 3 (November - December 2004)

Of course we had to fix some bugs in our first prototype and we had to re-implement some modules e.g. changing the structure to implement the model-view-control (MVC) concept. As an additional feature we added a sound search that works the same way as the image search. We decided on the presentation form (installation) and defined our worst-case scenario (our minimum goal). The *megaMERZ* should be an installation consisting of one white cube (like marble) in the centre of the room and 4 projectors. The *MERZed* sculpture is growing out of nothing. We also defined some extended versions with improvements to our project after reaching the worst-case state.

The worst-case scenario had the following functionality: A keyboard is used to input the search term. The output image is shown on a screen. A mouse is used to apply filters like crop and scale. The new image is shown on the same screen. We search for images and sound and insert both into megaMERZ. On the 3D level we wanted to have the same viewpoint of the megaMERZ projected on four sides of the cube. An algorithm should be responsible for placing the images in the existing megaMERZ depending on their size and their characteristics. The extended version might additionally have an interface that works with image recognition (e.g. Quicktime for Java) to influence the growth of the sculpture. We developed a little prototype but we decided not to use it in the final installation.

3.4 Stage 4 (January 2005)

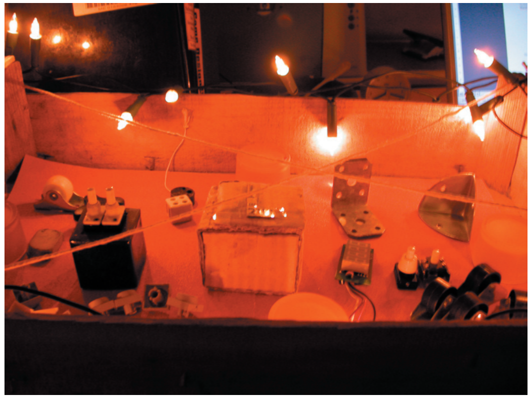


Figure 7: First scenario model for an installation space with three MERZer terminals

One thing we concentrated on in the last stage was (apart from debugging and little extensions) the planning of the exhibition. We finally specified the installation in the following way:

Before entering the room, the visitor can get an overview of the different steps in the megaMERZ art and algorithm room installation. A plan in front of the entrance informs about different possibilities of interactions at three stations in the room, which are called MERZer terminals. Each terminal has one button: search, decontextualize and MERZ. The three MERZer stations are arranged like a sequential trace, which symbolizes the sequence of an algorithm. Just one person is allowed to use the algorithmic terminal trace at a time. The visitor can choose an image by typing in a personal word. The image can be formed through the "decontextualizer" device and in the end the visitor can decide, if the image should be inserted into the sculpture. A white column is hanging from the ceiling. Also there are some network cables which symbolize the relations between each single element in the room.

1st Terminal: Search

After entering the room the visitor has to type in a word (e.g. on a keyboard or an old typewriter). With this action the person feeds the first MERZer with his/her own sign. The process of typing in a word follows the metaphor of typing in a password. At the first MERZer terminal the visitor is invited to type in a word. An application (for instance the WebSpeech Reader, http://www.webspeech.de) reads the individual letters of this word, for example in a way that Schwitters wanted his "Ursonate" to be read. You can hear the sound in the whole room. The word is shown on a display at the first station: the search terminal. After pressing the "search" button, the megaMERZ application searches for the image in the Internet. The word on the display disappears and the image can be seen on the display of the second station.

2nd Terminal: Decontextualize

When the visitor turns the "decontextualizer" device (some sort of rotary input unit) the megaMERZ application starts to form the image (by using filters like crop or lasso, cutting geometric forms and applying color changes) with an automated filter sequence. The filter function follows the MERZ design principles of balance and rhythm. With every turn of the device the image loses more and more of its semantic signification, its original context becomes less and less obvious. This aspect gave the device its name. The visitor can observe the image forming process on the display and can influence the level of change. When the editing process is finished the result is shown on the next station.

3rd Terminal: MERZ

If the person is pressing the big red MERZ button the image is pasted into the 3D megaMERZ column. The corresponding sound of the word can be heard. While the image is transferred to the column an animation shows what happens to the image. There is the possibility to sit on cushions around the column to observe the growth process of the sculpture. An additional feature could be that the sculpture grows into whatever direction most visitors are standing. This could technically be solved through image recognition with a web cam and Quicktime for Java.

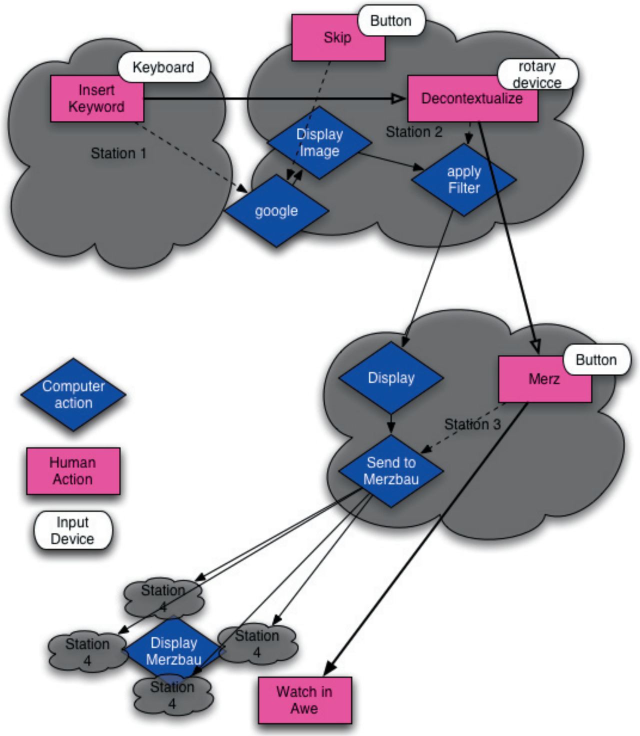


Figure 8: MERZer terminal steps shown in a technical diagram

4 megaMERZ
The final installation

4.1 The idea

After studying Schwitters for more than half a year we were ready to refine the concept for an interactive spatial media installation. We want to introduce this with some statements on the renewed self-conception of megaMERZ:

megaMERZ is a space, which picks up some categories of Schwitters MERZbau and provides a basis of some experiments on art and algorithm issues. In the space the spectator is allowed to "MERZ" and thereby get an idea of artistic and algorithmic aspects in Kurt Schwitters' work.

megaMERZ is an algorithmic-artistic strategy to re-understanding signs from the Internet. The Internet has developed into a system, which extremely speeds up the production of signs. These signs are carriers of significations, which have cultural and economic value in our society. Schwitters alienated signs of his time, the time of the Weimar Republic, in producing MERZbauten. megaMERZ follows the idea of alienating images from the Internet, taking them out of their original context – "decontextualizing" them – and rearranging them in a possibly aesthetically appealing manner to form a virtual sculpture. New significations might become visible once the images move around on the surface of this sculpture and the contradiction between the aesthetic and the algorithmic point of view on an image might lead to a reflection about the "crisis of representation" concerning the production of signs in the age of digital media. The interpretation of pictures depends on our knowledge, cultural background and physical capabilities. Also a dominating power can influence the obvious meanings of pictures and the way in which we construct new contexts around the pictures we see. A lot of manipulation is possible. In this context megaMERZ could be seen as a game between the belief and disbelief in the representation of digital images and what we as visitors, already used to consuming pictures without thinking about it, can expect from them and how much we know about their meaning, relation or context.

Frieder Nake summarized the main idea behind megaMERZ in its best: "The idea is to pick up more or less randomly images from the Internet as visual answer to symbolic queries, and arrange them in a Merz-like column. The internet adds an element of uncontrolled and of unfinished. The unfinished as Schwitters' category. There are the finished actuality of material and the unfinished virtuality of ideas. Contradiction of image and thought behind." (comments on the project, Frieder Nake, October 2004)

The installation picks up some basic design rules in general and the idea of the MERZ process in particular from Schwitters work of art. Furthermore the megaMERZ room installation was inspired by the first demonstration room concept of El Lissitzky, who worked with Schwitters for a while.

4.2 The process of MERZing

In the MERZing process different materials are combined to a new "no-meaning" or "nonsense" collage. Nonsense has no purpose. Schwitters was interested in the process of making art, in which "the material loses through decoding their individual character, its *'Eigengift'* (own poison). The original signification of the original material is insignificant and arbitrary." (Schulz 2004) The interest is lying on a process of creating an undetermined, open and dynamic system. (Braun 1999, p. 25)

On the other hand algorithms follow purposes, and developing them requires concentration on precise rules. Everything that is based on rules supports the machine of sense making. Schwitters always neglected the circumstance of making sense with his art. He wanted to make no sense.
Our concept is picking up the nonsense idea of the MERZing process to adapt Schwitters' way of making nonsense in an algorithmic sense. Thus the challenge in our work was the contradiction between the implementation of nonsense software through an algorithm with a purpose.

figure 9: view into the installation room

Following Schulz, “to MERZ” in the sense of Schwitters “is to form and to form means to decode. To form means to set in relation, to judge different materials by formal aesthetic design rules along the design aspects rhythm, balance and harmony.” (Schulz 2004) In investigating the aesthetic rules of different MERZ works of Schwitters, we came up with our own understanding of the aesthetic algorithmic MERZing process. To MERZ - in the context of megaMERZ - means to choose, to form and to arrange images. Different images are chosen from the Internet. Like Schwitters’, the search for material has no explicit criteria and can be seen as a semi-random search. The images are formed – or “decontextualized”, as megaMERZ calls it. The digital material is algorithmically arranged on a geometric display following rules of balance. The result is a landscape of images displayed on a physical column. The goal of MERZing is the same in MERZ and megaMERZ: “to get a balanced whole from each single element of a space” (Schulz 2004) These three MERZing steps are displayed by three different MERZer stations and are further described in the following.

4.3 The megaMERZ space

The main inspiration for the megaMERZ space was the MERZbau as a “prototype of environment sculpture” Schulz 2004) Schwitters was interested in dissolving old room functions in an atelier of artistic experiences

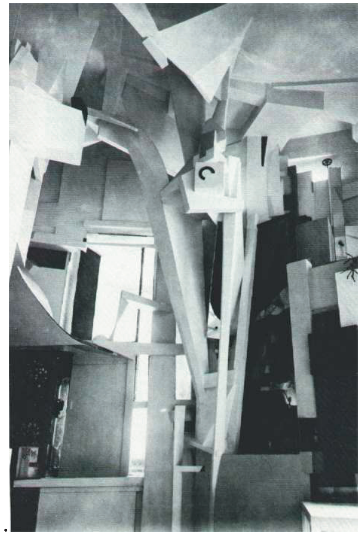


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Figure 10: Schwitters, 1923-37, Merzbau

One concern behind the spatial design of the megaMERZ installation room was to allow the visitor to leave his or her distance to the virtual sculpture through the interactive participation in its creation. Like the MERZbau the megaMERZ is an open work in process. The visitor is walking on the sequential traces of the megaMERZ algorithm. The algorithm is made visible and tangible through the three MERZer terminals. Like the sequence of instructions of an algorithm, the MERZer terminals are arranged to form a line and indicate their sequential order.

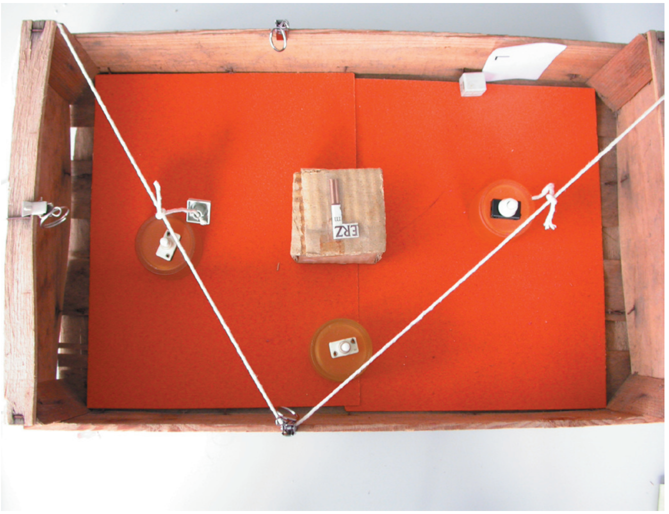


Figure 11: Space model with the 3 MERZER terminals and the column

4.4 MERZer Terminal 1: collecting material

As stated earlier Schwitters used all kinds of materials, from tram tickets to wire fence pieces, but all those things are treated as equal parts of his MERZ compositions. And they all got similar treatment. Schwitters would for example paint color on a piece of wood as well as on a newspaper fragment, so in this context we regard all the materials he used as images. In a megaMERZ sense, all materials are images in the end. When we talk about image and image manipulation in megaMERZ we must first broaden the term image.

Frieder Nake points out that a digital image is always an algorithmic sign. Algorithmic sign is meant in a sense of invisible content in addition to the visible output. The computer needs code to create pictures on the screen. The algorithm expresses the calculable part of the picture. The invisible picture could be seen on a screen. There are many different notions of a picture depending on who is the beholder of the picture. A computer scientist is used to seeing pictures as representations. An artist might be more interested in the content of personal expression of a picture. (Nake 2001)

The megaMERZ machine makes use of the Google image search (http://images.google.com) in order to collect material. The visitor enters a search term via the keyboard and an image appears at the second station. The idea to start the MERZing process with a keyword is inspired by the topic-oriented grottos and caves that Schwitters included into his MERZbau, as mentioned earlier. But of course Google is just a "stupid machine", that works on the syntactic level and depends on analyzing the contexts and relations in which people publish images on the Internet. Thereby the Google image search finally sets up its own network of relations between words and pictures from the web. If we enter a search term and get an image in return, we get to see a small cutting of this network that already leaves a lot of space for interpretation.

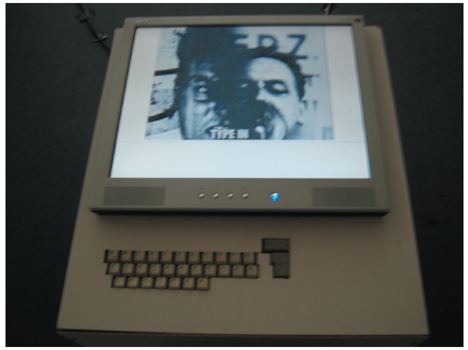


Figure 12: MERZer Terminal 1

4.5 MERZer Terminal 2: decontextualizing material

In a way a machine could be the answer to Schwitters' demand for his material to be freed from all original significations in order to be used as nothing but formal shapes and graphic elements. (Schulz 2004) Our megaMERZ machine has no choice but to make all its "aesthetic decisions" depending on the pure syntactic aspects of the material. By following Schwitters' method of alienating the picture, by transforming it into abstract colored shapes (or rather by making the nature of the digital image as consisting of these concrete elements easier visible), the visitor symbolically performs this reduction to the syntactic level.

Figure 13: MERZer Terminal 2

It did not seem appropriate to us to just transfer the manipulations Schwitters used on his images and use them on our digital images, so we did a little translation from the analog (or real) world Schwitters worked in to the digital (or virtual) world where megaMERZ exists. Most of Schwitters' alterations were very simple, like just painting some color over one piece or cutting away half of another piece. Some of those manipulations were very simple in the real world but hard to recreate in the digital realm. So we tried to find some similarly simple digital operations.

Figure 14: MERZer Terminal 3

The first step for every piece of material to become a part in a MERZ painting was to be washed very consciously (See Lach 1981, p. 88). This is of course not really applicable to the digital world, because everything here is always clean. But one important side effect of this washing process was that many of the pictures had very irregular borders. We figured this was a very important aspect of the MERZ look, so we decided to create a filter that would alter the alpha channel of the image to let the borders look frayed.

Schwitters often covered elements of his works or parts of them with paint. This is translated by adding pattern masks to one or more color channels of the digital images. This adds color as well as structure to the images just as Schwitters did with his brush.

Another important element in Schwitters' works were single colored shapes which he cut out of advertisements or other printings with big color surfaces. Since single color images are not often found in the Internet, especially not with the Google image search, we use a simple "equalization" algorithm. We just set every pixel of the picture to the color value that represents the statistical average. Thus we end up with a single color image with the average color of the original. Schwitters used quite a lot of black and white images from photos and newspapers. Since the Internet features not very many black and white or grayscale pictures we have a simple grayscale filter that removes the color from an image. Schwitters sometimes tried to enhance the effect of a dominant color in a picture by painting more of this color onto the picture. This effect is quite complex to do for a computer, so we decided to just to enhance the most dominant color channel. We also feature some filters that do not have a direct relation to Schwitters. In this category is the invert filter, as one of the simplest digital image filter, as well as three filters that where created accidentally while trying to implement the other filters. We kept those mistakes that created not the expected result but nevertheless visually interesting images. We believe this would be in the MERZ spirit.

The application of the filters is done in a semi-interactive process by the user.

Station 2, the decontextualization MERZer terminal, features a silvery rotary input device, which controls the decontextualization meter. This scale features an eye on one side representing concrete contextual pictures, and a triangle on the other side for abstract context free pictures. When the user rotates the device, the computer chooses filters depending on a random factor calculated from the position of the decontextualization meter and the image size. The combination of those two factors results in random numbers, which are predictable for each image. So the same meter position on the same image (more precise every image of the same dimensions) will result in the same combination of filters applied to the image. This consistent feedback is supposed to make the visitor's influence in this step more transparent and easier understandable.

4.6 MERZer Terminal 3: arranging material on the column

The third terminal presents two buttons to the visitor, offering the choice whether to use the decontextualized image by inserting it into the column or to discard it. If the visitor chooses to add the image into the virtual sculpture, it is (in the exhibition version) placed at a random position on that side of the column, which faces the third terminal. This white column of canvas, hanging upside down from the ceiling of the room, is the center of the megaMERZ installation. It refers to the beginning and the heart of the original MERZbau of Kurt Schwitters – the earlier mentioned KdeE: “The overall form structure of the “cathedral of Erotic Misery”, as Schulz pointed out, “followed the early Dadaist design principles of collage and of constructivist design of geometric structure and order.” (Schulz 2004)

megaMERZ picks up the column as a symbol of the contradiction between the early understanding of Schwitters’ aesthetics on the one hand, based on collage and geometric principles, and the algorithmic-aesthetic balancing principles of megaMERZ on the other hand. The column also symbolizes the contradiction between its pure physical appearance as canvas material and at the same time immaterial and visual output of a machine-based process. In the original MERZbau the KdeE as a starting figure was dissolving when the MERZbau started growing. Likewise the canvas column in the megaMERZ adapts the shape of its virtual counterpart. The visitor creates, with the help of the balancing algorithm, a dynamically changing column that is never finished. It rebalances its visual surface every time a new image is inserted. Thus the visitor has the possibility to reflect the altered meanings and functions of the manipulated images.

Technically speaking the column consists of four canvases onto which the image collage is projected by two projectors. This makes it possible to use only one computer with a dual head graphics adaptor instead of two or even four computers. This eliminates the synchronization problem, but brings up the new problem of image distortion. Since each projector is projecting on one of the edges of our column, the image gets the more distorted the further it is away from the edge. To compensate for this we make use of the fact that we do not take the third dimension into account in our balancing.
We actually use 5 instances of each image. Each one is rotated and translated in a different way, so they all move differently through the three dimensional space when the invisible original is translated on the x-y plane. This results in a clutter of five images moving in different directions. Therefore we use clipping planes to display only a small segment of the three dimensional space. This results in only one picture being visible at any given time except in those cases when the image comes close to the edge, where part of one picture is cut away by the clipping planes and parts of the second instance, 90 degrees rotated, become visible, creating the illusion of the image folding around the edge of the column.

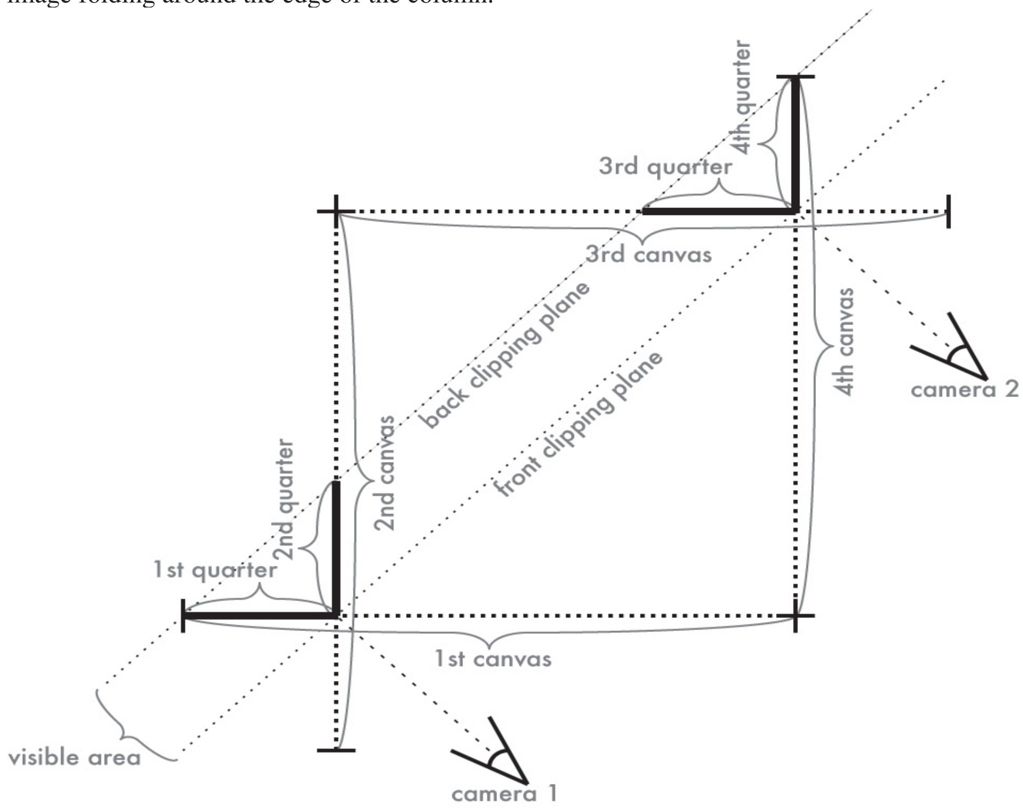


Figure 15: Image of distortion compensation setting

The heart of the megaMERZ machine is the balancing algorithm, which arranges the images on the column. Arranging is an "ongoing process". The column is never a final work of art or work of algorithm. Through an iterative design process the column is reworked all the time and is running through an algorithm again and again.

"Die Aufgabe von MERZ in der Welt ist: Gegensätze ausgleichen und Schwerpunkte verteilen."(Malsch 1993, p. 66) – "The challenge of MERZ in the world is: balancing oppositions and distributing centers of gravity."

Searching for a suitable model to represent Schwitters' compositional principles of balance, we developed a pseudo-physical simulation. Every image that has been MERZed is treated as one body that has a mass (depending on its size) and deals a certain force (either attraction or repulsion) to every other image on the column. Apart from these mutual forces, an image can also be affected by singular forces that only depend on its own attributes.

$$\vec{F}_{total} = \vec{F}_{mutual} + \vec{F}_{singular}$$

Each of the balancing principles is represented by one or more forces. In our exhibition version, six forces were at work. The only singular power we used ensures that the images do not stick to the upper or lower border of the column, even though they might repell each other. (The size of the column surface is given through x_{max} and y_{max}, the length of the diagonal vector $|\overrightarrow{x_{max} y_{max}}|$ is used as a standard distance unit. The distance ∂ between two images is the length of the distance vector divided by this diagonal length. Furthermore each force has another static modifier μ.)

$$\vec{F}_{center} = \mu_{center} \cdot \frac{(y_{max}/2 - y_i)^3}{|\overrightarrow{x_{max} y_{max}}|^3}$$

The sum of the mutual forces $\vec{F}_{mutual}$ is the product of the distance vector $\vec{d}_{12}$ connecting the two images and a factor b that is the sum of all factors of the individual forces. Thereby the force has the same (or exact opposite) direction as the distance vector. The proportionality between $\vec{F}_{mutual}$ and d is not intended and is corrected through the b-coefficients, where needed. It would have also been possible to work with a unit vector from the outset.

$$b = b_1 + b_2 + b_3 + \ldots$$
$$\vec{F}_{mutual} = b \cdot \vec{d}_{12}$$

The first of the mutual forces ensures that the images distribute somewhat equally over the whole surface and do not stick to each other.

$$b_{repulsion} = -\mu_{repulsion} \cdot \frac{m_1 m_2}{\partial}$$

The next force is 0 if the pictures do not overlap. Otherwise it is used to arrange the pictures next to each other instead of directly over each other.

$$b_{overlap} = \mu_{overlap} \cdot \frac{m_1 m_2}{\partial^2}$$

The remaining three forces are the most interesting ones, as they compel the images to arrange in a way that might represent Schwitters' manner of balancing compositions by arranging similar elements far away from each other and contrasting elements next to each other. We regard three aspects of the image: height, width and ratio.

$$b_{height} = \mu_{height} \cdot \left(\log_2 \left(\frac{y_1}{y_2} \right) \right)^2 - b_{maxrepulsion}$$

$$b_{width} = \mu_{width} \cdot \left(\log_2 \left(\frac{x_1}{x_2} \right) \right)^2 - b_{maxrepulsion}$$

$$b_{ratio} = \mu_{ratio} \cdot \left(\log_2 \left(\frac{x_1 \cdot y_2}{x_2 \cdot y_1} \right) \right)^2 - b_{maxrepulsion}$$

All the maximum repulsion and all the μ values for these three forces are the same in our installation version. They are calculated to deliver b = 0 if the logarithm of the compared aspects is 1.5. The exact parameters and details of our force model were determined through repeated tests and evaluations of the resulting compositions, deciding whether or not they looked as if they followed Schwitters' principles in a way that we had intended them to do.

The resulting force $\vec{F}_{total}$ divided by the image's mass m delivers the acceleration for this step, this is added to the movement vector of the image.

$$\vec{a} = \frac{\vec{F}_{total}}{m}$$

$$\vec{v}' = \vec{v} + \vec{a}$$

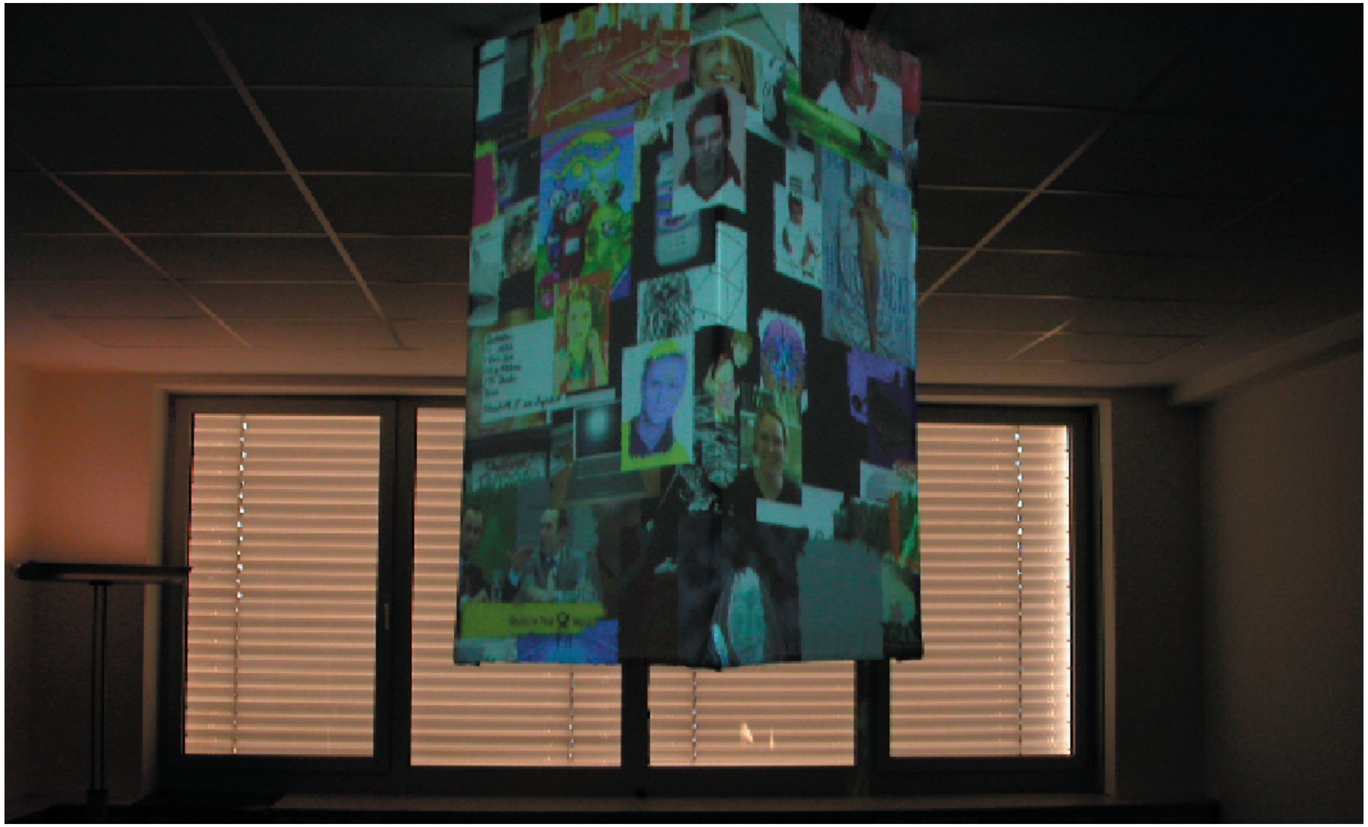
This movement vector is then reduced by a static friction value, and, together with the old position vector, determines the new position of the image. When this is done for every image, the next cycle begins.

4.7 The exhibition

The result of the megaMERZ project was the exhibition of the installation that took place on the 31^{st} of March 2005 in room 3010 at the OAS building. The event started at four o'clock in the afternoon, with the sun still shining outside four the next couple of hours. We used the building's Venetian blinds to darken the room, but nevertheless the projections would have been much more impressive in a darker environment, with the room only being lit by the glowing column and the screens of the MERZer terminals. For this it would have been necessary to block the windows with cloth or to postpone the event a few hours. The room was empty apart from the things that were necessary for the presentation – the canvas for the projection of the virtual column, hanging in the center of the room, the two projectors with the computer controlling them, the three MERZer terminals, arranged in a quarter circle leading from the entrance halfway around the room to the other side of the column – and a sofa corner for those visitors who have already passed the three stations to sit down and watch the megaMERZ column shifting and developing.

We started the exhibition with the column being totally empty. In combination with the empty room this appeared to make the visitors feel a bit uneasy to be the first to use the megaMERZ machine, maybe thereby destroying the immaculate emptiness of the canvas. In the beginning most visitors tended to ask for some explanations. Before entering a word, many of them wanted to know what was about to happen with it. But very soon the visitors started to become familiar with the way the installation worked, and kept playing around with it, trying out the results for different search terms, starting the MERZer circle over again at terminal one as soon as they had finished MERZing an image at the third station. The installation was active for about four hours. During this time people kept adding elements, so that the column's surface was covered with images to a large extend at the end of the exhibition.

It was interesting to see how people related to the images that they had brought up onto the column. They kept looking for "their" images, where they were moving and what other pictures they related to or arranged themselves with. People also talked a lot about the words that were "behind" their images and kept wondering what words must have been the basis for other pictures. Visitors compared the way that people related to the signs that had been left by themselves to graffiti, bearing the possibility of leaving a certain personal and/or cultural expression in public spaces. And only they knew the reason why they had added this element the way it was now and what had inspired them to enter the keyword that delivered the material – in a way similar to the original MERZbau, where only the artist himself, Schwitters, knew the secret original meanings of each of its elements or what his personal relationship to each of them was.



5 Conclusion

In his opening speech for the presentation of our results Frieder Nake pointed out the broad spectrum of projects in Bremen over the years. There are projects with a very precisely defined task, which merely needs to be put in code and on the other hand there are projects that only deliver a broad topic, which the students have to narrow down to an implementable idea by themselves. Art and Algorithm is on the second end of this spectrum. The topic was broad and open, as well as, on the first glance, contradictious. So it was not surprising that it took us quite a while to find and specify an idea.

In the case of megaMERZ the idea was born quite early but evolved a lot through the passage of time and the growth of the subgroup. This development of the idea in the subgroup was probably the most important and rewarding factor for us in the project. The idea went through a lot of changes and many aspects of it have been cut away. This led to many prototypical software parts that have never been used in the end but nevertheless have been important experiences for the group and valuable influences of the idea. But this also led to a slim but convincing installation that reflected the core of the first idea behind it and interested quite a lot of people.

The state of the megaMERZ column at the day of the final presentation was a stable and complete one. Of course it would violate the very basic spirit of MERZ to call it a finished thing. Therefore we want to spend some lines in the end of this subgroup report to take a view into the possible future of the megaMERZ.
The only real bug in the system is found in the ordering of the pictures on the column. Right now there is no way to tell if a picture will appear in front or behind the other images when it is inserted into the column. This is due to the fact that all images must exist on the same plane in order for our distortion compensation algorithm to work properly. We expected the Java3D renderer to render the images in the order of their insertion into the scene graph. In reality the renderer renders all the leaves of one scene graph node in parallel. Therefore it is impossible to tell in which order the images will appear on the column. There are two possible solutions for that problem, but both of them are too time consuming, so we did not manage to implement them in time for the presentation. One of them would be to change the scene graph structure of our column. The other one would be to modify the Java3D renderer itself.

The most obvious extension to the megaMERZ would be in the realm of the balancing algorithm. Here are still a lot of factors that are unconsidered yet. Color distribution and shapes in the image are two examples of factors we would have liked to incorporate.

An idea that regrettably only came to us on the day after the presentation was to include a fourth MERZer terminal that would enable the visitor to influence the balancing algorithm itself. This easily could be done by changing the factors of the several forces that the algorithm incorporates. On the other hand some complained that the third terminal in its current shape was not necessary, but could be included in the second one.

Many people suggested we should use some semantic information of the pictures as well. Even though this would violate the foundation of our idea to only use syntactic information about the pictures, this could be worth further thoughts.

From Frieder Nake came the suggestion to use the search words the user typed in at the first MERZer Terminal in the collage. Or maybe to project the words onto the surrounding walls of the MERZ room so the visitor would be trapped between the words and the pictures, between semantics and syntax.

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chapter 3

Can creativity be encouraged or produced in a game? Can two strangers have fun in making an artistic picture while they are confined to the rules of the system?

combart

Jin Li, Maria Iqbal, Srikanth Nagandla

I Introduction

An algorithm is carried out as a finite sequence of steps. The result of an algorithm is predictable. But “there do not seem to be any ‘laws’ of art that will predict artists’ behaviors, or that explain the ‘evolution’ of art history by detailing what ‘succeeds’ in making a work beautiful or significant”(Freeland 2001, p. 208). In this sub-project, Combart, the relation between art and algorithm is explored in the context of petite art and computer games.

Games can produce unexpected results which can be considered for their aesthetic quality. Petite art is the term used to refer to a production which can be considered as an art work, but is not expected to compete with the expectations of fine art. Combart creates examples of petite art which are being considered in relation to the algorithmic environment in which the game is played.

Games are played with an agreed upon set of rules. The rules are definite. Thus rules are realizable by algorithms and this is done explicitly by programming in the case of computer games. This is how games are considered as a proper and joyful way to explore art and algorithm in the Combart project.

This project uses a computer game as a tool to make petite artwork. It is an exploration to approach art through the process of choosing, drawing, judging, expressing and combining. Combine to make art, petite art, is the idea behind Combart and also explains from where the name comes. So Combart is totally different from another game genre, combat. It is the power of combat with the extra R of art.

2 Description of Combart

Combart can be accessed at the address, www.Combart.info. This domain is dedicated to the purpose of allowing access from anywhere in the world on the internet. The website contains the necessary information to understand the game.

Combart is an online game played between two people to create a petite artwork with unexpected content. It involves bi-active interaction between two independent actors and as such can be considered a mechanism for non verbal communication. There is a popular word game called Mad Libs (Price & Stern 2000). It produces an unexpected story by filling in the blanks without seeing how the story will be construted finally. Combart might be thought of as a visual Mad Libs.

First a player logs in to the game server. The first task is to choose a partner, a theme, and the game mode. A list of themes is given. Each player can also create a new theme. The theme can be about life, nature, philosophy, politics or anything in which the player is interested. All the players can chat here to discuss their interests and decide on a theme. The game is designed only for two people. So, a pair of players takes one theme and enters the game. There are two game modes: cooperative and competitive. In the cooperative game the rules encourage supportive play and in the competitive game the rules encourage oppositional play.

Similar to the starting of a role playing game, the players will equip themselves before beginning the game. Instead of choosing different fighters and guns, the players choose their favored artists' images, drawing tools, and colors. The images are categorized into images from artists and images which represent a theme. All of the images are irregularly cut shapes from art sources. The variety of images can be immense. They are from traditional fine art, revolutionary art, chinese art, indian art, african art, and fractal images. Several women artists are also represented.
The game logic of Combart is that an artwork needs an investment to start. For instance, a painter needs to buy a brush and a canvas before painting. In Combart each player uses their initial money to purchase necessary equipment. Then each player will start the real play, a process of creating an image together. There is one canvas. Each player has their own images, drawing tools and colors which are used on the canvas. The game is turn based. That means that when one player has the control over the common canvas, the other player observes.

The rule system of Combart is based on rewarding specific performance of the players. The rules also reward art content. Each player can put an image onto the canvas, draw shapes and manipulate the elements according to the rules. Different actions will increase scores and have effects on how the other player will perform in their turn. There are two outputs at the end of game - picture and score. In the cooperative game there is only one final score for the two players. Success is reflected by the highest scores. In the competitive game, there are scores for each of the two players. The winner is the player with the highest score. Cooperative players try to reach the highest possible score, but competitive players only strive to beat each other. This difference of goals may lead to a different quality of the picture being made.

3 Goals of Combart

Combart is designed to achieve the following goals.

1. Combart is intended to interest all people in playing Combart.
2. Combart is intended to challenge the individualism in fine art.
3. Combart is designed to create two person interactions. Interpersonal interaction is richer than human computer interaction.
4. Interaction in Combart is intended to be a stimulus for creativity. Combart is meant to produce an improvisational performance art.
5. The rules of Combart intentionally try to limit the freedom of artistic expression and influence the results. But at the same time the rules try to provide a platform to express creativity.
6. The picture made in Combart is intended to be considered as a work of collage and petite art.
7. Combart is intended to be less male oriented and more female oriented than most computer games.

Since games are rule based and the goal is to reach a certain result, games share common features with algorithms. Programmed algorithms create the rule based game environment. Different algorithms for different rules produce different petite art.

Combart is intended to be available to everyone and interest them to play. In the AAA project, we have a common orientation with another project called iDIA about Art and Politics. Art used to be only relevant to a particular class in the society. Traditional fine art is only for the upper classes. Only a few people are able to make art for a small number of people to enjoy. Fine art is limited and expensive.

Fine art is also elitist in its stress on the rarity of the true artist. "The bourgeoisie always shuts out proletarian literature and art, however great their artistic merit" (*Talks at the Yenan Forum on Literature and Art* 1942). Any production from a famous artist can be considered as a masterpiece even it would not be significant to have come from a non artist.

Games, as basic human activities, are accepted by high or low class, children or adults. The rules of different games are developed through experiences by varied people. So games are mass activities. Combart includes different classes of art, european artists, women artist, chinese artists and russian artists. A wide range of fine art is included to appeal to many tastes. And the modular nature of Combart makes it easy to include new content.

Combart is intended to be a way to build a bridge between the art of the elite and the algorithms of the ordinary. It offers a way for everyone to access different pieces of existing artwork and use them for their own good.

Combart is intended to challenge the individualism in fine art. "In the western world the association between art and individual expression took shape about 1500 and flourished in the 1700s. The idea that art should be a form of self-expression has remained an important part of our definition of art to this day" (*Microsoft® Encarta® Online Encyclopedia* 2005). But the sub-project iDIA demonstrated an exception in revolutionary art. "Works of literature and art, as ideological forms, are products of the reflection in the human brain of the life of a given society. Revolutionary literature and art are the products of the reflection of the life of the people in the brains of revolutionary writers and artists"(*Talks at the Yenan Forum on Literature and Art* 1942). Artists rarely sit together to create one single piece. However, traditional games are usually played by more than one person. Combart is intended to be a bold experiment for people to create an artwork together in a game environment. Interactive participation from two people in art-making makes Combart unusual.

Combart is designed to create two person interactions. Games in general, and computer games in particular, are rule-based activities into which two or more persons, or one or more persons and a computer, are involved. The challenge for Combart was to design interaction of two people such that the rules of the game were obeyed, the players could experince some fun, and some aesthetically interesting collage could emerge. Interactions of two people are richer than human computer interaction. Chris Crawford points out, "Perhaps the most compelling aspect of networked multilayer games is their ability to provide interpersonal interaction"(Crawford 1998, p 241). He also thinks that connecting real humans by computers, rather than simulating biactive interaction is a great advantage for computer resources. "Who needs artificial personalities when we can have the real thing? And no computer model will ever rival the richness of human interaction!"(Crawford 1998, p 241).

Interaction might be a stimulus for creativity. Creativity is an essential part of art. When art is standardized, it becomes mere artifact. For rich or poor, art requires newness. Inspiration comes to artists in many ways. In Combart, interaction between two people can be studied for its effects on the emergence of creativity. Combart also supports a way to carry out communication in the process of creating a picture. Improvisation is necessary here since the continually changing canvas is not predictable by either player. Combart supplies a stage for two players to perform interactively based on turn based rules.

The rules of Combart are intended to limit the freedom of artistic expression and influence the results. But limiting choice can enable creative results. There are many choices to be made in the process of making art, where to start, what kind of perspective, what color, which place for each object, which size and so on. Artists are rarely restricted by rules when they create. They express themselves freely. In Combart the degree of freedom is limited. Since it is a game, the result will be influenced by the rules. If definite effects are discernible, the rules are shown to be algorithms for these effects.

The picture made in Combart is intended to be considered as a work of collage and petite art. In Combart, people make pictures by putting together pieces of miscellaneous images cut from existing paintings and drawings of their own. Collage, as a legitimate art form started from the time of Cubism (Wolfram 1975). The essential idea of collage is to bring into association unrelated images and objects to form a different expressive identity.

Combart is intended to be less male oriented and more female oriented than most computer games. The current computer game market is filled with shooting games, action games, sport games and so on. Many games are full of violence. These kinds of games attract the adolescent males most. How could a game be less male oriented? Celia Pearce thinks, "Real-time text communication is a natural for the female, and women are flourishing on the Internet". "After testing and watching literally hundreds of people, both male and female, playing a wide range of different multiplayer games, I'm convinced that multi-user interactivity is the answer to the 'female' problem" (Pearce 1998, p 209). In Combart, communication by a chat window is possible and necessary, and interaction is integral. So Combart is addressing the gender aspect along with its online two-player feature and art content.

4 Background of Combart

In this section, the background of Combart has been discussed from two perspectives - art and games. Later, the development of Combart from its basic idea to a concrete project is discussed.

Fig. 1 - Raoul Hausmann Dada Conquers 1920

4.1 Art

There is a radical shift in the boundaries of art over the last century. Previously art was produced in historically validated media, fixed purposes and contexts such as for the sake of beauty, perfection, religious exaltation. In this age of experiments with unorthodox materials, new tools and digital media have already raised questions about art. Iconoclasm and interdisciplinary perspectives of art no doubt have changed the scenario completely

Selection of the art techniques for the project was really a difficult question as Combart is expected to create a comprehensive compendium of Rules - technology - inspired art. It has taken art broadly to include photomontages, existing artistic expressions, and multiple free form tools. Therefore, collage is a main style used in the project. Collage was often called the art form of the 20th century, but this was never fully realized. Surrealist games such as parallel collage have used collective techniques of collage-making. Collage is also used in the divination process known as ceromancy.

“Collage is the assemblage of different forms creating a new whole”(*Collage* 2005). An artistic collage work can contain newspaper clippings, ribbons, bits of colored or hand-made papers, photographs, pasted onto canvas. Two examples are shown in Fig. 1 and Fig. 2.

There are some historically recognized forms of collage for example, Decoupage is one of the common collage techniques defined and used as a craft, the basic purpose for its usage is to beautify an object by pasting motif or picture onto it with the illusion of depth. In this technique one image glued on the surface of the object and after that pasting more images with progressively cut background to create depth in the design. Another massively used technique is “Photomontage, a collage made from photographs or parts of photographs.”Surrealism has made extensive use of this technique.

Cubomania is a collage made by images cut into squares and rearranged afterwards automatically or randomly in the collage. Cubomania was first used by the Romanian surrealist Gherasim Luca. Decollage is considered as a style of surrealist collage, In this style parts of the images are cut away to expose other images. Etrécissements by Richard Genovese from a method first explored by Marcel Mariën. Genovese also introduced the “excavation collage (this also includes elements of decollage) which is the layering of printed images, loosely affixed at the corners and then tearing away bits of the upper layer to reveal images from underneath, thereby introducing a new ‘collage’ of images. Penelope Rosemont invented some methods of surrealist collage, the prehensilhouette and the landscape.” Surrealist games like parallel collage have used collective techniques of collage-making”(*Collage* 2005). Digital Collage follows the traditional techniques of the collage in the making instead of traditional media. Here, digital photographs, video footage, 3d images, .and image manipulation software are used for execution.

The project also aims to undertake exploration of new possibilities in interdisciplinary relationship, and cultural implications in the creation and admiration of art. The assimilation of computer interactivity and traditional artistic media concepts lets common people to enjoy and also let them participate, enhance the existing artistic expression without having technical expertise in the field. The project took the innovative concepts of collaborative art and computer interactivity which is followed by the traditional concepts of collaborative art like murals. V. Sorensen encourages, "As artists, we face the possibility of mastering new aesthetics involving interactive technology and newly developing forms of multimedia" (Sorensen) Developed possibilities of internet and facile accessibility of the net has provided new avenues for cooperative environments. Sharing expressions without the limits, all those media innovations have played a major role in the collective expression of artistry.

4.2 Games

Games are as old as the human civilization. It is no wonder that games are found in Egyptian paintings from 4,000 years ago (*Academics get serious about video games* 2004). Game studies are also called ludology, from the Latin word "ludo" for "game". Juul (2001) in her review of *The Study of Games,* tells that the subject of games has previously been taken seriously and, perhaps, forgotten now. Juul futher states that this has happened once before in 1903 by quoting a statement from the book : "The popular notion that games ... are trivial in nature and of no particular significance as a subject of research soon gave way, under the well-conducted studies of Mr. Culin, to an adequate appreciation of their importance as an integral part of human culture"

This section on games, compares and contrasts a few definitions of games and then goes on to categorize games in the context of Combart. Later, computer games are taken up and a few interesting observations are noted.

There have been a lot of definitions for the word "game". We shall look at a few of them and see how they would help us in game design. One of the definitions about the activity of playing a game is given by Bernard Suits in 1978. In his view, "To play a game is to engage in activity directed towards bringing about a specific state of affairs, using only means permitted by rules, where the rules prohibit more efficient in favor of less efficient means, and where such rules are accepted just because they make possible such activity" (Juul 2003). Three years later, Avedon & Sutton Smith gave a definition for a game. At its most elementary level, they defined a "game as an exercise of voluntary control systems in which there is an opposition between forces, confined by a procedure and rules in order to produce a disequilibrial outcome" (Juul 2003) From the above definitions, we observe that a game needs two main entities – a goal and a set of rules to achieve it. Although these definitions give us a basic understanding of what a game is all about, they seem to be very generic and are not of much help to a game designer.

Crawford (1984) gave a more detailed explanation in his book titled "The Art of Computer Game Design". He actually perceived a set of common factors after observing board games, card games, athletic games, children's games and computer games. According to him, the common factors are

1. Representation,
2. Interaction,
3. Conflict and
4. Safety.

In representation, he states that "a game is a closed formal system that subjectively represents a subset of reality". About interaction, he opines that the highest and the most complete form of representation is *interactive representation* and that's what makes a game more appealing. A direct consequence of interaction is a conflict between the players. Conflicts bring in danger and allow a player to experience danger in a situation (game) away from reality. This leads to the fourth point that games are safe.

Recently, Salen & Zimmerman (2003, p. 96), state that "A game is a system in which players engage in an artificial conflict, defined by rules that result in a quantifiable outcome." The main segments of this definition are – system, players'

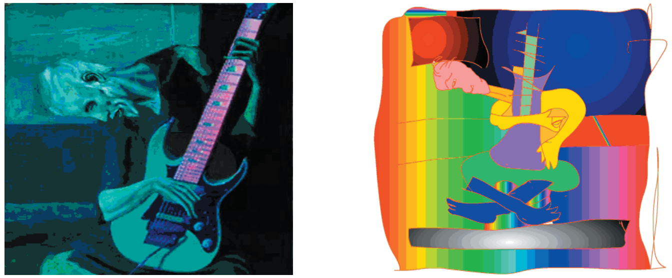


Fig. 3 - First prototype of combart

Fig. 4 - Paper prototype of combart

engaging, artificial conflict, rules, quantifiable outcome. On analyzing at a deeper level, the first three seem to satisfy Chris Crawford's definition of a game and the last two satisfy the older definitions of a game. As a whole, this definition gives us a comfortable platform with which a game can be designed.
In the interest of Combart, games could be categorized into two broad categories – the traditional games and the computer games. We shall first have a look at the different types of traditional games. Board games are the best known of the traditional games, and have a long history. Some of the well known examples are chess - originally Shatranj, Backgammon - originally senat (Masters). The next set of most popular traditional games is the card games. Later, table games, pub games, lawn games, athletic games, etc. came into being and are still being enjoyed by all. One important aspect that is mostly common among all these traditional games is that, they needed at least two active agents to play the game and this conflict would be between two humans. Since the interaction happens between two active humans, this type of interaction could be referred to as bi-active interaction.

This changed with the advent of a new genre of games called the Computer games. Although, two agents were necessary in this case too, one of them was mostly the computer itself which is not an active agent. In reality, the opponent is mostly an algorithm which enacts the role of the second player. If the human player recognizes the hidden algorithm after a few games, he can outwit the computer every time and win always! Game Designer Chris Crawford believes that these primitive forms of computer games are actually not games but just puzzles, which could be solved on knowing the algorithm behind the game(Crawford 2003). In the recent years, with the advances in networking and hardware, computer games are again going back to the good old formula of the traditional games – bi-active interaction. For this "bi-active interaction" to be successful, the computer game should provide an environment in which the players interact with each other in an intuitive manner. According to Talin (1994), there is a special class of algorithm-based games in which the algorithms define the behavior and provide a good interactive environment.

He also further states that "Algorithms make much better environments than they do opponents". From the above statements, it is observed that algorithms play a major role in building up a good computer game.

The design of Combart follows the same principle and has a lot of algorithms behind the simple looking interfaces which provide a comfortable and challenging environment for two players to make art. Hence, art and algorithm, both equally contribute to the design of Combart. Moreover, the multiplayer nature of Combart stands as a good example of bi-active interaction as well.

4.3 Development of Combart

4.3.1 Development of idea

Combart was originated from personal interests in the combination of art and game and the interaction between human beings. There were 10 different possible games at the beginning. Two prototypes were developed.

The result of the first prototype is shown in Fig. 3. In this game, the task for two players is to recreate and reconstruct one existing painting. This prototype wasn't developed further. Because in this game the originality of two players in creating one picture together seems to be confined. The game is more of a game about testing memory, rather than a game about art. In second prototype the idea of, Combart, was originated. More artistic content was added. The game was prototyped on paper and played by two groups under the same theme. The two groups produced totally different results. One result is shown in Fig. 4. The feedback is that the result was very interesting and unexpected. It was developed step by step based on another player's performance. It was a kind of improvisation. But in these two prototypes, the players grade on each other in each turn. The final score of each player is computed by adding the grades given by the other player. This kind of scoring system produced disagreement and dissatisfaction. So giving a score based merely on the judgment of aesthetic artwork was problematic.

Based on the second prototype, Combart was further developed. The size of group increased from one to three and Combart was made into an internet-based computer game. In the beginning, only drawing on the same canvas was possible between two users. Then image selection and manipulation was added. Rule system was implemented. More functionality was offered. With the support of new algorithms, Combart became more and more capable as a tool to make art and as a game to have fun to play with. The development of Combart with time is shown in Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

4.3.2 Research on similar projects

When developing Combart, the group members did some researches on similar approaches over the internet. There are several projects which relate to the concept of art game. Most of them are about learning art history, introducing common knowledge about art skills, or just incidentally having pictures from some artists.

These website are collected below.

1. An adventure in art history, http://www.eduweb.com/insideart/
2. Art detective, http://www.eduweb.com/pintura/
3. ArtEdventures, http://www.sanfordartedventures.com/play/play.html.

Some knowledge about art can be learned through playing Combart. But education on art is not the main goal of Combart. Later, with the further development of Combart, the group paid attention to other people's work in making collage artwork and creating one picture collaborative. One example is from http://www.pentacom.jp/soft/ex/collage/collage.html. It supplies some categories of images and functions in manipulating images. Another project in http://www.vectorama.org allows many people to draw and use supplied black and white shapes in one single canvas.

These previous projects touched the issue of designing, making a sort of art collage and collaboratively making pictures. But they were not really dealing with the topic about art and game. They did not develop a game to allow people to make artwork based on rules. They did not pay attention to the interaction between two players, who make one picture together. Some of them supplied image pieces to allow you to drag onto canvas. But they did not use the resources of traditional fine art. Some of them were named to relate the concepts of art and games. But they were not about making artwork, judging artwork and combining artwork.

4.3.3 Scandinavian approach

The important aspects and theme of Scandinavian designs is democratic participation and skill enhancement and not productivity and product quality alone. In this, some ideas inspired by Ludwig Wittgenstein's philosophical investigations were applied to the everyday practice of skill-based participatory design in games. The concept of design-games is associated with playful activity, but what practical conditions are needed for such pleasurable engagement in design? Is the right to democratic participation enough? Participatory design started in Scandinavia - a partnership between academics and trade unions. Combart's design approach is inspired by the Scandinavian Design approach towards games and particularly participatory or iterative design experience which was developed in Scandinavia over the last two decades; the history

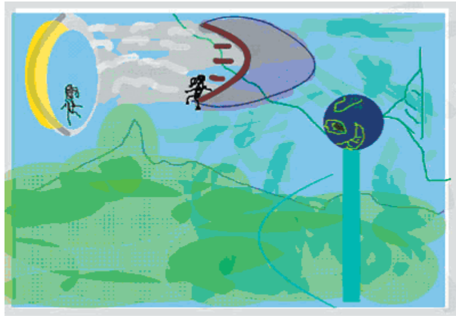


Fig. 5 - Combart with drawing

Fig. 6 - Combart with drawing and images

Fig. 7 - Combart with drawing, image and rules

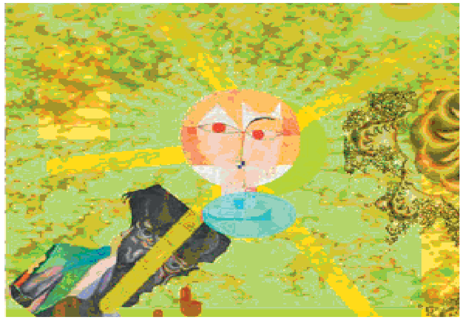


Fig. 8 - combart under the theme - "Sunlight"

is reviewed by Ehn & Kyng (1987). It started with a discontent with the way in which computers were introduced and the way they have changed work processes in Scandinavia.

The goal of a game is entertainment, a good game is also highly interactive, deliberately generating tension between the degree of control the imposition of rules and the player's freedom of interaction. But here, in this game the randomness, free will and creativity are equally important as mere challenges in game design. The main focus is the user's experience. We started with the very basic idea of rules and creative expression to create a montage on canvas. There were some important points observed during such trials of game playing experience. Initially the game was so flexible and could be modified by users by mutual agreement playing with their own rules and evaluate the contribution on highly personalized way. They start with a creative idea and approach, to play and cooperatively exhibit their visual and ideological creativity.

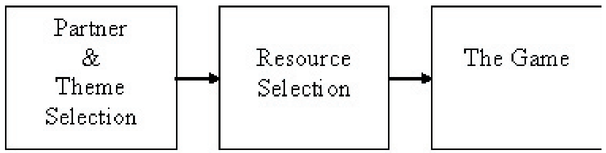
5 Environment of Combart

The environment of Combart consists of three main components - a game-playing interface, the rules which influence the game-play and the software architecture of the game. Algorithms play a major role in all the above components. This section tries to justify the claim made earlier, in the section on games– *algorithms play a major role in building the environment of Combart*.

5.1 Game Interface

The interface of Combart plays an important role in enhancing the players gaming-experience. A game interface-design here means much more than just designing the screens. It involves designing the interaction mechanism to be followed, the workflow of the game, etc. The starting point was to identify a real-world metaphor which could be applied to the interface. Since the game is about making art, a sketchbook metaphor was chosen. To create a good ambience to the players, a good colour scheme, fonts to be used, buttons, etc. were designed. In making a colourful interface, care was also taken that it is not too distracting. In short, Aesthetics and Usability were both considered while designing the interface.

An example of an interface which could be considered intuitive and easy-to-learn is discussed here. In the artist selection screen shown in Fig. 9, the player must select artist images to be used in the game. First, the artist should be selected, then the category should be chosen. A preview of the images under a particular category belonging to the chosen artist is shown. The problem was to display more than 10 artists to be chosen from. A conventional solution would be to use a list-box or a combo-box to give the artist names. A more intuitive solution is to display the photos of the artists along with their names. Although this demanded more space, a box area was identified on the screen in which the artist portraits could be shown. Since a regular scrollbar would be a boring method to scroll through the artists, an auto scroll method was designed with an interesting algorithm in the background. This way, the player just has to take his mouse over the portraits and as he approaches the end of the list, the list automatically scrolls slowly showing more artist protraits.



The next step was to prepare a workflow of the game and design algorithms to carry out the tasks involved. At a high-level, the workflow of the game could be shown as three phases of the game.

They are:

1. Partner and Theme Selection,
2. Resource Selection,
3. The game.

Following a top-down approach, the phases identified were decomposed into sub-tasks to be performed by the player. The level of decomposition is consistent across phases and is such that each phase can be represented by a taskflow diagram. The taskflow diagrams were finalized after a few rounds of peer reviews. Once the taskflow was finalized, the screens and the algorithms behind them were designed and implemented. The

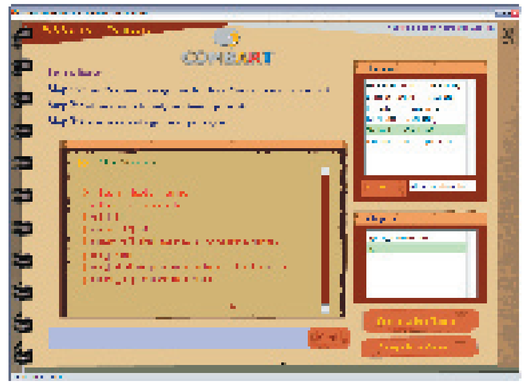


Fig. 9 - Partner and Theme selection Screen

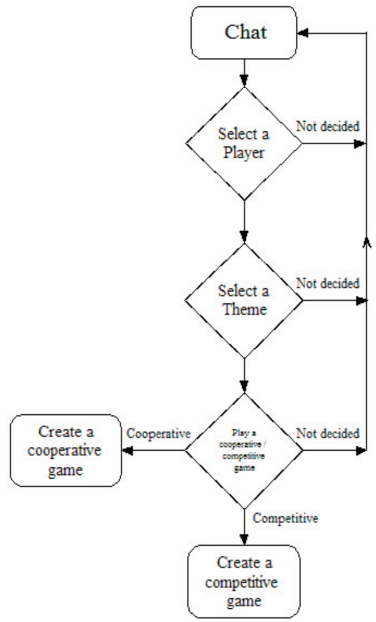


Fig. 10 - Partner and Theme selection

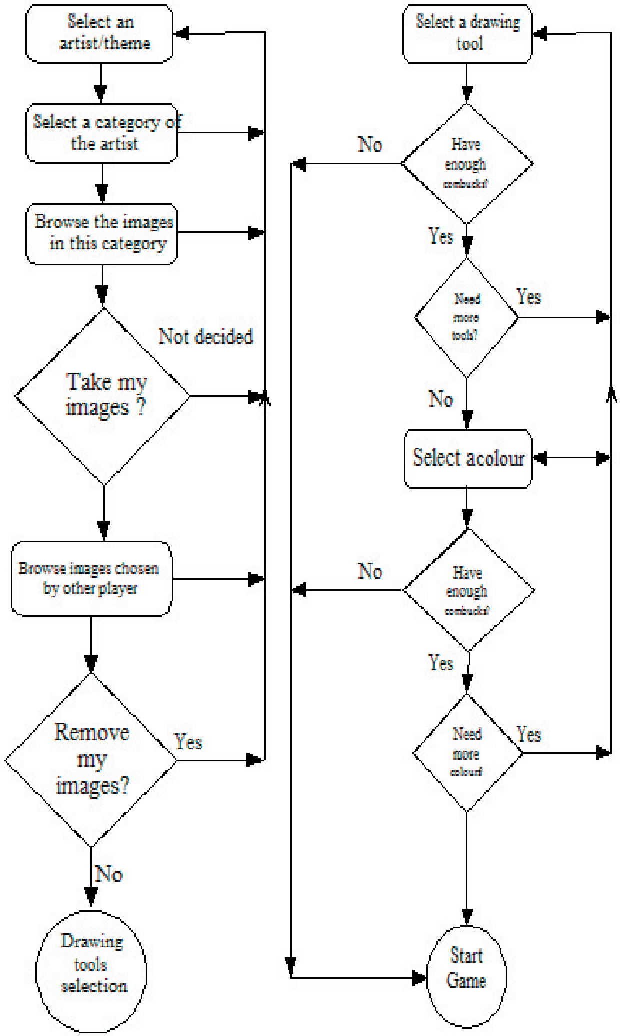


Fig. 11 - Resource selection

task-flow diagrams are shown in the follwoing figures - Fig. 10, Fig. 11 and Fig. 14.

5.1.1 Partner and Theme Selection

The requirements of this phase demand an interface for chatting, display of the available themes and display of the available players in the room. A screenshot is shown in Fig. 9. The chat interface was designed in a standard manner while

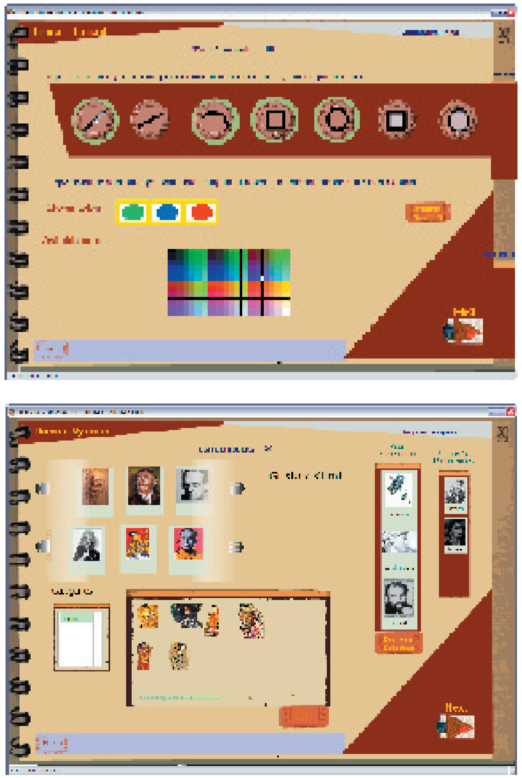


Fig. 12 - Resource selection Screens

list-boxes were used to display the themes and the players present. Creating a new theme is made easy (a single click) by providing a textbox for writing the theme name and a button to create it. To help the new players, a set of quick instructions are shown on the top of the screen.

5.1.2 Resource Selection

This phase has two main tasks – selecting images and drawing tools. In the former, the player should be able to browse through the different categories of images available and select the ones needed for the game. In the latter, he should have the facility to select the drawing tools and the colours required. The screenshots are shown in Fig. 12. Since these two tasks are different from each other the task flow diagrams are given separately.

The taskflow diagrams have been mapped to two screens for this phase. The first screen is the images selection screen. Here,

Fig. 13 - The Game screen

the artists/themes for the images are shown. Since there are many artists/themes, an image selection menu has been created to save space and mouse-clicks. As discussed earlier, the menu scrolls when the player moves the mouse over the artist/themes and does not involve mouse clicks, thereby making it easier and faster for the player. The second screen is the drawing tools selection screen. This is a simple screen where the player clicks on the drawing tools required and similarly chooses the colours as well.

5.1.3 The Game
The main task in this phase is the game itself. A screenshot is shown in Fig. 13. Here we shall just look into the tasks involved and in a later section; the actual rules behind the tasks are detailed.

The main panels of this screen are,

1. Canvas: This is the main panel where the artwork is made. It is common for both the players.
2. Images Panel: This panel has a tabbed list of images chosen by the player in the resource selection phase.
3. Drawing Panel: This panel provides the user with 7 tools for drawing shapes: freehand drawing, line drawing, curve drawing, oval (including circle) drawing, rectangle (including square) drawing, filled oval and rectangles. The colours and the brushes chosen by the player in the resource selection phase are also at his command.
4. Chat: This allows the player to communicate with the other player during the game.
5. Score visualization: The scores are visualized as bars to give a direct feedback on the players' skill development.
6. Hint box: There is a hint box at the bottom to give help/hints to the player during the game. A normal method of providing help/hints is with a messagebox which we have avoided.

In Combart, we have minimized the usage of message boxes only to error messages. All other messages/hints/help are provided through the hint box thereby not distracting the player while in game.

5.2 The rules of Combart
The rules of Combart form the most important algorithmic part of the game. These rules act as algorithms which influence the artwork being made by the players by rewarding and penalizing them for their actions in the game. While artists have all the freedom to be creative, Combart players face a challenge to be agile and creative at the same time.

The rules of Combart are tightly coupled with the currency and scoring system used in Combart. In the real world, when one wants to make a collage using pictures and images, an investment is needed in terms of buying the required resources like colors, brush, images, etc. Following the metaphor, Combart has combucks as the currency with which each player can buy images, drawing tools and extra time.

The currency imposes a few rules which restrict the players from using a particular feature of the game while the rules imposed by the scoring system motivate the player to make use of all the features in the game and also affect the outcome of the artwork.

5.2.1 Partner and Theme Selection
The rules of the game would be explained with respect to the three phases discussed earlier and with respect to the scoring system.

In this phase, the players can chat with others in the chat room and find a partner to play with. They must decide on a theme and select it from the list. The theme helps the players to work towards a single goal. If the players do not like the themes in the list, they can also create new themes. Although the rules force the player to decide on a theme, they give the flexibility to the player to create their own themes too. After choosing a theme, the players must decide between playing a cooperative game or a competitive game. In a competitive game, the players compete with each other while making the artwork and the winner is judged based on the skills they develop during the game. In a cooperative game, both the players cooperate

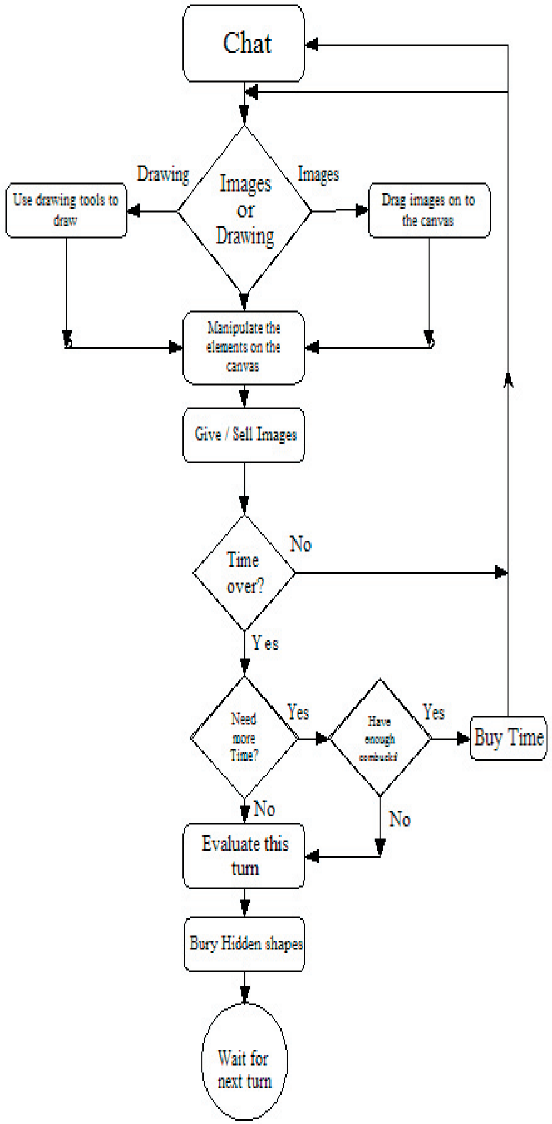


Fig. 14 - The Game

with each other to develop their combined skill while making an artwork. The player who creates the game will have the chance to play first in the third phase.

5.2.2 Resource Selection

This phase allows the players to collect the resources needed and get prepared for the game. To start with, in the cooperative mode, the players are given 80 combucks each while in the competitive mode, they are given 50 combucks. They should make use of the combucks to buy the necessary resources in this phase. They can buy 3 categories of images, each category containing 6 images. They have to spend 10 combucks for each category. The drawing tools available are free-hand, line, curve, rectangle, oval, filled rectangle and filled oval tools. Each of these tools cost 5 combucks. They should also buy the colours that would be used during the game. Each colour costs 2 combucks. After buying the necessary resources, the player moves on to the main game.

5.2.3 The Game

This is the main phase and the players are ready to start the game with the resources bought in the previous phase. This screen has a canvas which is common to both the players. This is the canvas on which the players would make the collage. The players take turns to draw or place images on the canvas. Each turn lasts for 60 seconds. The players can buy 15 seconds more and it would cost them 5 combucks. In their turn, they can drag images onto this canvas and would be able to perform operations like rotation, resizing, copying, modifying the transparency, bringing the image to front and flipping. They can also draw on the canvas using the drawing tools and colours chosen earlier. Each drawing tool can be used only 10 times and should be renewed again by spending 2 combucks if needed. However, in the case of images, they cannot buy more images after starting the game. The players can also to chat with each other during the game. A player can also sell images to the other player. If a player is in need of an image and can afford the price quoted by the player selling the image, he can buy it with his combucks. Once the game starts, the rules behind the scoring system start affecting the way the canvas gets filled up. The score is also coupled with the combucks. For every 10 points scored, the player gets 5 combucks. The scoring system is detailed in the next sub-section.

5.2.4 The Scoring System

As we have already seen, there are two game modes in Combart. One is cooperative mode and the other is competitive mode. In the cooperative mode, there is only one total score for both players. The total score is computed by adding the scores of both the players. There would be a score list in the website. The players could compare their new scores with their history score. In competitive mode, the players have individual scores and the winner is the person who has the highest score. The score also helps the player to fetch more combuck. For every 10 points scored, the player gets 5 combucks which could be used to buy resources while in the game.

The scoring system has been designed based on the four skills necessary to play Combart.

They are:

1. Drawing Skill,
2. Image Skill,
3. Cooperation Skill,
4. Collage Skill.

Each player's score is decided by the players' proficiency in each of the above skills. The player is said to have mastered the skill if he has acquired 50 points in that skill. The scoring system follows the fact that, the more something is practiced by a player, the more skillful he may become. The players have 8 turns to go through this challenge between time and creativity. We shall look at the skills and the corresponding scoring schemes in detail.

5.2.4.1 Drawing Skill

The more the player draws, the more skillful he may become and hence the rules encourage him to draw more. However, there is also a space control rule which restricts the player from cluttering the canvas.

The scoring scheme for each of the drawing tools is mentioned below,

1. Free-hand – for the first 10 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
2. Line - for the first 10 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
3. Curve - for the first 10 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
4. Rectangle - for the first 7 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
5. Oval - for the first 7 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
6. Filled Rectangle - for the first 3 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.
7. Filled Oval - for the first 3 drawings 2 points each are awarded and 1 point is penalized for every drawing after that.

5.2.4.2 Image Skill

The more the player manipulates images, the more image skillful he may become. However, he is restricted by the two rules discussed below.

First, a space-control rule, which states that the first 5 images dragged on to the canvas will earn 3 points each, while each successive images will result in losing 3 points. At any given point in time, it is ideal for the player to have 5 images on the canvas. If the images are too crowded, the possibility to delete them is also available. For example, if the player has got 15 points in the image skill by placing five images on the canvas, placing a sixth image would deduct 3 points from the score making it 12.

Second, the manipulations performed on the images contribute to the score. The manipulation tools are resize, rotate, flip, copy and to front. The first 10 usages of each tool would each contribute 1 point to this skill. An exception to this is that, the score would not increase if the same image is manipulated using the same tool in repeated successions.

5.2.4.3 Cooperation Skill

As the name suggests, the player gains more points for cooperating with the other player. At the end of each turn, the players give a grade from -5 to +5 according to how this turn is done. If the work is appealing, a higher grade is given. If the work is ordinary or bad, a lower grade is given. The final score in this skill category is computed according to how different or close the grades are. Whether they rate high or low won't have direct influence on winning the game. This sounds controversial since the players can chat with each other and exploit the system to gain more points. However, the chat system has filters to avoid a situation where the players discuss the scoring issues. Even if the players find a hack around this, they cannot win the game with this skill alone and have to get points in the other skills too. However, we assume that the players will give grades fairly. The players can gain 5 points or lose 5 points at most in every turn.

Under this skill category, there are two ways to gain bonus points,

Communication bonus: Sending out messages by chat window is a rewarding act and the player gets bonus for that. For every 5 messages sent, 2 points are awarded. If more than 10 messages are sent out in a turn, the player is penalized 2 points for 5 messages and so on.

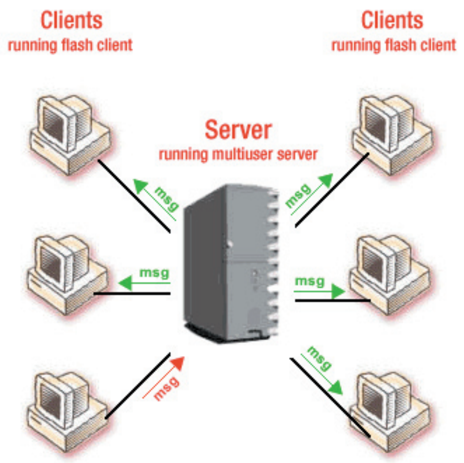


Fig. 15 - Client-Server architecture

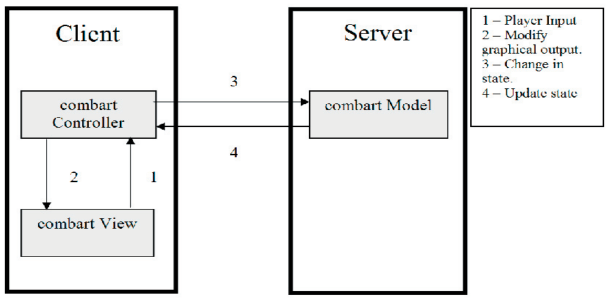


Fig. 16 - MVC Model of combart

Friendship bonus: In a cooperative game, if a player gives images to his partner, he will gain friendship bonus. For the first image he gives, he will be awarded 1 point, for the second image he will get 3 points and 5 points for the third image he gives. He would not get any further bonus for giving even more images.

5.2.4.4 Collage Skill

This category mainly emphasizes that the players should overlap images. The more overlapping, the more skillful the player may become. If the player overlaps another players image, he gains 2 points, while he would get only 1 point for overlapping his own image. The player has an opportunity to gain some points by placing his image at some specific locations. The opponent buries some hidden shapes in these specific locations. Each turn, the player who finished his turn can bury some shapes on the canvas which will be invisible to the other player. In the competitive mode, if the other player places his image on the buried shape, then he would lose points and the player who buried the shape would gain extra points as bonus. In the cooperative mode, if the other player places his image on the buried shape, both the players would gain points as bonus. This rule is referred to as the hidden bonus rule.

At the end of the game, in the competitive mode, if a player's score reaches a certain level; he will have a turn to modify two elements owned by another player. This includes deleting and manipulating images and drawings. In the cooperative mode, if the total score reaches a level, two players will both be able to modify two things of each other. This includes deleting or manipulating images and drawings.

Since the above rules influence the artwork in an algorithmic way and bring about visible changes in the outcome of the artwork, they are said to be the algorithm behind the artwork.

5.3 Architecture Design

Combart is a web-based two-player game providing the facility to play the game from home across the internet. It follows a simple client server architecture where a server listens to clients and serves the requests from the clients as shown in Fig. 15.

The client is programmed in actionscript using Flash MX2004 and SmartFoxServer (Lite Edition) acts as the Server. Flash MX2004 was chosen to create the client for two primary reasons. Firstly, Flash MX2004 provides a good platform to design an attractive and usable game interface for the internet. Secondly, it provides a facility for network programming which is a crucial factor for Combart.

The SmartFoxServer was chosen as the server due to its compatibility with flash and the powerful set of features provided. It is a socket server written in the java.nio libraries which provides great performance and scalability. Being a pure java application, the server could be installed on many operating systems like Windows, Linux, MacOS X, etc. It also provides a facility to simultaneously run many applications on the server through the "zones" concept. Being an online game, Combart requires a server with all the above said functionalities.

From the programming perspective, the game was designed using a classical paradigm of GUI design, namely the MVC paradigm that originated with smalltalk at Xerox PARC (Burbeck 1992). MVC stands for Model-View-Controller and is quite different from the traditional programming practices.

According to Burbeck (1992), it has three components,

1. View – This manages the graphical and/or textual output to the portion of the bitmapped display that is allocated to its application.
2. Model – This manages the behavior and data of the application domain, responds to requests

for information about its state (usually from the view), and responds to instructions to change state (usually from the controller).
3. Controller – This interprets the mouse and keyboard inputs from the user, commanding the model and/or the view to change as appropriate.

Following the MVC paradigm at a high-level, the architecture of Combart basically consists of three components as shown in Fig. 16,

1. Combart view,
2. Combart model,
3. Combart controller.

5.3.1 Combart view

The Combart view, as the name suggests, manages the graphical/textual output on the screen. It resides on the client side and is programmed in Flash MX2004 using actionscript 2.0.

5.3.2 Combart model

The Combart model maintains the state by managing the data and behavior of the game. For e.g. Data: The title of the game and Behavior: Idle time logout. It supplies data to the Combart view and changes its state based on the commands from the Combart controller. The SmartFoxServer Lite Edition helps us in having a Combart model on the Server.

5.3.3 Combart controller

The Combart controller interprets the player inputs and controls the Combart View and Combart model. The rules of the game and the other algorithms required to bring about changes in the interface based on user action are bundled into this component. It resides on the client side and is programmed in Flash MX2004 using actionscript 2.0. Internally, it is uses an event-driven architecture to capture the input. When it receives an input, it modifies the visual output by sendinga message to the Combart View component and also sends a message to the Combart model component on the server. The Combart model component changes the state of the game and sends a message to the Combart controller component of the second client. The Combart controller in the second client sends a message to the Combart view component to reflect the changes on the first client.

6 Result of Combart

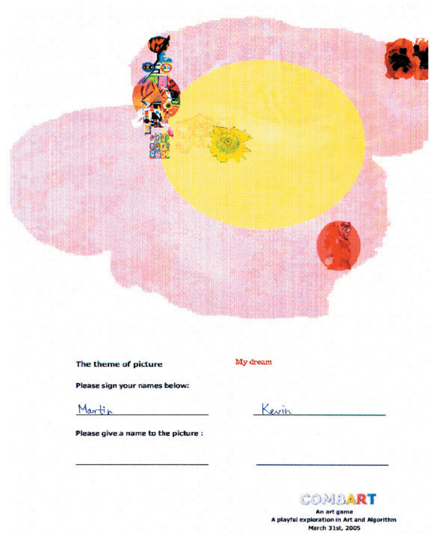


Fig. 17 - Exhibition image 1

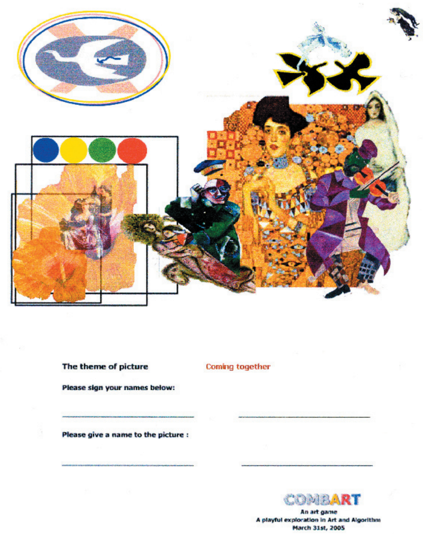


Fig. 18 - Exhibition image 2

6.1 Installation

The installation took place on 31st of March, 2005, in an event organized for the project AAA. The Combart installation was one of the four installations of the evening. We used two different locations for our installation. Each location had two computer terminals to play the game. This meant that two games can be played at the same time. The idea behind dividing the installation to two locations is to make the players in location 1 to play with the players in location 2. This helped to maintain anonymity between the players, which would actually be the case when the game is played over the internet. By doing this, we wanted to see how players interact when the game is played anonymously. One terminal at each location was projected on to the screen so that other people can observe the game better when they don't get a chance to play.

The players started playing the game on a first-come-first-serve basis. In the first hour of the installation, it was observed that many visitors were interested in playing the game but were not able to due to the availability of only a few terminals. Since each game lasted a little more than 20 minutes, not many visitors had the patience to wait for their turn to play the game. Some had left, while others went around the other installations and returned back after a while. The players were first briefed about the rules of the game. Then, they logged into the system and chose their partners from the chatroom and started playing the game. The players were allowed to explore the game interface on their own, although our team members were present to assist them. At the end of the game the players were able to print the artworks made by them. Some of the artworks made during the installation are shown in the following figures - Fig. 17, Fig. 18,Fig 19 and Fig. 20.

6.2 Observation and Feedback

The players were observed during the game and they were also asked to give feedback after the game. Since each game lasted for more than 20 minutes, only 4 games were played during the evening. The prominent observation was that the players enjoyed playing the game. However, they had to spend some time initially in understanding the rules. Once they understood the rules, the players were full of enthusiasm all through the game. This was evident from the time spent by each player. Although each game lasted for more than 20 minutes, the players enthusiasm kept them glued to the game until they got their artwork printed. This meant that we were successful in fulfilling the basic objective of creating this game. Another interesting feedback was about the vast collection of images available to make the collage. People said that they were surprised by the unexpected nature of the images.

Getting into the details of the game, it was observed that most of the participants preferred to play the game in the cooperative mode rather than in the competitive mode. Given the fact that they had to cooperate to make the artwork in both the modes, three teams out of four chose to be cooperative in sharing the resources and score as well. We also observed the usage of the chat system. Since most of the games were played in the cooperative mode, the players made good use of the chat system. From the games played it was observed that communication improved cooperation which resulted in a picture pleasing both the participants. Another interesting observation was made about the usage of the tools provided to make the artwork. Most players preferred to use the images rather than to draw on the canvas. The drawing tools were more difficult to quickly learn to use.

When asked for a feedback, most of them felt that the rule system was a bit complex and required more time to understand it. Some of the players thought that it is normal for games to have a complex rule system and it did not discourage them from playing the game. Some players felt that the system was good as a collaborative art making tool, as well as a game and wanted to have a version which is only for making collaborative art. One of them said that this game is a good example of how artworks could be used by algorithms to make new artworks.
An enthusiastic visitor, specializing in cultural studies, was very much interested in the game and said "Combart is more than only a game". He felt that, in spite of the fact that the players play against each other in a competitive game, it helps the players in honing their cooperative skills encouraging them to cooperate to create a good artwork. He said that, "Combarts' larger potential lies in the process of the play, developing a strong cooperative and communicative portion. So the "art-production" in Combart itself contains or better processes a media-situation." He felt that the pictures produced look a bit unusual due to the creative competition and the assortment of tools and options. He further says, "I would be interested in testing the game with young pupils. I am sure, that the interface and the system of interaction in the game would be quite easily understandable even for them".

The above observations and feedbacks have shown us the

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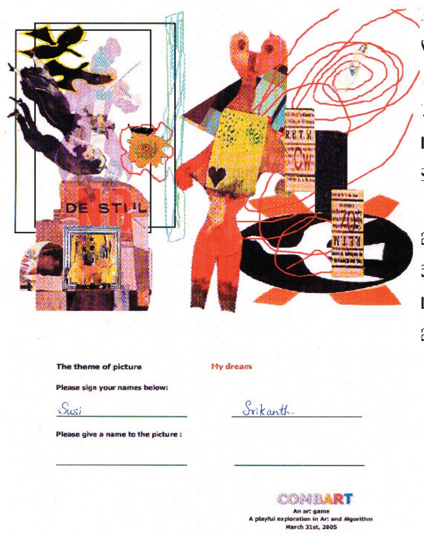

Fig. 19 - Exhibition image 3

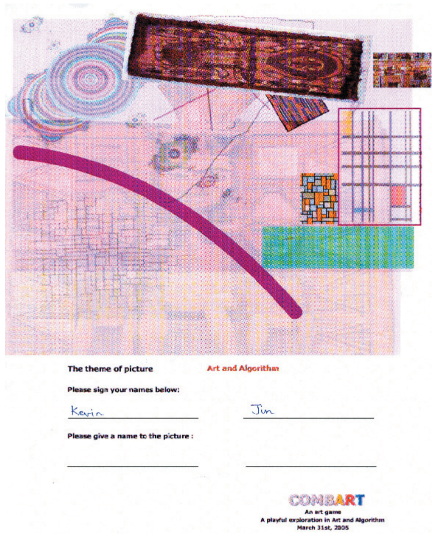

Fig. 20 - Exhibition image 4

7 Conclusion

The final evaluations of the goals of this project are as follows. Combart is free and accessible to anyone with an internet connection. More server capacity is needed if the usage is high. To the degree Combart players can make good art while playing, it is from a joint effort incorporating spontaneity and improvisation. Combart creates a pleasant and productive interaction between two people. The unexpected characteristic of Combart images is creative by the definition of ideational fluency which is a major approach in studying creativity. Although no comparison has been made to a human computer interaction, it is expected that Combart has the advantage of creating surprising but meaningful newness. Computer partners tend to create surprising and meaningless newness. Combart's rules have created a feeling of enabling while limiting choices. Comments from observers seem to indicate that a certain kind of style is resulting from the rules. The overlapping of images was popular with players and demonstrated the fun of creating collage and petite art. And finally, the preferred style of play in Combart seems to be cooperative rather than competitive showing that Combart is good at cooperative style that females enjoy.

The final statements should be evaluations and images from the event: evaluations by the creators of Combart and images from the use of Combart. But the single question of the success of the project is answered by a clear and emphatic yes.

The overall project of AAA grew through confusion and compromise. The project was created with great diligence to develop creativity in the participants and not make the project into simply an assignment. It is likely that the project advisors are disappointed because they did not get the results which they expected, but did not ask for. But the issue here is what the three members of the Combart team got out of their participation in the project.

The experience and result of creating Combart was difficult and rewarding. Many hurdles were crossed. Three individuals speaking their second language learned to work together in a strange environment. Cultural backgrounds were as different from each other and as different from the German location as were the languages. And through all of this a new creation came into being of which we are proud. We believe that our work can and will find acceptance. To the best of our knowledge, we have created something new and we will anticipate finding out the effect of our approaches over time.

The images shown in the figures - Fig. 5, Fig. 6, Fig. 7 and Fig. 8, are examples of drawings which were made during the development of Combart. They are not made by seasoned artists. The making of these images produced three clear results. They were fun, they were surprising, and they taught

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chapter 4

This report is supposed to mark an end of what can only be called a remarkable Journey. But instead it seems only to serve as a marker for a new starting point. A point that will help us to look back, reflect and ultimately continue on with the journey with new rigor and zeal. This is what seems to be a common resolve among all the members of this group.

TiLT

Ahsan Fayyaz, Saira Rana

I The Journey

This report is supposed to mark an end of what can only be called a remarkable Journey. But instead it seems only to serve as a marker for a new starting point. A point that will help us to look back, reflect and ultimately continue on with the journey with new rigor and zeal. This is what seems to be a common resolve among all the members of this group.

This amazing journey started under the umbrella term of "Art and Algorithm" (briefly referred to as AAA from here on). At this point it seems important to at least characterize the backgrounds of the two individuals that actually participated in this sub-project under the title of AAA. The one having a background in theoretical Computer sciences, and the other a rich background in English literature and Political science, topped off with some grounding in Computer science. In this respect, having some common disciplinary skill influenced our decision to work together. The other perhaps crucial factor was a very early interest in the themes of Tiling. This interest may also be attributed to a sub-consious factor. Having grown-up in a Muslim society we had taken the Tilings that appear in Mosques, the historic architecture as well as the current architecture, for granted. But the truth of the matter is that Tiling became a very developed mathematical craft in the Golden Age of the Muslim Civilization, which can be said to begin at approximately about the mid-Eighth century. "For 400 years from the mid-9th century until the sack of Baghdad by the Mongols in 1256, Muslim culture was unparalleled in its splendor and learning."[Matthews 2004] This era was a direct result of "the wisdom of India and China mingled with that of Persia, ancient Greece, Rome, and Egypt." [Matthews 2004] We will delay the discussion of the tiling and patterns of the Muslim era to a later chapter but suffice it here to say that this craft was lost in the sands of time. Today only speculation exists as to the techniques that were employed by these craftsmen.[1]

During the course of our background research on tiling, we also came across a particular kind of tiles called the "Domino tiles" or "Wang tiles". The properties of these tiles provided an excellent opportunity to explore the subject theme of our project, namely AAA. It seemed like an excellent amalgamation of art and algorithm which could serve to explore the aesthetics therein of both. Thus the project TilT or "**Til**ing the **T**uring Machine" was born.[2] The title now introduces the name of Turing machines which formed the second mainstay of our project. In fact the Turing Machine is what uniquely put the activity of our group at the algorithmic end of the spectrum more then the artistic one. Art is all about perception and personal opinions. The production of any piece of art can or cannot be commanded by a set of rules. If it does follow some set of rules, than it is possible that these rules could only be in the mind of the artist and thus be his tacit knowledge which may not be explicable at all. Thus any possible interpretation that exists outside of his mind, in the mind of another, cannot come close to the results that were achieved by that particular artist. In the best case we could only make guesses and approximations. This is what would make the artwork truly unique and not exactly reproducible by any other person. Whereas when a machine is used to produce art, it is rarely

1 See [Abbas & Salman 1998] for a discussion of nearly 250 Islamic patterns and some algorithms for 2D periodic construction.

2 Thank you to Frieder Nake for coining the full form of TilT as "Tiling the Turing Machine," whereas we had suggested "**Til**ing and **T**uring machines."

anything more than through a set of rules layed down for it and perhaps the factor randomness at play here and there. This is the sort of conclusion that we come to towards the end of our journey.

Thus in this overview of our journey, we donot expect the reader at this point to make much of it. But as we reaccount much of the details of it in the next sections, we hope that the reader will also come to an understanding perhpaps similar to ours. Or at least come to understand the lessons that this journey taught us and take with him part of our experience of the same.

2 Tiles and Patterns

2.1 A Brief History

The domain of tiling was the starting point of the whole journey. This is a phenomenon easily observable even in nature, for example, in the form of cracked mud or a honey comb (as seen in figures 1 and 2 respectively).

Figure 1 Cracked Mud [Alexander, I., (c)1996-2004]

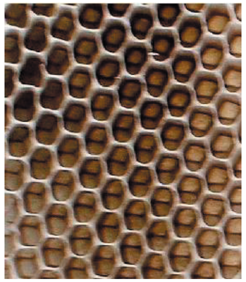


Figure 2 Honey comb[Alexander, I., (c)1996-2004]

The phenomenon of tiling has also been present in the artefacts of almost all cultures. There always has been interest in this phenomenon and thus many original and gradual contributions to this phenomenon have resulted from these artisans of almost all eras and civilizations. In some cases the tiling patterns were greatly influenced by culture and in other cases even by religion. This section will provide a look back on the phenomenon of tiling across the cultures, with the help of a few examples.

The Romans and the Mediterranean played with pictures of human beings and nature. A rich use of figurative images can be found in the ancient Roman civilization. A Roman mosaic in figure 3 shows the images of philosophers arranged in a geometric fashion. The use of geometrical shapes in the mosaic is remarkable in the sense that it melts in beautifully with the images not overshadowing them too much and perhaps a hidden political[3] message symbolised with the use of particular shapes.

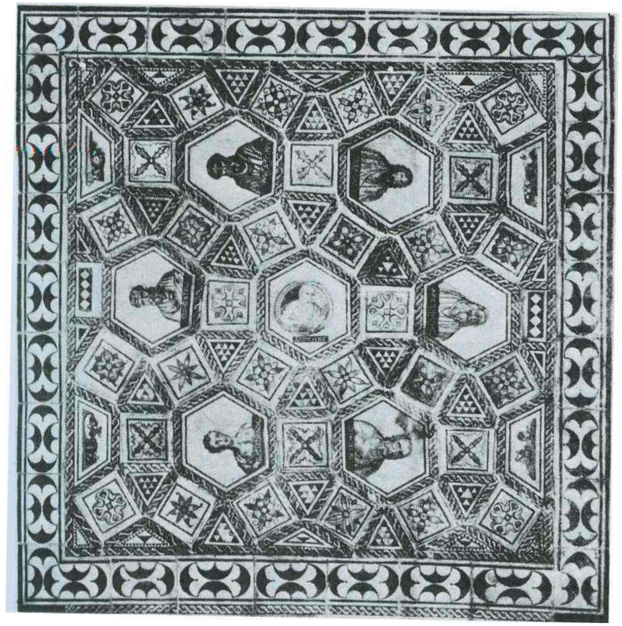


Figure 3 A Roman mosaic portraying busts of philosophers and stylized flowers in an intricate geometric setting. [Grünbaum & Shephard 1987, pp.1]

Another example is that of the artefacts of Hindu culture based on religion. The mixing of iconic narrative symbols prevails in the Hindu culture's art. A dominance of religion can be seen in form of idols (of Gods) in Temples, the Hindu worship places. The following figure 4 shows the use of abstract geometry along with narrative idols and floral patterns in a Hindu temple.

[3] The Roman civilization being affected by the Greek and the dialectics of geometry associated with metaphysical qualities in Greek philosophy.

[4] Maurits Cornelis Escher (1898-1972) was a very famous artist, known for some intriguing artworks of tiles and patterns.

Figure 4 Hindu temple with floral designs and abstract geometry[Marx 1998, figure 8]

Another pattern from an Indian fabric, in figure 5, shows a similarity with the Escher[4] style of tiling. Such similarities across the cultures are rooted in similar basic geometric considerations. [Grünbaum & Shephard 1987, pp. 4]

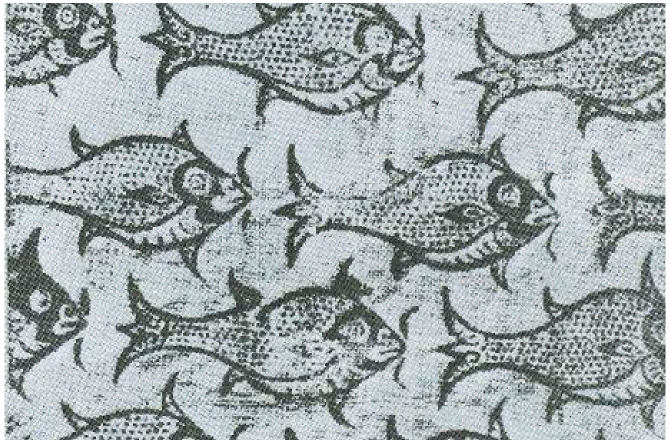


Figure 5 : A printed fabric from India [Grünbaum & Shephard 1987, pp. 4]

Patterns similar to tiling can also be found in one of the world's ancient civilization, China. Figure 6 and 7 shows such tilings of Mongolian origins.

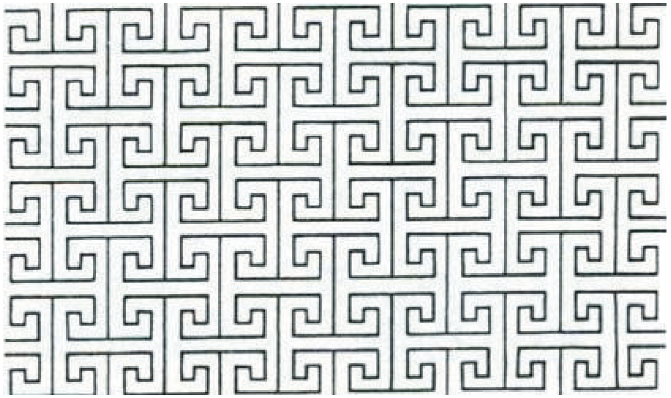


Figure 6 Mongolian designs which may be interpreted as tilings [Grünbaum & Shephard 1987, pp.11]

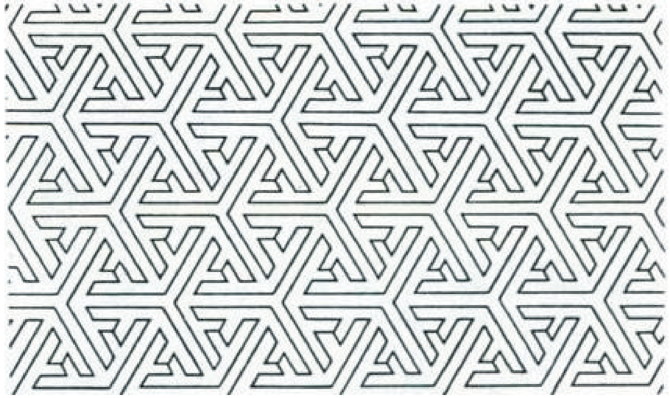


Figure 7 : Mongolian designs which may be interpreted as tilings [Grünbaum & Shephard 1987, pp.11]

2.1.1 Muslim Civilization

The Muslim Civilization dominates when it comes to tilings that specialize in geometric shapes and colour. The use of tiles in Muslim architecture has been studied and frequently referred to whenever tiles appear in literature. The famous ones have their roots in Iran (Persian tiles) and in Granada, Spain (Alhambra, Figure 8).

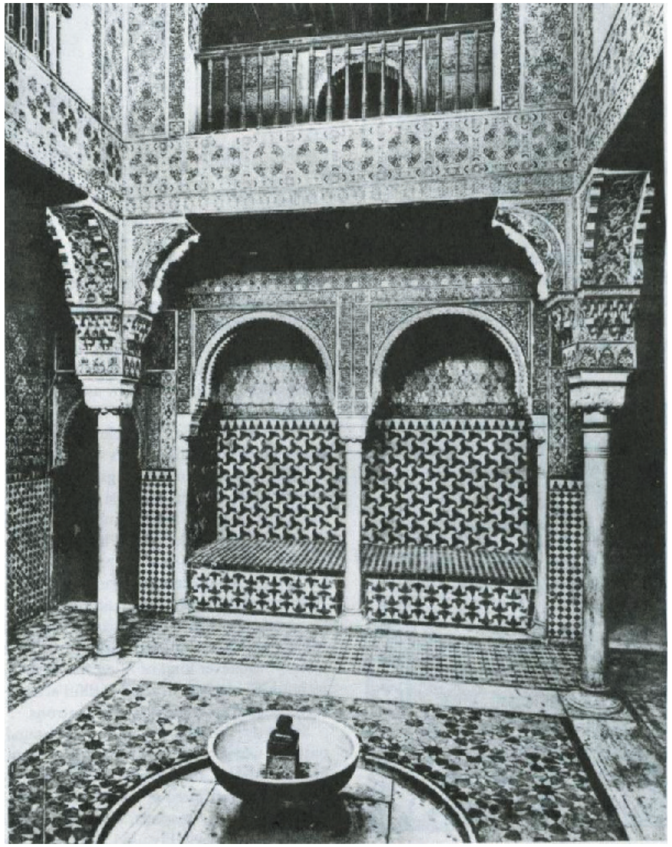


Figure 8 : A view from the Alhambra showing the wealth of tilings by Moorish builders [Grünbaum & Shephard 1987, pp.2]

Islamic tiles are of consequence not only because of their aesthetic values but also due to the political and religious meanings associated with them. The richest occurrence of Muslim art is based at the Alhambra, well known for the extremely aesthetic geometric arrangements with a strong mathematical background. A glance at the Islamic Art reveals a frequent use of geometric shapes, in particular star shapes. This use of geometric shapes is not only limited to the buildings but it appears abundantly in other artefacts such as pottery or carpets among other crafts. The carpets from Muslim countries are still famous to this day and involve the weaving of tessellating patterns.

An interesting questions arises as to why was this 'geometric theme' so prominent. Was it because of a prohibition of figurative work of any kind? This holds true only for the places of worship. The reason behind this is the fear that any figurative art, with time might lead to idolatry.

Abas[5] also gives some philosophical reasons from the Muslim point of view to explain the adoption of these geometric themes. He totally rejects the notion that this was adopted due to any ban on figurative art, examples of which are also very rich in the Muslim culture. The Persian miniatures, paintings of the Mughal era in India or the paintings of the kings on the ceilings of the Hall of the Kings in Alhambra are quite good examples, just to name a few.

Abas opines in his paper that some of the other reasons could be that "the only material image of God that the Koran offers is that of Nur, meaning light. "God is the light of the heavens and earth", it proclaims."[Abas 2001] The excessive use of stars in Islamic patterns could have been affected by this notion of stars symbolizing light. Also, there are five basic pillars of Islam as well as five prayers in a day coinciding with the five corners of the star. Also the wandering nomads had to know which direction to pray in and the stars were again a guide.

[5] Syed Zafar Jan Abas Bilgrami is a well known mathematician and research scientist born in Allahabad, India. He is earned a Ph.D. in applied mathematics from London University (1967) and 27 years of teaching experience in the same field at the University of Wales. Inspired by the magnitude of symmetrical art done in Alhambra, he co-authored a the popular work "Symmetries of Islamic Geometrical Patterns". It is a comprehensive collection of nearly 250 Islamic patterns with algorithms in graphics for 2D visualization. He is also credited with numerous other publications and also earned a recognition as an artist. His art work has been exhibited in England, Wales, USA, Italy and Korea.

Thus the Quran also says:
"Allah it is who hath set for you the stars that ye may guide your course by them amid the darkness of the land and the sea" (V: 98, The Holy Quran)

All of these factors in conjunction must have produced a strong influence on the minds of the Muslims then to develop star shape and these other geometrical forms as well.[6]

2.1.2 Classes Islamic Patterns

Abas has classified the Islamic geometric patterns into three major classes namely:

1. Calligraphic,
2. Arabesque
3. and Space Filling Polygons.

The first form uses Arabic letter forms to produce geometric patterns. As an example figure 9 shows the Arabic word *'Muhammad'* moulded to form a symmetric pattern.

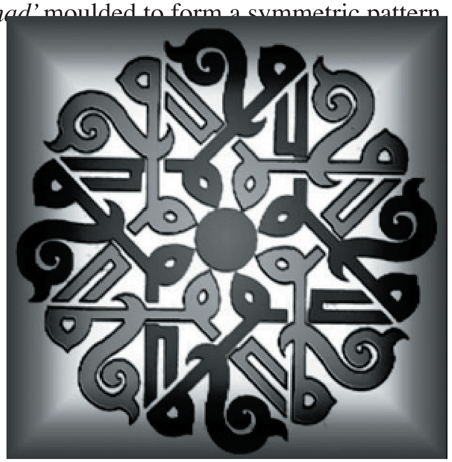


Figure 9: Calligraphic tiling pattern from the tomb of the Sufi poet Shah Abdullah Ansari in Herat, Afghanistan [Abas, S. J. (2001)]

The second form, Arabesque (Arab-Style), involves the use of vines, flowers, leaves and simple lines as motifs to produce aesthetically appealing patterns. These patterns are also widely applied in fabric embroidery, pottery painting and Henna[7] designs across the Muslim culture. Figure 10 gives a clear picture of the idea.

Figure 10 : Bowl from Iran with Arabesque Design(12th-13th Century) [Miho Museum (c)2003].

The third form, space filling patterns, is used to fill planes by a combination of polygons and arcs. A sample pattern is mapped onto a cell which is called a prototile[8] and this pattern is then repeated. The patterns generated by this technique have a homogenous appearance as there is no particular focal point of attention. The technique is used in two dimensional as well as three dimensional scopes. In a two dimensional environment the pattern is simply repeated symmetrically to fill the plane. An example of three dimensional areas is that of Qubbas[9].

[6] The interested reader is again directed to [Abbas & Salman 1998].

[7] A reddish-orange dyestuff prepared from the dried and ground leaves of this plant, used as a cosmetic dye and for coloring leather and fabrics (dictionary.com).

[8] Prototiles - The smallest collection of tiles, say t, which is a subset of a Tiling T such that every tile in T is congruent to some tile in t.

[9] Qubba - Domes in Arabic.

Domes have a significant importance in the Islamic culture and magnificent architectural examples can be found in Jerusalem and Cairo. To use the basic cell or the prototile on the inner and outer sides of the domes, they are scaled and deformed carefully in a manner which preserves the original essence of the design and makes perfect fittings on the circular surfaces.

Not only are the three forms used individually but they are all mixed to result in exquisite formations, as shown in the figure 11.

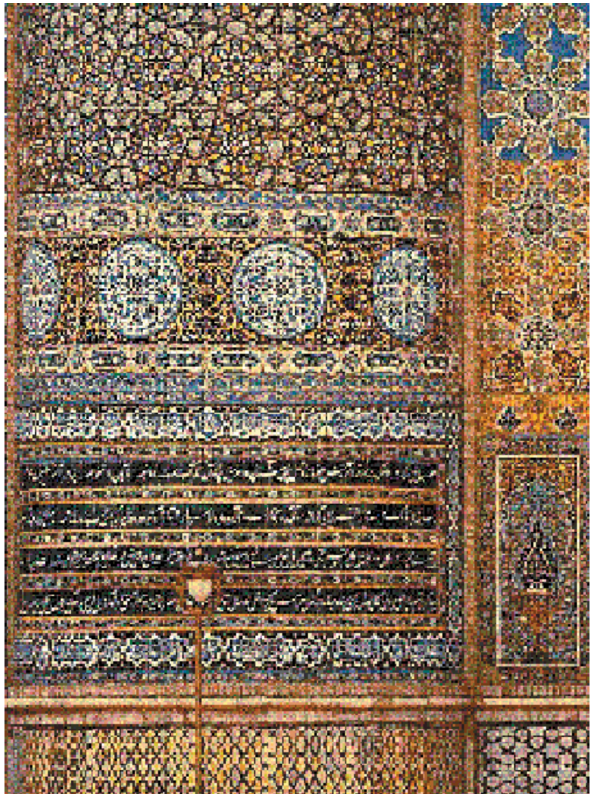


Figure 11 : Jamai Mosque Herat, Afghanistan (Timurid Dyansty – 8th -15th century)[Mann 2005]

2.2 Definition :Tiling Plane

Generally described "a plane tiling T is a countable family of closed sets $T = \{T_1, T_2, \ldots\}$ which cover the plane without gaps or overlaps. T_1, T_2.... denote the tiles of the set T and are employed to cover the whole plane and the interiors of the sets T_i are to be pair wise disjoint [Grünbaum & Shephard 1987, pp. 16]". Simply put, given a set of prototiles they should cover the tiling plane in such a manner that there are no gaps in between and no overlapping of tiles.

2.2.1 Types of Tiling

Broadly speaking tiling can be categorised into two major categories namely *Periodic Tiling* and *Aperiodic Tiling*. The Wang tile which are part of this project belong to the family of *Aperiodic tiles*. Here we first give the notion of *Periodic* Tiles and then present *Aperiodic* tile sets.

Periodic Tiling

"If symmetry group of a tiling contains at least two translations in non-parallel directions then the tiling will be called periodic."[15] [Grünbaum & Shephard 1987, pp. 29] Or very simply speaking periodic tiling is such a form of tiling which fills the tiling plane by repetition of a pattern in a regular manner. The regularity implies that, for example, in a two dimensional plane the pattern repeats itself in both x,y coordinates.

Aperiodic Tiling

Aperiodic tilings are remarkable, in that they are formed by "the sets of prototiles which admit infinitely many tilings of the plane, yet no such tiling is periodic." [Grünbaum & Shephard 1987, pp. 520] The set of prototiles should be such that every tile admitted by it must be non-periodic. For an example of this we can consider a modified version of a set P1 of tiles by Penrose (figure 12) which admits a tiling that is non-periodic shown in figure 13. The labeling of edges serve only as matching conditions to produce the aperiodic tiling; the 0 matching 0, the 1 1 and the 2 2 .

[10] For a complete understanding of this definition, consult [Grünbaum & Shephard 1987] to learn more about symmetry, symmetry groups and isometries.

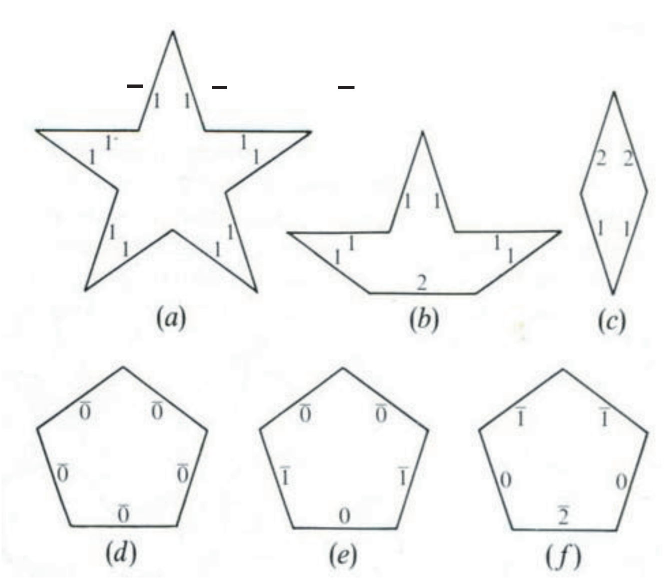


Figure 12 : Six edge-labeled tiles that correspond to the Penrose tiles of set P1 [Grünbaum & Shephard 1987, pp. 531]

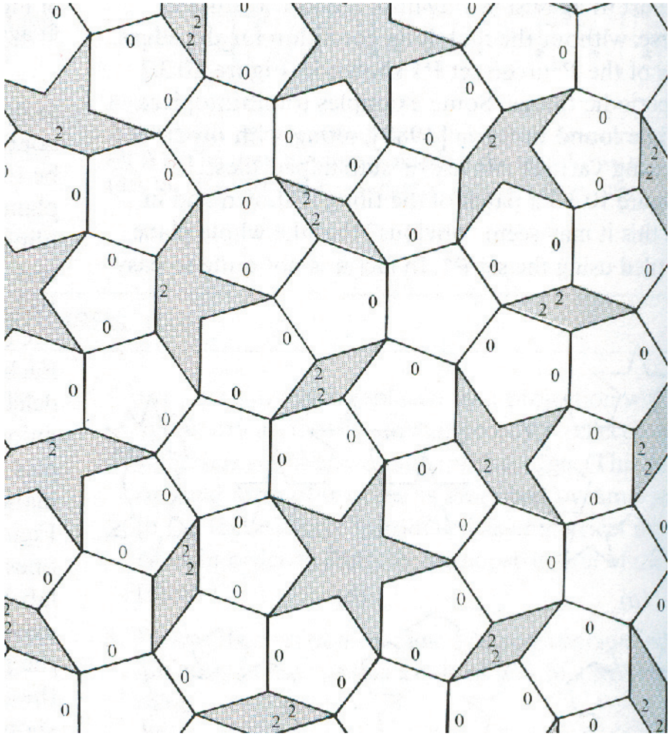


Figure 13 : Six edge-labeled tiles that correspond to the Penrose tiles of set P1 [Grünbaum & Shephard 1987, pp. 532]

Other significant examples of aperiodic tiling include Robinson's Aperiodic Tiles (1971) and Amman Aperiodic Tiles (1977). But what caught our interest were the Wang Tiles. These aperiodic set of tiles, thier properties and the implied results due to these properties were what caught our interest. The next leg of the journey for out AAA sub-project had now begun.

3 Wang Tiles

"Wang tiles are square tiles with coloured edges which must be placed edge-to-edge; colours on contiguous edges must match and only translations (not rotations or reflections) of the prototiles are allowed." [Grünbaum & Shephard 1987, pp. 584]

Wang tiles were the first set of aperiodic tiles to be discovered in 1966. This discovery is attributed to Robert Berger who discovered the first set of aperiodic tiles. His set was composed of 20,426 Wang tiles. He himself later on reduced this set to a subset of only 104 tiles. Various other attempts followed to reduce these number of tiles. In 1968 Donald Knuth reduced the number further to 92 tiles. In 1971 Raphael Robinson presentied a set of 35 aperiodic Wang tiles; and later reduced that also to only 32. A yet smaller set of such aperiodic tiles was discovered by K. Culik in 1996 containing only 13 tiles. [Cohen, Shade, Hiller & Deussen 2003]

The significance of this discovery of aperiodic sets of tiles lies in the fact that they provided an answer to the "Tiling problem". The tiling problem says that "given a set *S* of prototiles, does there exist an algorithm or procedure which can decide if *S* admits a tiling?" If there is such a procedure, to tile a plane in a finite many steps, the problem is said to be decidable. Hao Wang[11] was a person who became interested in this problem. He observed that when a set *S* of prototiles admits a tiling than one of the three possibilities below hold true:

a) *S* admits only a periodic tiling
b) *S* admits both periodic and non-periodic tiling
c) *S* admits only non-periodic tiling, or in other words, is an aperiodic set

He then went onto show that the Tiling problem is decidable if conditions (a) and (b) are satisfied.[21] [Grünbaum & Shephard 1987, pp. 602]

In 1961 he went on to conjecture that condition (c) will never occur. At that time no set of aperiodic tiles, or how to construct one for that matter, were known. But as we know, Berger (a student of Wang) discovered the first aperiodic set of tiles using the Wang Tiles in 1966. This upset Wang's argument and it is known today for a fact that the Tiling problem is undecidable. The reader can verify that the algorithm of appendix C will fail if we take a set of aperiodic Wang tiles. In this case we would have an infinite number or $m*m$ block of tiles to test as there will be no block that will ever reappear periodically. Thus one can easily see that this algorithm will never terminate. So we know that there isn't any algorithm, or for that matter, there never will be any algorithm that will be able to tell us this.

3.1 Computing by Wang Tiles

With the discovery of aperiodic sets, Hao Wang came to believe that there exist sets of tiling which, if suitably applied to any Turing machine, could carry out the computation. His basic idea was to use rows of tilings as a simulation of the tape and the states could be a procedural row of tilings. This belief of his became the concentration point of our journey.

Wang presented this idea of computing with Wang Tiles (also known as Domino Tiles) for the first time in 1965 in Scientific American. He said that "we can use dominoes to simulate various Turing machines and to create an equivalent of Turing's important "halting problem."[Wang 1965]

He further went on to say that "now, it is possible to find for each Turing machine a set of dominoes such that the machine will eventually halt if and only if the set of dominoes does not have a solution. It is then a direct consequence that the domino problem (tiling problem as discussed earlier) is unsolvable. If we could solve the domino problem, we could solve the halting problem; we cannot solve the halting problem and so we cannot solve the domino problem."[12]

[11] Hao Wang was a Chinese born logician, philosopher and mathematician. He started off with a B.Sc degree in mathematics in 1943 from the National Southwestern Associated University followed by a master's degree in Philosophy in 1945 form the Tsing Hua University. He went to Harvard University in America for his Ph.D. and started off as an assistant professor there in 1948. He was a close contemporary of the great mathematician and philosopher Kurt Gödel. His scientific paper entitled 'Games, Logics and Computers', published in Scientific American, was of particular interest to us. It for the first time presented the idea of computing by tiling.

[12] For the more visually oriented, this argument is presented as a flow chart in Figure 15.

This was the possibilty that this sub-project ultimately sought to pursue, thus the reader has to understand that this is the converging point of the whole journey - the reduction of any Turing machines to a corresponding set of Wang tiles that would perform the same computation as the Turing machine for a given input. This would lead to a production of patterns that would correspond to the computation performed by a Turing machine. Thus an interesting way of visualizing what an algorithm is doing at each step and point in time.

The edge-color matching property of Wang Tiles is what makes this mapping possible. These edge-color matching property can be employed to design signals along the tiling grid that ultimately result in a desired computation. For simple examples of addition, calculation of fibanncio series and calculation prime number see [Grünbaum & Shephard 1987, pp. 605].

We employed a generic mapping taken from [Harel 1987] that can reduce the computation of any Turing machine to an equivalent tiling by a set of Wang tiles. But before we describe any such mapping it would be better for the reader to take a side trip and understand the working of the Turing Machines first. This we describe in the next section.

4 Turing Machines

The Turing machine was described in 1936 by the British mathematician Alan Turing[13]. Turing identified that if there was to be a 'definite method' for solving mathematical problems it had to be applied mechanically and therefore designed a 'machine'. [Hodges 1988]

Here we will define a variant of Alan Turing's machine that we actually used in the project. In all respects, it is as powerful as the original model proposed by Turing in his paper[7]. The explanation is as it is adopted from [Hopcroft & Ullman 1979].

The basic model, illustrated in figure 13 has a finite control, an input tape that is divided into cells, and a tape head that scans one cell of the tape at a time. The tape is semi-infinite i.e. it has left most square but it is extended infinitely to the right. Each cell of the tape may hold exactly one of a finite number of tape symbols. Initially, the n leftmost cells, for some finite $n \geq 0$, hold the input, which is a string of symbols chosen from the subset of the tape symbols called the input symbols. The remaining infinity of the cells each hold a blank, which is special tape symbol that is not part of the input symbols.

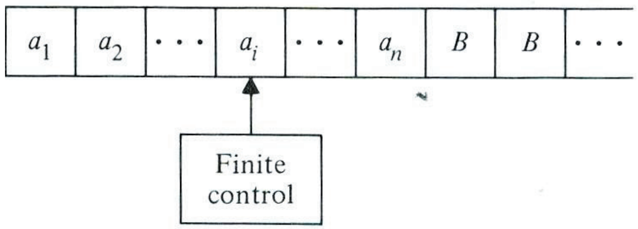


Figure 14 : Finite Control and Input Tape [Hopcroft & Ullman 1979, pp. 148]

The tape serves the purposes of input and output as well as a working memory to store the intermediate results. In one move the Turing machine, depending on the symbol scanned by the tape head and the state of the finite control :

1. changes state,
2. prints a symbol on the tape cell scanned, replacing what was written there, and
3. moves its head left or right one cell.

Formally a Turing machine (TM) is denoted by

$$M = (Q , \Sigma , \Gamma , \delta , q_0 , B , F)$$

Where

Q is the finite set of states,
Γ, is the finite set of allowable tape symbols,
B, a symbol of Γ, is the blank,
Σ, a subset of Γ not including B, is the set of input symbols,
δ is the next move function, a mapping from Q x Γ to Q x Γ x { L, R }(δ however maybe undefined for some arguments),
q_0 in Q is the start state,
$F \subseteq Q$ is the set of final states.

We denote an instantaneous description (ID) of the Turing machine M by $\alpha_1 q \alpha_2$ .Here *q,* the current state of M, is in *Q;* $\alpha_1\alpha_2$ is the string in Γ^* that is the contents of the tape up to the rightmost nonblank symbol or the symbol to the left of the head, whichever is rightmost. (Observe that the blank *B* may occur in $\alpha_1\alpha_2$). We assume that *Q* and Γ are disjoint to avoid confusion. Finally, the tape head is assumed to be scanning the leftmost symbol of α_2, or if $\alpha_2 = \varepsilon$ (empty), the head is scanning a blank.

We define a move of M as follows. Let $X_1 X_2 ... X_{i-1}\, q\, X_i \dots X_n$ be an ID. Suppose $\delta(q, Xi)= (p, Y, L)$, where if i-1 = n, then X_i is taken to be B. If i = 1, then there is no next ID, as the tape head is not allowed to fall off the left end of the tape. If i > 1, then we write

$$X_1 X_2 \dots X_{i-1} q X_i \dots X_n \vdash_M X_1 X_2 \dots X_{i-2} p X_{i-1} Y X_{i+1} \dots X_n \qquad (1)$$

[13]Alan Mathison Turing was British, born in an upper-middle class family, running the British royal administration until the First World War. He went to King's college Cambridge University in 1934 and graduated from there in 1934 with a distinction.

In 1936 he won himself a place in the logicians group by providing a solution to the famous *Entscheidungsproblem* of David Hilbert with the help of his famous Turing Machine.

Among his other exploits are the decoding of the German Enigma Enciphering machine, work on an Automatic Computing Engine (which unfortunately did not go very far due to hardware limitations), and the famous "Turing Test".[Hodges 1988]

However, if any suffix of $X_{i-1} Y X_{i+1} \dots X_n$ is completely blank, that suffix is deleted in (1).

Alternatively, suppose $\delta(q, X_i) = (p, Y, R)$. Then we write:

$$X_1 X_2 \dots X_{i-1} q X_i X_{i+1} \dots X_n \overset{M}{\vdash} X_1 X_2 \dots X_{i-1} Y p X_{i+1} Y p X_{i+1} \dots X_n \qquad (2)$$

Note that in the case i - 1 = n, the string $X_i \dots X_n$ is empty, and the right side of (2) is longer than the left side.

If two ID's are related by $\overset{M}{\vdash}$ we say that the second results from the first by one move. If one ID results from another by some finite number of moves, including zero moves, they are related by the symbol $\overset{*}{\vdash}_M$ We drop the subscript *M* from $\vdash_M$ or $\overset{*}{\vdash}_M$ when no confusion results.

The language accepted by M, denoted L(M), is the set of those words in Σ* that cause *M* to enter a final state when placed, justified at the left, on the tape of *M,* with *M* in state q_0, and the tape head of M at the leftmost cell. Formally, the language accepted by M = (Q , Σ , Γ , δ , q0 , B , F) is

$$\{ w \mid w \text{ in } \Sigma^* \text{ and } q_0 w \overset{*}{\vdash} \alpha_1 p \alpha_2 \text{ for some p in F, and } \alpha_1 \text{ and } \alpha_2 < x_2 \text{ in } \Gamma^* \}.$$

Given a TM recognizing a language L, we assume without loss of generality that the TM halts, i.e., has no next move, whenever the input is accepted. However, for words not accepted, it is possible that the TM will never halt.[14]

[14] See Appnedix A for a working example.

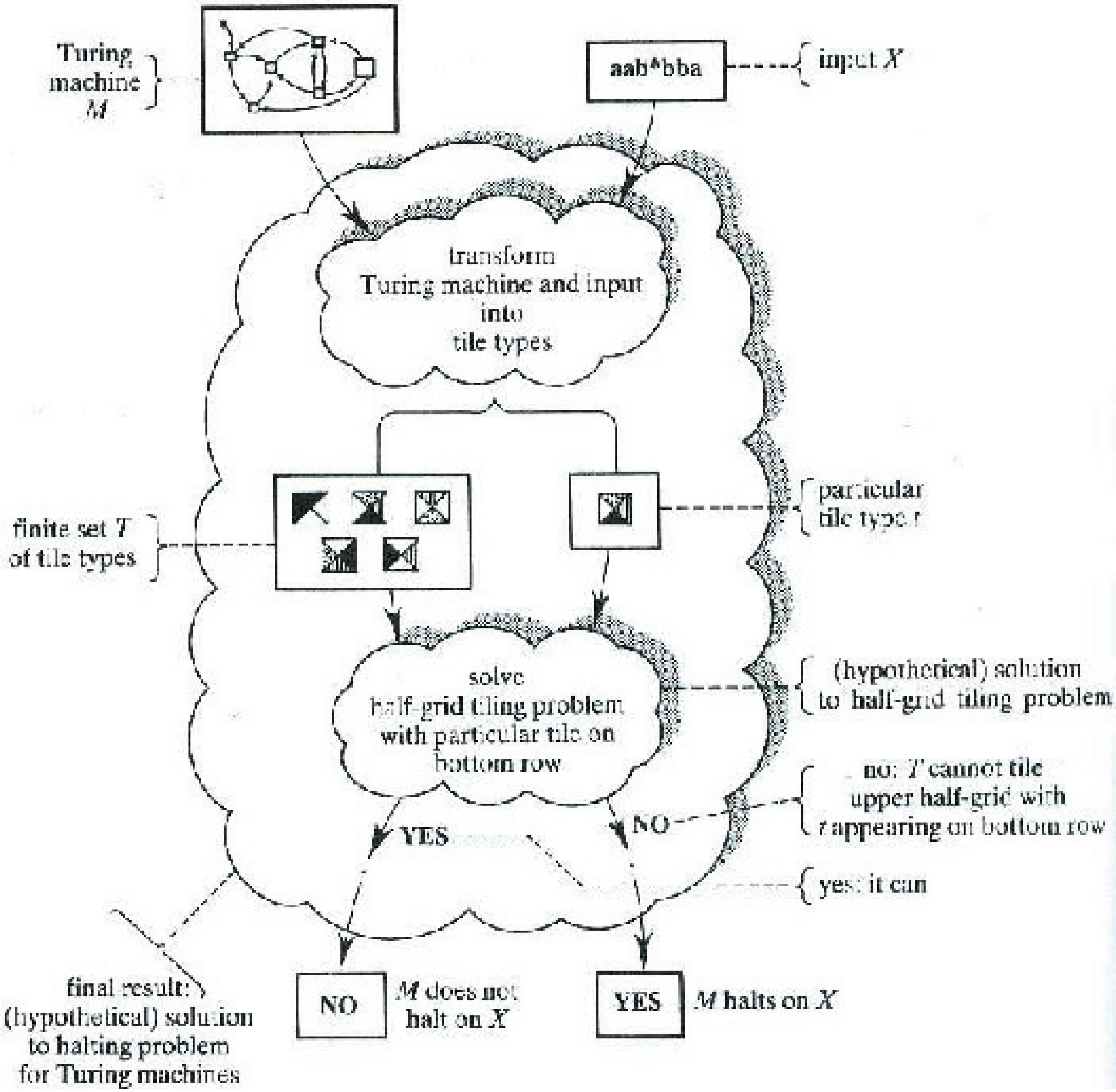


Figure 15 : Pictorial representation of 'tiling the Turing machine' [Harel 1987, pp. 240]

5 Mapping
Turing Machines to Tiling Half-Grids

A Turing machine M and an input sequence of symbols X, given by the pair <M,X> has a mapping to <T,t>, where T is a set of tiles that will be used to perform this mapping along with a special tile t, that must appear in the beginning to initiate this tiling. M does not halt on X if we can tile the plane with <T,t>. So for every computation that will halt at some point, the tiling produced can be viewed as an equivalent visual computation of the same. The stated can be seen in the figure 15.

The underlying concept to the mapping is as follows. Each row of tiles is made to encode the contents of the input tape, the current state of the Turing machine and the position of the tape head using appropriate colours. Furthermore an upward tiling of the plane is in accordance to the rules that are defined in the state table or the transition diagram for the Turing machine. This is guaranteed by having these tiles constructed in a very precise fashion which is described shortly in the next section. Thus with this mapping each row will correspond to a legal computation step in the Turing machine. The horizontal dimension caters to our concept of space, having encoded the input tape. The vertical dimension corresponds to our notion of time to compute. Thus being able to tile the entire half-grid would correspond to an infinite computation.

5.1 Rules for encoding the set <T,t>

To demonstrate the encoding, symbols will be used here. A different combination of symbols corresponds to a different colour to be used in the tiling process. And the symbol s+ only specifies that a new unique colour should be chosen for this symbol.

The first type of tile that we need in the set T is one that is able to pass on the input symbols, unchanged to the next step. This is done by the tile t1 below. Every input symbol on the tape has this type.

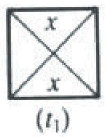


Figure 16 : Tile t_1 for every symbol x [Harel 1987, pp. 243]

The next types of tiles that make up are tile of type t_2 and t_3. They both encode the configuration of the Turing machine that says that it is now seeing the symbol x and is in state s. Additionally t_2 says that the symbol in question on the input tape was approached from the right and t_3 says that it was approached from the left.

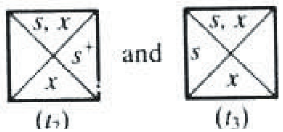


Figure 17 : Tiles t_2 and t_3 for every symbol x and state s[Harel 1987, pp. 243]

The last types of the set are the tiles of type t_4 and t_5. They define what will happen in the tiling plane when the Turing machine is in a state v and goes into state s when it reads the symbol r and writes it with the symbol w. The tile type t_4 is for the case when the tape head should move towards the right and t_5 defines the case when the tape head should move to the left. Notice that tile t_4 can now be matched only by a tile of type t_3 and t_5 with the tile t_2. This now perfectly encodes our representation of the Turing machine computation steps.

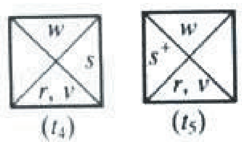


Figure 18 : Tiles t_4 and t_5 covering the change of symbols and states [Harel 1987, pp. 243]

Finally the last tile that we need is of the set <T,t > is “t” itself. This is simply obtained by appending the start state symbol to first input symbol in the very first row of the encoding. Thereby getting a different sequence of symbols that would be represented by a unique colour and initiate the tiling that would correspond to the computation on the Turing machine.

The reader armed with this understanding of mapping can now look at screenshot 4 in appendix B to see a working example. This tiling is produced for the Turing machine example of appendix A. A same state table representation of this Turing machine appear in screenshot 1, whereas screenshot 2 gives the more intuitive graph based representation. The tiling is done for the input string “0011”. Screenshot 3 is the same tiling with each sequence of original strings represented by unique colors.

5.2 Wang Tiles Other Applications

Wang very early on had pointed out the possibility of the mapping the operations of a Turing machines using Wang tiles. At the same point in time he had also pointed out another theoretical application in logic, whereby any arbitrary statement in “AEA formula (any statement beginning with “For all x there is a y such that for all z…,” followed by a logical combination of predicates without quantifiers.”) can be reduced to a set of Wang tiles as well. The point such a mapping demonstrates is that, since the general tiling problem is unsolvable, thus so is the problem of deciding whether the encoded formula is self-contradictory.[14]

But another interesting example would be the use of Wang tiles to generate non-periodic texture (or patterns or geometry). In this technique a non-periodic n*m grid of non-periodic Wang tiles is generated. Each unique square is filled with textures (or replaced with patterns or geometry) to give the effect of non-homogeneity in texture generation. The basic idea is to avoid visual artefacts arising from use of a same sample data set over a plane. An example of this is figure 20(b). Figure 19 and 20 demonstrate the eighteen Wang tiles used to generate this texture based plane. [Cohen, Shade, Hiller & Deussen 2003]

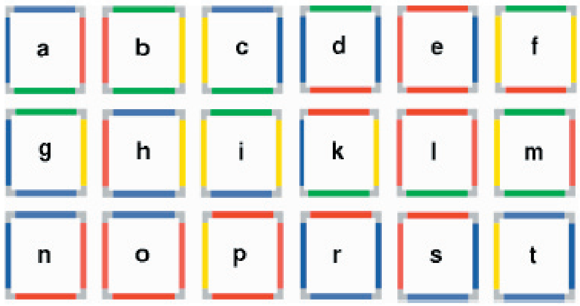


Figure 19: A set of 18 Wang tiles [Cohen, Shade, Hiller & Deussen 2003]

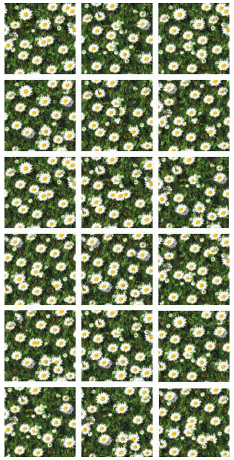


Figure 20(a) : 18 Wang Tiles automatically generated based on set in Figure 19

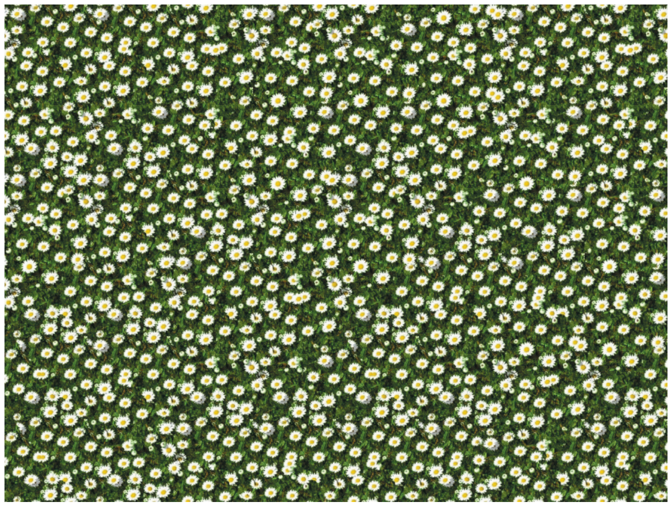


*Figure 20(b): Resulting part of infinite texture (8*6 tiles) with some tile instances highlighted above[Cohen, Shade, Hiller & Deussen 2003]*

[14] See [Wang 1965] for details.

Towards
"A new kind of Science"

Each journey undertaken is supposed to bring along with it its own lessons. These, for us, have been the answers to the questions of the relationship between art and algorithm. We seek to explain these answers with "A new kind of science" presented by Stephen Wolfram.

Wolfram does simple experiments with computer programs having simple rules and then shows how these programs provide complex results. He talks about how we, to date, have not been able to resolve the issue of complexity in many systems. Instead we resort to limiting the scope of these systems. Then, going to the micro level of these systems, we seek to try and find an explanation of the behavior of the constituents. Only then do we try to unify these micro-behaviors that we discovered and explain the behavior of the whole complex system. This is a strategy that has been very successfully employed by physics.

Thus, he states that as a consequence to this approach whenever we encounter a phenomenon that is complex, we immediately assume that it must be a result of a similar complex behavior of the underlying constituents. Thus seeing these complex behaviours around us he suggests one would think "that such complexity-being so vastly greater than in the works of humans-could only be the work of a supernatural being".[Wolfram 2002] But he says that through his experiments with computer programs he was surprised to see complex behavior could easily be demonstrable by a set of rules that are very simple in themselves. And so he states that that his discovery of simple programs producing "great complexity immediately suggests a rather different explanation"[Wolfram 2002]. Though this argument of his does not really convince us, as one can immediately turn it around and counter argue his claim of the existence of a greater or a supernatural being. But it would not deny the fact that his observation still remains valid, and thus significant; namely - simple rules for behavior can exhibit complexity.

He thinks we can learn from these experiments of his and use them to explain the many outstanding issues of complexity that are contained in various fields like mathematics, physics, biology, social sciences, computer science, philosophy, technology and of particular interest to us here, Art. This now brings us to the hypothesis that he finally proposes - the Principle of Computational Equivalence.

The key idea behind this principle is "that all processes, whether they are produced by human effort or nature, can be viewed as computations." [Wolfram 2002] The principle goes on to say "whenever one sees behavior that is not obviously simple - in essentially any system - it can be thought of as corresponding to a computation of equivalent sophistication."[Wolfram 2002] And this computation of equivalent sophistication is what demonstrates computational equivalence of the same.

This brings us to what this hypothesis means for us, to our understanding, in our project, and in particular to our little contribution. If we look in retrospective to our little experiment, what our program does is that it sets-up some simple rules of behavior for our Wang Tiles. These rules are of course the mapping to the domain of Turing machines. (as in the section "Reduction of Halting Turing Machines to Tiling Half-grids"). Now already we have a simple program whose behavior is visually observable. The visual behavior additionally is a function of the underlying Turing machine governing the tiling and the input being processed by it. We think that this little program perfectly supports the notion of Computational Equivalence. We have a visual pattern; and we have an underlying computation that is equivalent to it. Thus, in a sense we a have the computational equivalent of the computing that a person would perform using a Turing machine in a visual manner.

This leads to a whole new set of ideas. What if we consider Art as a process? Then does the principle of Computational Equivalence implies that then any piece of art-work can be mimicked by some reasonable computations. Immediately it would seem so but let's analyze this a little further. Wolfram's introduces a clever concept of computational irreducibility, which simply means that "that the only way to work out how a system will behave essentially is to perform this computation – with the result that there can fundamentally be no laws that allow one to work out the behavior more directly."

The idea of Computational reducibility is the same notion as the concept of "Decidability"; a problem that arises as soon as we ask the question, what will be the result of a computation after some infinite number of steps. It is a widespread phenomenon which occurs in many systems "in nature and elsewhere." [Wolfram 2002] Another interesting remarks that he makes is about the working of the brain. While talking about the issue of free will in human beings he says that, "even though all the components of our brains presumably follow definite laws, I strongly suspect that their overall behavior corresponds to an irreducible computation whose outcome in effect can never be found by reasonable laws". [Wolfram 2002] Alan Turing did resolve the issue of undecidablility but he never explored what it meant as a mental issue. So this statement of Wolfram is somehow trying to relate the cognitive-psychological issue of intuition or the sudden jumps to conclusions that we as human have. He essentially says that some of our particular style of doing things or the aesthetics (or characteristics) of our work or behavior that is governed by intuition or these jumps of conclusion could be viewed as computationally irreducible. If we wish to perform an equivalent computation to this effect we need to perform all the steps of the computation, so as to arrive at the same result. And since we are not aware of the steps, in case of human thinking, this computation corresponds to a computationally irreducible one. Or in other terms we have a problem that is undecidable.

The above argument now gives us a framework to debate on the dialectics of Art and Algorithm. If a person explicates or can explicate the set of rules that do or will go on to produce his work of art then any algorithm can mimic his behavior to reproduce that particular piece of art. Or if it is the case that the set of rules only layout a principle of production than we would go on to get finished pieces that are in that particular stylized form. Otherwise it will be a computationally irreducible task to mimic the same. To say it in a different way if we try to find an algorithm without prior knowledge of the steps in the computationally irreducible task, chances are we are going to end with undecidablility. We will not be capable of exact reproduction.

Appendix A

An Example Turing Machine

This example is adopted as it is from the book “Introduction to Automata theory, languages and computation” [6]

The design of a TM M to accept the language L = $(0^n 1^n \mid n > 1\}$ is given below. Initially, the tape of M contains $0^n 1^n$ followed by infinity of blanks. Repeatedly, M replaces the leftmost 0 by X, moves right to the leftmost 1, replacing it by Y, moves left to find the rightmost X, then moves one cell right to the leftmost 0 and repeats the cycle. If, however, when searching for a 1, M finds a blank instead, then M halts without accepting. If, after changing a 1 to a Y, M finds no more 0’s, then M checks that no more1’s remain, accepting if there are none.

Let $Q = f\{ q_0, q_1, q_2, q_3, q_4\}$, $\Sigma = \{0, 1\}$, $\Gamma = \{0, 1, X, Y, B\}$, and $F = \{q_4\}$. Informally, each state represents a statement or a group of statements in a program. State q_0 is entered initially and also immediately prior to each replacement of a leftmost 0 by an X. State qi is used to search right, skipping over 0’s and Y’s until it finds the leftmost 1. If M finds a 1 it changes it to Y, entering state q_2.

State q_2 searches left for an X and enters state q_0 upon finding it, moving right, to the leftmost 0, as it changes state. As M searches right in state q_1, if a B or X is encountered before a 1, then the input is rejected; either there are too many 0’s or the input is not in 0*1*.

State q_0 has another role. If, after state q_2 finds the rightmost X, there is a Y immediately to its right, then the 0’s are exhausted. From q_0, scanning Y, state q_3 is entered to scan over Ys and check that no 1’s remain. If the Ys are followed by a B, state q_4 is entered and acceptance occurs; otherwise the string is rejected. The function δ is shown in Fig. 7.2. Figure 7.3 shows the computation of M on input 0011. For example, the first move is explained by the fact that $\delta(q_0, 0) = (q_1, X, R)$; the last move is explained by the fact that $\delta(q_3, B) = (q_4, B, R)$. The reader should simulate M on some rejected inputs such as 001101,001, and 011.

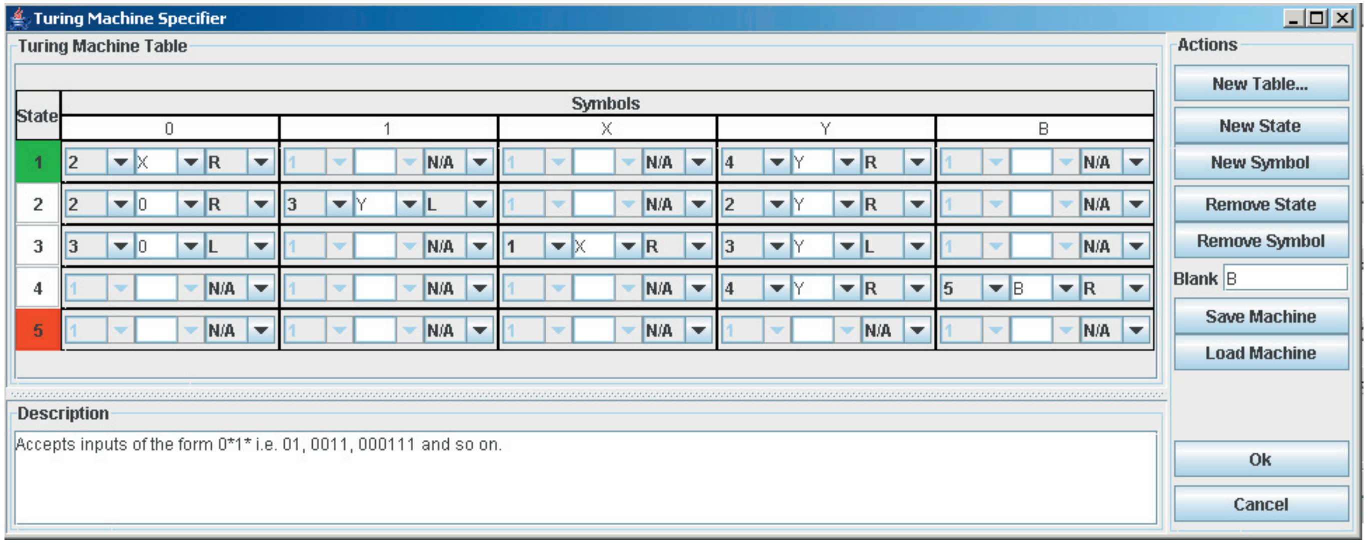
	Symbol				
State	**0**	**1**	**X**	**Y**	**B**
q_0	(q_1,X,R)	----	----	(q_3,Y,R)	----
q_1	$(q_1,0,R)$	(q_2,Y,L)	----	(q_1,Y,R)	----
q_2	$(q_2,0,L)$	----	(q_0,X,R)	(q_2,Y,L)	----
q_3	----	----	----	(q_3,Y,R)	(q_4,B,R)
q_4	----	----	----	----	----

Figure 21: The function δ (State table).

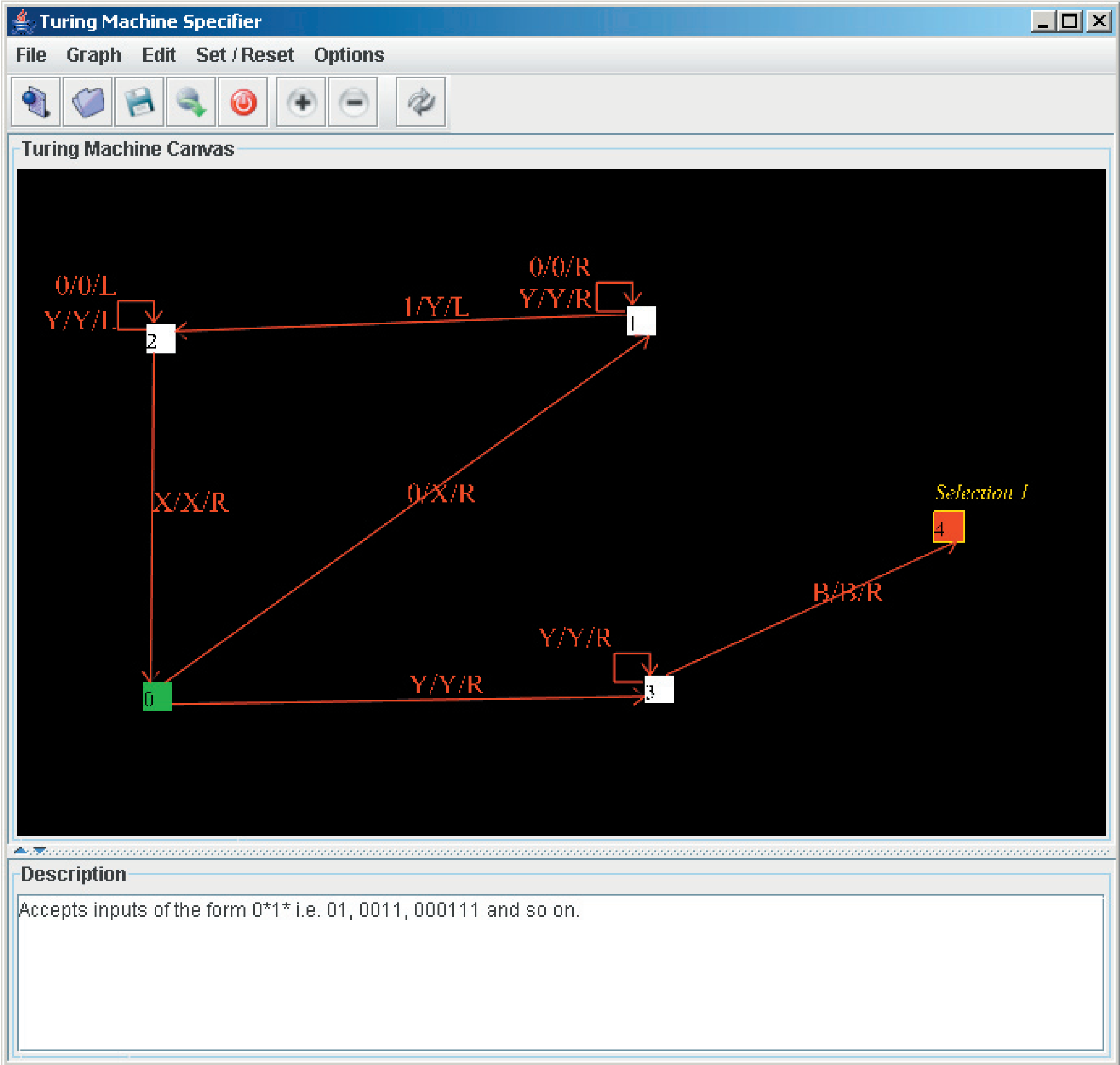
$q_0 0011 \vdash X q_1 011 \vdash X 0 q_1 11 \vdash X q_2 0Y1 \vdash q_2 X0Y1 \vdash X q_0 0Y1 \vdash XX q_1 Y1 \vdash XXY q_1 1 \vdash XX q_2 YY \vdash X q_2 XYY \vdash XX q_0 YY \vdash XXY q_3 Y \vdash XXYY q_3 \vdash XXYYB q_4$

Figure 22: A computation of M.

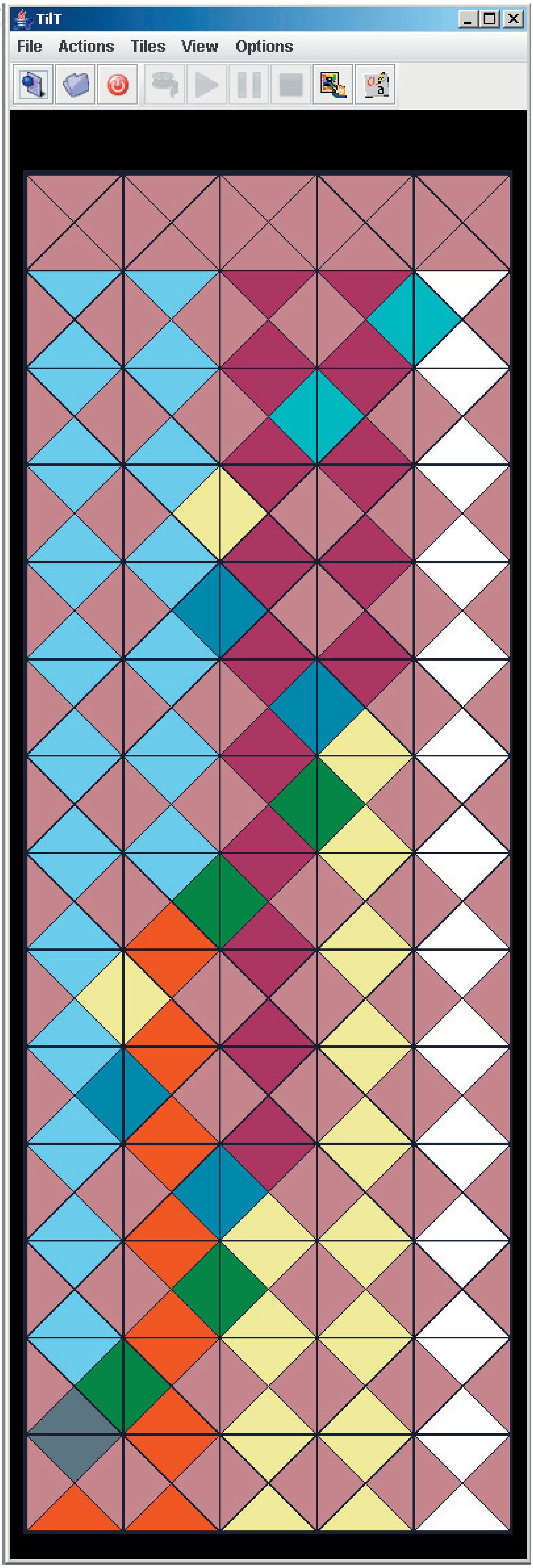
This appendix gives the screenshots of the application TiLT developed for the AAA project. The first screenshot shows the sample Turing machine of appendix A, represented identically by a state table with the help of the TiLT application. The second screenshot shows the same state table represented as a graph in the graph mode. The next set of screenshots, numbered 3 and 4, show a sample run of the tiling produced for the input string “0011”. The former is taken in the colour-mode of the application and the later in the text-mode. One can now easily verify from the text-mode screen shot how the tiling takes place with the prototiles generated according to the rules described in the section “Rules for encoding the set <T,t>”.



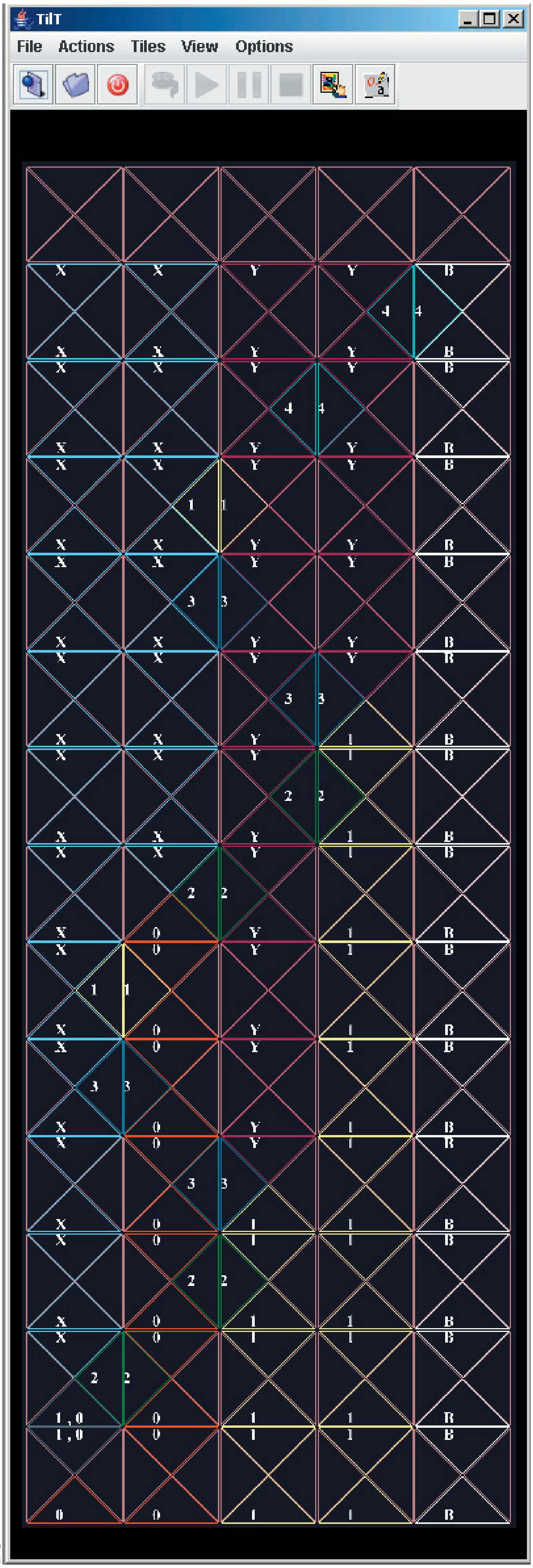
Screenshot 1: State table representation of the Turing machine example of appendix A (same as figure 21, with state 1 representing state q_0, state 2 representing state q_1 and so on) from the Table Editor in TiLT software. The green marked state specifies the start state and the red marks the end state(s). Each cell of the table simply describes the next state the head should move to, the tape-symbol to write in place of the one read and the direction the tape head should move to in the respective order.



Screenshot 2: Graph representation of the Turing machine specified as a state table in figure 21 and screenshot 1, from the Graph Editor in TiLT software. The green state symbolizes the start state and the red, final state(s).Each link is labeled with it's δ move function



Screenshot 3: A tiling run on the input string "0011" for the example Turing machine of appendix A, figure 21, in colour mode with TiLT software.



Screenshot 4: A tiling run on the input string "0011" for the example Turing machine of appendix A, figure 21, in colour mode with TiLT software. One can easily see the the tile 't' of the set <T,t> in the lower left corner that starts the tiling process. The rest of the prototiles of the set 'T' are also easily observable the encode this Turing machine.

Appendix C
Hypothetical Tiling Algorithm

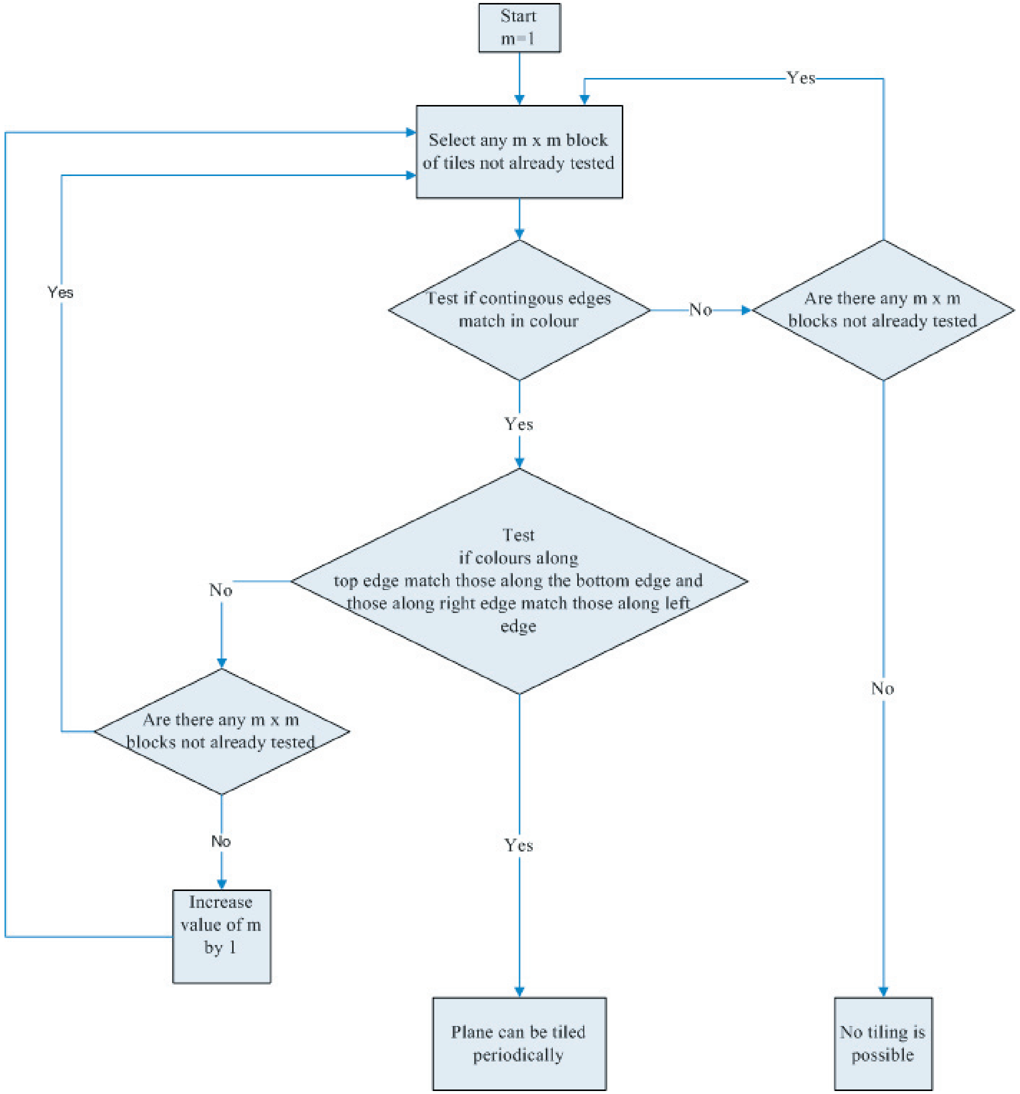


Figure 22: The flowchart of a suggested algorithm to decide whether a given set of Wang tiles admits a tiling of the plane.

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chapter 5

"Art should serve the people". Mao Tse Tung (MT 13)

iDIA - Political Animation

Eric Engle

I. Introduction

“Art should serve the people”. *Mao Tse Tung* (MT 13)

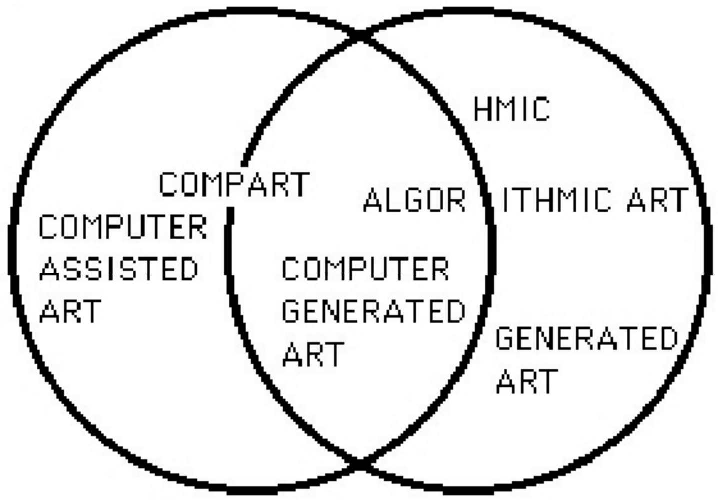
iDIA projects animated political art. ***Political art*** is the use of artistic means for political propaganda. (Nake, 2005) ***Animated political art*** is the creation of motion pictures by any method where the intent of the artist is focussed on communicating a political message. The name ***iDIA*** means „Internet Design In Art“. iDIA was chosen as a name for this sub-project both to inspire inquiry and to reflect that some of the animations (notably of Bruce Cockburn and Sarah Jones) are largely animated diaporama, that is slides. iDIA is also a bit of a self deprecating pun - „i“ in lowercase. I choose Mao as a starting point for artistic expression and chronicling because his thought is the most progressive and likeliest to most effectively reduce the risk of human extinction due to war or environmental disaster.

In the Art and Algorithm project we were asked to investigate the relation of algorithms to artistic creation and/or aesthesis in digital art. „***Digital art*** is art that uses digital technology in any of three ways: as the product, as the process, or as the subject.“ (Soban, 2002) Digital art is either computer generated or computer aided. My work in digital art is largely computer aided, not computer generated.

I first explored computer generated art. ***Computer generated art*** is art which created „using autonomous processes with no direct human control. The role of the human is to create the process (to develop a computer program), to start the process (to run a program) and to make the selection of generated works. ... The program can be run at any time and space. ...computer generated art [includes] ... generative art, algorithmic art, random art, software art, artificial art, mathematical art, cellular automaton art, fractal art“ (Soban, 2002) Computer generated art relies on algorithms to generate the art: All computer generated art is algorithmic. In contrast, most, but not all, algorithmic art is computer generated. Computer generated art is a subset of algorithmic art.

I define ***algorithmic art*** as the use of a repetitive process to generate an artistic work. That is, the piece of art, e.g., a painting, must be generated as the product of a computable function. It must be reproducible, although reproduction may be computationally intractable if pseudo random or stochastic functions are invoked. Existing definitions of algorithmic art focus on rule based generation of art: „Algorithmic art is a movement in which the artists create software code that then generates images or sounds.“ (McPhee, 2004) Similarly, Bern states that „Algorithmic art is rule-based art, usually made with the aid of a computer.“ (Bern, 1998) All computer generated art is algorithmic art, but not all algorithmic art is computer generated.

The relations between art and algorithm can be shown with a picture:



Algorithmic art, to me, is limited. To me, the literal significations of an algorithm seems trivial or too abstract to be interesting. Metaphoric and mystical significations of algorithms are at least more interesting. We might say Eratosthenes sieve is symbolic of the sorting of pure souls (primes) from impure ones (composites) and that the square root of 2 is symbolic of insanity. But mysticism, while a curiousity, is not objectively scientific because it is bound to idealism and not connected with material reality. Pre-scientific ideas were thus excluded from iDIA. That was unfortunate, since cabbala and pythagoreanism both offer esoteric alpha-numeric theories as does Leibniz. But it was also unavoidable. Metaphor and mysticism could not be taken up as raw materials since they contradict scientific materialism.

Because of the limitations of computer generated art I ultimately chose to focus on creating computer aided art (CAI). ***Computer aided art*** is art where „the computer is only a very powerful tool controlled by the artist, and work is created by human ([e. g.,] using Photoshop to create images).“ (Soban, 2002)

A. Theoretical Foundations

The theoretical foundations of iDIA, historical materialism, are found for example in ‚Talks at the Yenan Forum‘. (Mao, 1942) Maoism represents the furthest advance of Marxist thought. The proletarian revolution in China led by Mao was a protracted long term struggle. It took decades to win state power. Initially, Mao naively tried to apply Lenin‘s thought directly to China. But that did not take into account that China, a semi-feudal country, had different material conditions than semi-industrial Russia. Because of this error Mao’s revolution was nearly crushed in the 1920s. Then in the 1930s Mao was nearly eliminated again: Chiang Kai Shek had encircled the Jiangxi Soviet. The 90,000 communists broke out of the encirclement and fled. Thus began the long march. Half of the communists died in the march.

Immediately after the defeat and desparation of the Long March Mao discussed - art.

Why? Was Mao crazy or desperately ignoring more pressing problems?

Mao said:
„In our struggle for the liberation of the Chinese people there are various fronts, among which there are the fronts of the pen and of the gun, the cultural and the military fronts. To defeat the enemy we must rely primarily on the army with guns. But this army alone is not enough; we must also have a cultural army, which is absolutely indispensable for uniting our own ranks and defeating the enemy.“ (Mao, 1942)

Art is a weapon. In the wake of apparent defeat Art would rally the Maoists. Yenan would become the artists‘ foundry where the artists would meet the people to learn from the people and to express the people’s needs and desires:
„It is very good that since the outbreak of the War of Resistance Against Japan, more and more revolutionary writers and artists have been coming to Yenan and our other anti-Japanese base areas. But it does not necessarily follow that, having come to the base areas, they have already integrated themselves completely with the masses of the people here. The two must be completely integrated if we are to push ahead with our revolutionary work. The purpose of our meeting today is precisely to ensure that literature and art fit well into the whole revolutionary machine as a component part, that they operate as powerful weapons for uniting and educating the people and for attacking and destroying the enemy, and that they help the people fight the enemy with one heart and one mind.“ (Mao, 1942)

Knowing that art is a weapon studying it takes on importance. What is the purpose of art, this revolutionary weapon? The task of revolutionary art, according to Mao, is to extol and inspire the proletariat: „As for the masses of the people, their toil and their struggle, their army and their Party, we should certainly praise them." (Mao, 1942) But this praise must not be blind. Mao notes „The people, too, have their shortcomings. Among the proletariat many retain petty-bourgeois ideas, while both the peasants and the urban petty bourgeoisie have backward ideas; these are burdens hampering them in their struggle. We should be patient and spend a long time in educating them"(Mao, 1942)

Revolutionary art must also expose the corruption of capitalism:
„With regard to the enemy, that is, Japanese imperialism and all the other enemies of the people, the task of revolutionary writers and artists is to expose their duplicity and cruelty and at the same time to point out the inevitability of their defeat, so as to encourage the anti-Japanese army and people to fight staunchly with one heart and one mind for their overthrow." (Mao, 1942)

Because art is a weapon Mao defines the audience art should serve from the perspective of class struggle. For Mao, „There are three kinds of persons, the enemy, our allies in the united front and our own people." (Mao, 1942). The revolutionary artist must „adopt a different attitude towards each of the three." (Mao 1942) and recognize that „the audience for our literature and art consists of workers, peasants and soldiers and of their cadres". (Mao, 1942). Art should not serve the enemies of the people. It must serve the people, and persuade those that might become the friends of the people to take the side of the people:
„With regard to our different allies in the united front, our attitude should be one of both alliance and criticism, and there should be different kinds of alliance and different kinds of criticism. We support them in their resistance to Japan and praise them for any achievement. But if they are not active in the War of Resistance, we should criticise them." (Mao, 1942).

Of course, the work of the revolution was not Mao's alone. The Chinese people were the source and vector of the Chinese revolution. Mao did however guide and inspire the revolutionary as a helmsman guides a boat - but the people are the power of the revolution. Thus when I talk about Mao here I mean both the Chinese people, especially the Chineses revolutionaries as well as Mao himself.

Mao also raises a question that defined AAA for iDIA. „should we devote ourselves to raising standards, or should we devote ourselves to popularisation?" (Mao, 1942) A very similar question is, should art be „red" or „expert"? Algorithmic art seems to me to possibly raise standards but also to risk becoming pure art, i.e. bourgeois art and thus objectionable:
„One of the petit bourgeois fabrications about art is that proletarian art is ‚political' whereas art reflecting the dominant, bourgeois values is just aesthetic. Liberals refuse, for example, to see the creation of celebratory/simple landscape portraits, in the middle of a national liberation struggle, as a political act. As an article in Chinese Literature put it in 1974, „In feudal China paintings, whether of human figures, landscape or flowers and birds, reflected the life, views and sentiments of the feudal ruling class but ignored the major role of the labouring classes."(4) The bourgeoisie does not see anything wrong with producing art at the expense of the toiling masses, that has nothing to do with the masses' experience, that the masses will in most cases not be able to see or participate in, and that celebrates a beauty that comes with privilege and prosperity that they do not have." (MT 13, 2000)

I tried to popularise by using films as my medium. Raising technical standards (applying algorithms to artistic production) became secondary as the limited capacity for algorithmic art to express clear, conscious political messages became clearer. That was in fact the correct method:

„While it is important to raise artistic standards, which are often neglected, Mao added, ‚the political side is more of a problem at present.‘ So it may be one or the other, depending on conditions. Again the question of the stage of struggle is crucial. In the present in imperialist society, it is the content that is principal, precisely because of the worship of contentless art that dominates in the bourgeois culture. In fact, if we go up against the imperialists on the artistic quality criterion, we will surely lose at present, if only because they have the better computers, the years of exclusive training with the right materials, and endless study and practice subsidised by imperialist exploitation. So, while we appreciate artistic quality, content comes decisively first for us. MIM will not restrict art work we publish or distribute on the basis of its artistic quality. We will work to improve artistic quality to enhance the impact of our work when possible, but ahead of doing this we place encouraging young cadres to engage in revolutionary culture production, distributing our materials to the greatest numbers of people.“ (MC 12, 2000, 25.)

Of course, Mao wanted both improved standards and popularisation! (MC-12, 2000, 25) Not merely good content but also good form. But between the two he correctly placed the emphasis on popularisation (content)

„Since our literature and art are basically for the workers, peasants and soldiers, ‚popularisation‘ means to popularise among the workers, peasants and soldiers, and ‚raising standards‘ means to advance from their present level. ... We must popularise only what is needed and can be readily accepted by the workers, peasants and soldiers themselves. Consequently, prior to the task of educating the workers, peasants and soldiers, there is the task of learning from them.“ (Mao, 1942)

The correct emphasis is popularisation, rather than raising standards because the audience for progressive culture is the proletariat. The tastes of this audience must be taken into account. Mao describes the aesthetic perception of the proletariat in the following passage:

„Popular works are simpler and plainer, and therefore more readily accepted by the broad masses of the people today. Works of a higher quality, being more polished, are more difficult to produce and in general do not circulate so easily and quickly among the masses at present. The problem facing the workers, peasants and soldiers is this: they are now engaged in a bitter and bloody struggle with the enemy but are illiterate and uneducated as a result of long years of rule by the feudal and bourgeois classes, and therefore they are eagerly demanding enlightenment, education and works of literature and art which meet their urgent needs and which are easy to absorb, in order to heighten their enthusiasm in struggle and confidence in victory, strengthen their unity and fight the enemy with one heart and one mind.“ (Mao, 1942).

Mao argues that cultural work is nearly as important as military work because culture inspires and motivates us. He also argues that between art for the masses and art for the elite that art for the masses should be encouraged. Mao also argues against the metaphysical view of artistic dilletantes. In the best world, cultural work would be both politically progressive and expertly executed, a two front struggle:

„There is the political criterion and there is the artistic criterion; what is the relationship between the two? Politics cannot be equated with art, nor can a general world outlook be equated with a method of artistic creation and criticism. ...each class in every class society has its own political and artistic criteria. But all classes in all class societies invariably put the political criterion first and the artistic criterion second. . . . What we demand is the unity of politics and art, the unity of content and form, the unity of revolutionary political content and the highest possible perfection of artistic form. Works of art which lack artistic quality have no force, however progressive they are politically. ... On questions of literature and art we must carry on a struggle on two fronts.“ (Mao, 1942)

But in an imperfect world between expert art serving the wrong goals or inexpert art serving the right goals Mao favored the inexpert art, but with the constant exhortation to improve. This is why my work focussed on popularizing a political standpoint via film rather than raising of standards through algorithmic art.

We can distill the Yenan talks into several interlocking progressive positions which, in my opinion, are the most advanced view on art production in the world to this day.
1) Art is inherently political, at least in its production but also in its signification
2) Art must serve the people;
3) Culture is vital to survival
4) Art must be grounded in historical materialism.
5) Art must reject metaphysics
6) Art must both be understood by the masses and attain high technical standards;
7) cultural workers must be both politically progressive and expert.
8) All varieties of artistic form can and should be pressed into artistic creation provided that the artistic form is used to express progressive ideas.
These propositions were documented by and then guided iDIA.

The vitality of culture to revolutionary struggle is due to the fact that „To overthrow a political power, it is always necessary, first of all, to create public opinion, to do work in the ideological sphere. This is true for the revolutionary class as well as for the counter-revolutionary class." (Beijing Review, 1967, 17-19) The eclecticism of the revolutionary art is seen in the the slogans: „Make the past serve the present and foreign things serve China" and „Let a hundred flowers blossom; weed through the old to bring forth the new.(Beijing Review, 1972, 5) iDIA chronicles the different styles of art and shows that Chinese revolutionary art portrayed revolutionary themes using classical Chinese art, modern art, Chinese folk art, and socialist realism.

The Maoist view on art guided iDIA. Because art is inherently political and because computer assisted art, in my opinion, is better able to express nuanced political views than algorithmic art computer assisted art was chosen as the primary focus of iDIA. The remaining positions guided the subjects presented: Oppression in its various aspects, notably racism, sexisim, homophobia and war. iDIA attempts, primarily, to expose and oppose oppression using a mass hypermedium: several hyperCard and metaCard stacks, movies, and HTML documents to link them all up. Secondarily, iDIA seeks to attain high standards in animation. Thus, iDIA attempts to implement Mao‘s ideas on art by presenting art that is politically progressive, attractive, and that attains a good standard of animation quality. In sum, iDIA tries to expose the contradictions inherent in capitalism which shape all artistic creation but which are often only implict or even not consciously expressed at all (yet always lurking beneath the surface).

iDIA is tangentially related to CombArt and Merzbau. CombArt is different from iDIA in that it is a cooperative game. However, like iDIA, combart is an example of computer assisted art. Like iDIA, Merzbau combines various artworks created by others to form a new work of art. However iDIA does this using the computer as assistant to human judgement. Merzbau, in contrast, generates art collages programmatically and so is closer to computer generated art. TilT (tiling), is an example of computer generated algorithmic art. TilT and iDIA have little in common - though tiling in Islamic art is in fact a political expression in that Islam prohibits portrayals of living things, since only Allah makes living things and so this prohibition shows the power of Islam to compel persons to maintain their humility. iDIA and TilT can be seen as "opposites" computer assisted art on the one hand and computer generated algorithmic art on the other.

A. Problem

To represent the relationship between art and politics through dialectical resolution of contradictions.

iDIA addresses the relationship between art and politics. Politics, like Art is an essentially contested term (Connolly, 1993). No one agrees as to any one definitive signification of the cluster of concepts associated with „art“ and „politics“. But, we must have a term with which to work if we wish to communicate meaning. Let us describe politics as the process of human interactions centred on determining control of resources. That is, politics is the field of resolution of contradictions and is a dialectical process. For a historical materialist, history follows certain laws. The nomothetic nature of reality explains the promise of science. Since causality can be seen not only in material reality but also in social reality, humanity can control their environment – for good or ill. That raises the question whether and to what extent art can be used to represent these laws and how they influence the creation of art. To answer this question I focus not on algorithmic art. Rather I focus on conscious political art, especially animations, distributed via internet and/or CD ROM. That is, I use application software to generate digital media for dissemination of certain political convictions.

B. Hypothesis

The hypothesis of iDIA was that the development of historical laws could be represented using algorithms but that algorithmic art is fundamentally empty of intentional political signification. The first hypotheses proved problematic. Essentially, using historical statistics as data for artistic representation resulted in rather uninteresting art. Thus, instead of developing algorithmic art I focussed on developing politically conscious art using the computer to support this process. Thus a different thesis was developed than the original hypothesis. That is science: we develop hypotheses, test them, and if they prove untenable we abandon them and report the results, possibly developing thereby new hypotheses to be tested and proven as theses. Happily, this did occur: a tenable thesis was developed.

C. Thesis

The thesis of iDIA is that all art is political, either in its creation or in its content or both. Consequently, pure art is impossible. „There is in fact no such thing as art for art‘s sake, art that stands above classes, art that is detached from or independent of politics. Proletarian literature and art are part of the whole proletarian revolutionary cause; they are, as Lenin said, cogs and wheels in the whole revolutionary machine.“ (Mao, 1942) Algorithmic art is generally not explicitly or overtly political but nevertheless is the result of political processes like anything else in social life. The contradiction between my subjective interest in political art versus the limited room for political expression in computer generated art represented the principal contradiction in the AAA project for me.

Of course, that contradiction is not the principal contradiction in capitalism today. The principal contradiction in capitalism is between the first world, which consumes the bulk of the world’s wealth, and the third world which produces that wealth: „the principal contradiction is between the oppressed nations and imperialism.“ (MIM, 1999; Mao, 1968). However, the global principal contradiction is only one contradiction: there are contradictions within classes, nations, races and historical epochs. One contradiction for AAA was clearly between computer generated art and computer assisted art. The resolution of this contradiction may be the idea that algorithmic art – art where the artistic process is formalised as an algorithm and expressed as a computable function – merely makes conscious what is implicit in art generally. iDIA takes the position that computer assisted artist production results in better quality political art than computer generated art. AAA sought to explore the relation between art and algorithm, and that is my conclusion: I generated better political art using computer assisted art than by using algorithmic art.

The proof of the limits of algorithmic art for representation of political concepts is indirect. I created art using a computer. The process is represented algorithmically using pseudo-code. However formalizing the pseudocode into executable code was not necessary for the creation of the art. Further, such a formalisation, relying necessarily on judgement and taste, would be extremely difficult to implement as an executable program. iDIA tried to focus on popularisation of art rather than on raising standards – though high standards were sought.
Where an artist does not formalise the algorithm which they apply to create their work they can focus on making art rather than describing how they make their art. Further, a formal algorithm might limit creativity since rule breaking and execution of an algorithm seem contradictory - and creativity at least sometimes arises from rule-breaking. Formalising and implementing implicit algorithms would have distracted iDIA from the task of creating politically significant art. It would have raised technical standards at the expense of artistic popularisation. For this reason, algorithmic art may not be the best way to present political content.

Algorithmic also art risks obscurantism and elitism and opposes popularisation. Algorithmic art can easily result in "pure art", also known as "art for art's sake". But pure art is usually bad art because it ignores and/or at least implicitly denies the political nature of artistic production and consumption: „In the world today all culture, all literature and art belong to definite classes and are geared to definite political lines. There is in fact no such thing as art for art's sake, art that stands above classes or art that is detached from or independent of politics. Proletarian literature and art are part of the whole proletarian revolutionary cause; they are, as Lenin said, cogs and wheels in the whole revolutionary machine." (Mao, 1942, p. 86) It may achieves a high technical standard but ignores popularisation and usually extols, at least implicitly, the supposedly refined aesthetic sense of the bourgeoisie feeding elitism.

Algorithmic art can be said to be fine and subtle – a hidden algorithm and its visible artefact. This could even be subversive. But under imperialism this subversion will likely only encode one variety or another of fascist elitism. Even if the crypto-fascist danger is avoided in algorithmic art the subtle link between implicit algorithm and explicit artefact will be lost on most people. The subtle fine message will be missed by most unless active steps in popularisation are taken. Rather than look for fine or sublime or even subversive algorithms behind art I looked for ways to communicate a simple message as effectively as possible to as many people as possible. Algorithmic art was simply too subtle for that end.

D. Definitions[1]

As was already indicated in social discourse even basic definitions are often essentially contested. However, definitions are useful to help communicate ideas. Definitions proceed from indisputable or conventional atoms (axioms and postulates) and thus ultimately become tautologies. Further, definitions often become circular. We define A by B, B by C, and C by A. Yet, despite these inevitable problems found in all sciences definitions help us to communicate. However terms, though polysemic, are not merely conventional or intersubjective. They are attempts to reflect material reality. The following definitions indicate how I will use certain terms. These definitions explicitly state their primitives and avoid circularity.

Euclid's geometry proceeds from primitives: points, lines, and planes. These should also be the primitives of an objective aesthetics. Out of these objects are constructed and proofs derived. Would an aesthetics of geometry be possible?

The definitions are statements limited to visual representation

[1] On this section Professor Nake summarised this section as follows: „I will have to use certain terms that are hard to agree on. Therefore it is likely that every reader will read the text differently. Here are very brief indications of how I am going to use some terms. I assume that artefacts are made from compositional elements which are chosen from geometry and graphics (forms and colors). Those elements are combined in structured arrangements I call „designs". Aesthetics, I assume, is concerned with perception and, in particular, with perception of pleasing visual structures. The term „pleasing" here is totally subjective. In creating artistic works (artefacts), the creator follows some idea or intention. So it makes sense to think of art as the relation between an idea and a developing design. ..." This might be easier to follow but I did want to reflect an axiomatic structure. In all events, we should remember that: „In discussing a problem, we should start from reality and not from definitions. We would be following a wrong method if we first looked up definitions of literature and art in textbooks and then used them to determine the guiding principles for the present-day literary and artistic movement and to judge the different opinions and controversies that arise today. We are Marxists, and Marxism teaches that in our approach to a problem we should start from objective facts, not from abstract definitions, and that we should derive our guiding principles, policies and measures from an analysis of these facts. We should do the same in our present discussion of literary and artistic work."

and may (or may not) apply to music or dance. These definitions are presented to avoid confusion in the text and also as a very rough sketch of a possible aesthetics based on geometry. I would like to provoke interest in the idea of an objective aesthetics based on geometry.

Primitives: point, line and plane. Color is also a primitive. This primitive is necessary since Euclid was discussing something other than art. Music primitives are undefined.

A *design* is an arrangement of primitives intended to convey an unwritten message. Designs may either be harmonious (pleasing) or disharmonious.

Aesthetics is the creation of pleasing designs.

Harmony is the proportional arrangement of compositional elements.

A design is aesthetically *pleasing* when it invokes harmony, balance, structure, as reflected in the symmetrical and complementary arrangement of lines and colors.

An *idea* is a synthesis of observations of material facts into a general observation. If all observed instances of crows are black we synthesise the conclusion that the next crow will also be black. The statement „all crows are black" is an idea: the statement „this crow is black" is a statement of fact.

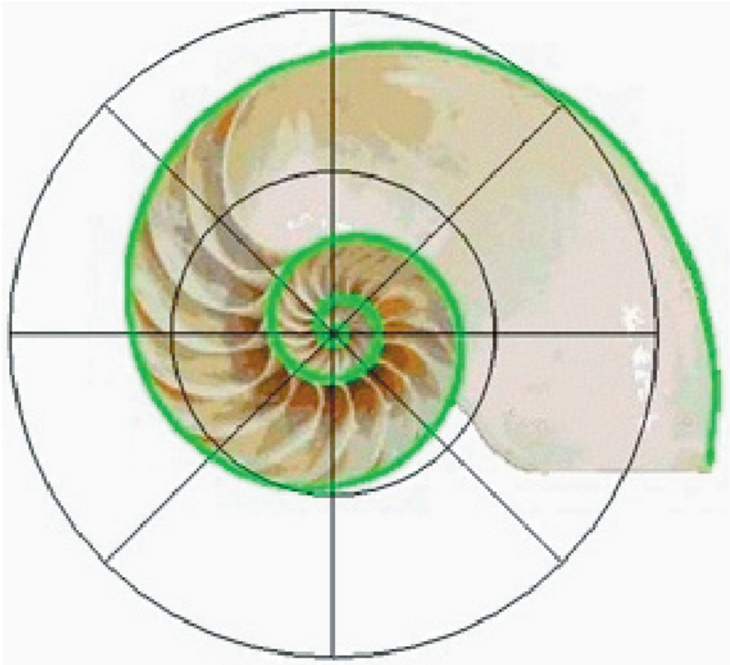
Art is the combination of design and an idea.

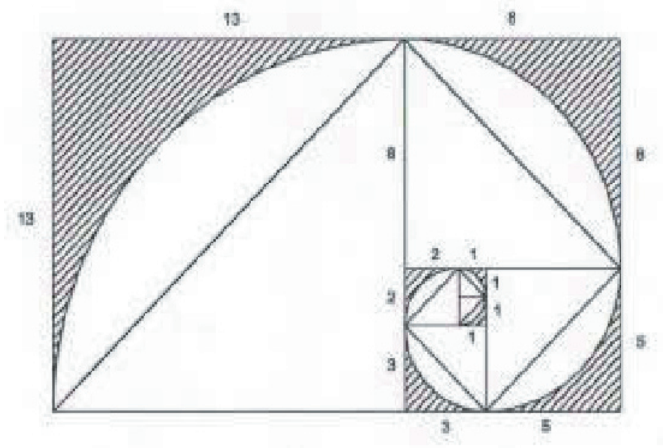
Other terms that would need to be defined to create a formal system to represent an objective aesthetics would include, but not be limited to:

*Balance, Symmetry, Contrast, Complementary Color, Proportion, Forms(*circle, square, rhombus, rectangle, trapezoid, ellipse, sphere, tetrahedron, cube, octahedron, dodecahedron, icosahedron).

Because of space limitations these concepts can only be briefly explored. However even with just a few definitions I can present my critique of algorithmic art. I think algorithmic art, at least to present, has presented designs, even pleasing designs, without going beyond design to express the algorithmic idea directly in its execution. The algorithmic message is lost on a mass audience. To me, there is not enough isomorphism or political direction in algorithmic art to make it as interesting as I would like it to be. More importantly, there seems to be little or no room for a political message using algorithms to generate art.

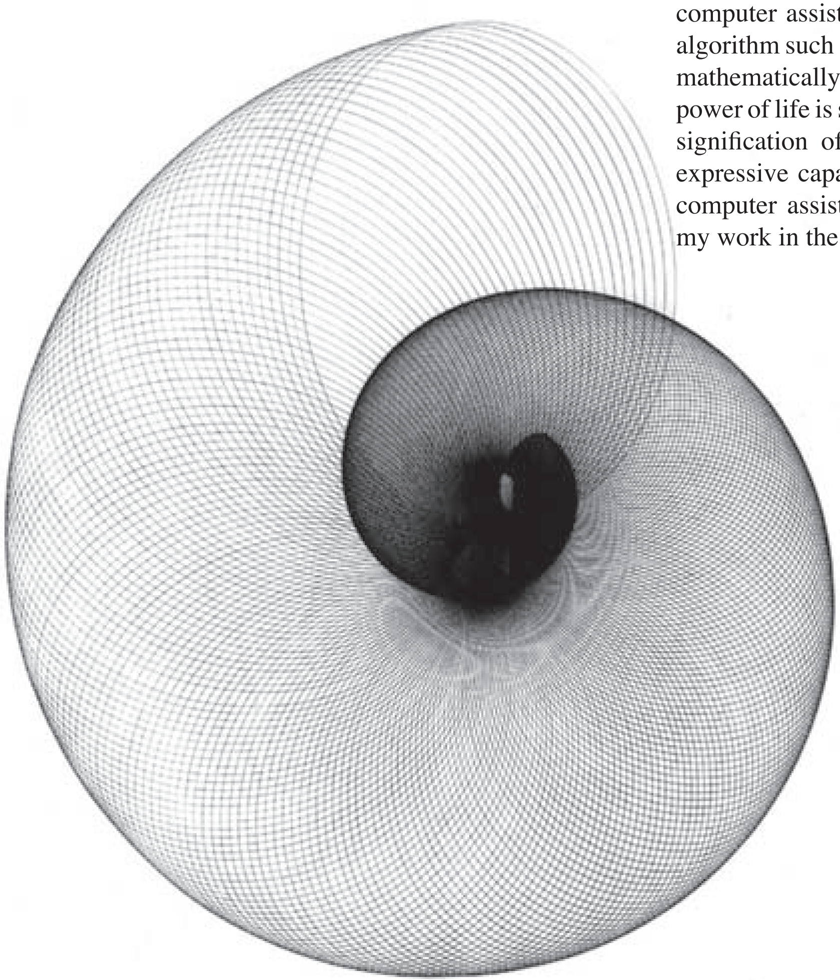
Algorithmic art expresses its idea most clearly in the algorithm itself - which is most often hidden to the viewer intentionally or not. Thus, the mass audience does not get the message. This makes algorithmic art politically useless. For example, most people see in the Chambered Nautilus a beautiful snail's shell, without realizing it is also an expression of the golden mean.





And indeed, this was the subject of one of the first works in computer generated art:

Popularisation of algorithmic art would be a way to overcome the limitation of hidden messages that viewers simply are unaware of. But even then the limited potential for algorithms for expressing political ideas explains why I chose to work on computer assisted art rather than computer generated art. An algorithm such as the golden mean, even if comprehended both mathematically and as a metaphor for the eternal blossoming power of life is so abstract and timeless that it has little practical signification of praxis here and now. The limited political expressive capacity of algorithmic art explains my choice of computer assisted art rather than computer-generated art for my work in the project.



II. General Description

A. Project tasks

This portion of the project used computers and software to generate films and hypermedia as political propaganda against oppression. Computers, the internet, and software make it possible for almost anyone with sufficient discipline and drive to generate films. The topic was especially influenced by Maoist China. Ironically, capitalist restoration after Mao has returned China to de facto capitalism. I tried to represent the various facets of oppression digitally to give political content and direction to the project. Rather than generating art algorithmically, I used computer programs to generate art (computer assisted digital art).

C. Assumptions

I assumed that I would be most effective making political art using a series of short films, stacks, and html documents each of which demonstrates a different aspect of oppression. Ultimately a succesful storyline was developed to link the short films into one long film. Racism links into sexism, sexism links into war, war links into resistance, and resistance links into rebellion. The viewer of the set of movies is taken from confusion, to anger at injustice leading first to resistance and then to rebellion against injustice. Rather than experiencing cathartic purging of revolutionary tendencies, the intent of classical theater per Aristotle, the audience becomes charged with energy to change the world. Interactivity was attained through hyperlinks (html) and also through the quicktime HREF track and director.

D. Method

iDIA is possible because we have a solid political understanding of the interlocking character of forms of oppression. Homophobia, Racism, and Sexism mutually influence and support each other. They are symptoms of fascism. Left unchecked, these symptoms become mutually reinforcing. To fight only these symptoms is sub-reformism. To fight the core disease requires an understanding not only of these symptoms but also of the underlying disease. This understanding is achieved through dialectical materialism. Here, CombArt stated „Elitism is the basic characteristics of facism. The core of anti egalitarianism is deeper than these manifestations.“ With this political understanding, even technically limited artistic expression using a simple medium such as film can have a positive impact on ending these problems. Without this political direction no amount of beautiful art will identify the problem or offer solutions to it. This is the essence of Mao’s writing in *Talks at the Yenan Forum:* Politics in command. I try to follow that motto.

E. Project Goals

The goal of iDIA project, primarily, was to construct politically exciting art. Secondarily, the art was intended to explore the concepts of algorithm, contradiction, and dialectic. The art is intended to illustrate the development of history according to social laws. The process of the unfolding of history reveals contradictions not only between different classes in one society at one time but also dialectics between different historical eras, different classes, and between the base (infrastructure – the forces of production) and suprastructure (the relations of production) of a given society. History reveals the ideas of absolute and relative contradiction quite well.

III. Project Documentation

The user of this project merely points and clicks to be presented with animations or texts. The UI could not be simpler thus documentation is very limited.

A. User Interface

The user interface is a completely normal web page. The page can be navigated like any hypermedium. No data is provided by the user. The computer calculations are limited to the ordinary navigational functions. The only data returned are texts, images, films and sounds. The web sites does not create, edit, or destroy any files. No intellectuals or machines were harmed in this production.

B. Testing

Throughout the project I have shown the hypermedia to my fellow students looking for critiques and user feedback. This peer review led me to abandon the hypercard for metacard, and then to abandon metacard for an internet web page. Unfortunately the test market was different from the target market. That problem was unavoidable.

C. Target Audience

The software is intended to be used by people, particularly from the third world, on any platform. Thus cross platform capability and low bandwidth were the two major design concerns and in that order. Cross platform compatability was nearly perfectly achieved. Forays into platform unique formats (notably WMV) were intended only to develop the author's technical competence in a variety of animation formats and also as experiments with quality of image and file size.

The hypermedium was tested on Macintosh Classic (7.5, 9.1), Macintosh OS X and Windows. The hyperCard stacks functioned properly on Classic (7.5) and OS X in classic mode. The hyperCard stacks were ported to windows and OS X native using MetaCard. Again, the stacks functioned, after localisations, flawlessly as stand-alone applications. The stacks were not ported to Linux but could have been.

The HTML files and associated animations (.mov, .wmv, .swf, .dcr) also exhibited cross-platform portability. With VLC on the macintosh OS X the WMV files were readable but not scaleable. The .mov files are readable on windows if quicktime is installed on that platform. Flash is available on both platforms and the browser pentration thereof is one more indication that it is probably the best medium for animations. Using the sorenson 3 compressor however quicktime films were produced that though large would through streaming be deployable. Quicktime seems the better tool for digitized film, and flash for animations. Since quickTime supports flash tracks it was possible to import the flash track to quicktime using the quickTime player. Sounds can also be imported using WireTap sound capture utility. Motion pictures on the mac were captured as quicktime using Snapz. Both WireTap and Snapz shareware, both available from Ambrosia software. Since I was limited to Quicktime pro 2.5 (free from apple) I was forced to test both Snapz and WireTap. Both give good results in terms of size of files generated, particularly after Sorenson 3 compression.

The navigation of the documents is entirely in English as this is a *lingua franca* today.

D. Functionality

I. Software Assumptions

The target audience determined the limits on the hardware and software to be used: low bandwidth programs where possible, capable of being viewed on almost any computer. This goal was at least partially met. A broad mix of file formats guarantees that all platforms will be able to view the message.

The software functions through a standard web interface: HTML, Quicktime (.mov), Flash (.swf), Director Shockwave(. dcr), and Windows Movie format (.wmv) are all used and accessed from html files. hyperCard and its successor metaCard were also used particularly for algorithmically generated designs. Technically these means are of course very simple - and for that reason cross-platform. The accent was placed on artistic content.

2. File Formats

The discussion of the file formats is based on my personal experience. Thus, the analysis of the various file formats is my own opinion based on personal experience.

The software assumes user may be using any platform – windows, linux, or macintosh. Consequently, the most popular video formats were used: Flash, QuickTime, Director and WMV. The design goal was to create high quality low bandwidth films. These constraints of cross-platform usability and low bandwidth transmission provided a perfect experimental opportunity to determine the strengths and weaknesses of the various file formats. This comparison follows.

Flash

This comparison revealed that Flash (swf) is clearly the most economical format in several respects. Flash files only took up from 1 to 5 megabytes and could be transmitted over a 56kbps or even 28.8kbps modem. Compression in flash is very nice since the images are vector based. No data was lost due to compression and flash images scale perfectly. Despite this flash files created are small. And finally the flash plugin is on most browsers –has 96% browser penetration. (Macromedia, 2005) The files were easily generated, the software was very user friendly.

I do have some critiques of flash. Flash films are really animations – cartoons. That is not the best format for all images. Flash did not seem to me the best way to make or edit films produced by cameras observing reality. Flash seems very well adapted for brief works of five minutes or less.

Windows Media Format (WMV)

WMV revealed itself to be a bad choice. The windows movie maker compresses pictures such that a fair amount of resolution is lost and the windows movie maker tool cannot be used to create complex effects or fine editing. I will not use wmv in future projects. The movie maker tool is clearly directed to amateur film makers – home movies – for private distribution. It is not advanced enough to be considered even an entry level professional tool.

Quicktime

Quicktime showed itself to be best for longer videos. Quicktime was definitely the easiest development tool to use (iMovie, quicktime pro and hypercard for frame by frame editing). It would be easy to make a high quality feature length low budget film using quicktime. The only possible disadvantage, large file sise, seems to be inevitable in any long film.

Unlike windows movie maker, iMovie allowed creation of complex effects while hyperCard allowed complex track editing. Simple single frame editing was done using the quicktime player (classic). Quicktime files were of excellent quality. However, quicktime files also are rather large (20 to 40 megabytes for five minutes with soundtrack). This file sise practically overwhelms a dial up modem.

Director (DCR)

Director has some of the advantages of flash (smaller file sise – 7 megabytes in the example provided). Director files can be distributed on the internet using the shockwave plugin. However the shockwave plugin has much less browser penetration than flash. The immediate question when using director is: why? Flash can do just about everything director can. The files flash generates may be a bit smaller. In my case, I found flash useful because its scripting language is similar to hypertalk. CombArt here pointed out that: „director has more advantages than flash over rendering 3D scenes, complexed image manipulation and compatibility with other programming languages.“ However, I was not doing 3d scenes.

3. Technology and infrastructure - Hardware assumptions

Given the goal, a universal message able to be viewed anywhere by the poor, low bandwidth applications were desired. This presented a dilemma: either low bandwidth poor quality images or high bandwidth images of good quality. In the end since this is an artistic project I compromised and accepted that at least some files will be quite large. Thus, the software presumes that the user has an internet broadband connection. Even short movies will overwhelm a 56k modem. Short silent films (less than one minute, no soundtrack) are possible over a 56k modem but anything at all complex soon reveals that a cable modem is necessary. Most of iDEA can be viewed on dial-up but some of it simply requires a broadband connection.

A. Previous work

My research during the past two years has focussed on the relationship between art and aesthetics on the one hand with politics on the other. The art I create is part of a dialectical process illustrating the contradiction that wealth is socially produced yet privately owned. I tried to explore whether and how algorithms can act as a mediating force between them.

I concluded early on that all art was political, that pure art was really not possible since the creation of art is itself political. Thus, rather than focussing on the interminable debates as to what art is, what algorithm is, and what aesthetics are – all of which can be found in the hypercard and metaCard stacks in the project – I focussed my energies on creating films – mostly music videos – with a progressive political content. This had the advantage of obviating needless and in my opinion often pointless effort and permitted me to focus on what I think is really important: ending war, hunger, and poverty. Further, by developing content rich political work I hoped to contrast by example my work with work that claims to be a-political and also to contrast my work with work that is purely algorithmic. Algorithmic generative art to me seems to be intriguing from a design standpoint but lacks political depth. Thus my work contrasts directly with TilT (the tiling group). The tiling group presents interesting mathematical designs, but what does it mean? I leave that question for the tiling group to answer.

B. Problems

The most difficult part of the project was relating my work to algorithm. I at first thought that a link between political art and algorithm could be made by looking at algorithms in the development of historical laws. That was problematic. I then thought to look at algorithms to represent political ideas. That was also troublesome. I concluded that I should focus on human generated art to contrast it with machine generated art. Thus I embraced the „art“ pole of the duality of art and algorithm.

A secondary problem is that I had hoped to make a more interactive work. However the message to be conveyed did not require an interactive format.

C. Innovations

My work is innovative in that it is essentially „bash ups“ and could be represented by an algorithm. Namely, I find a song which I think is politically interesting. I then scour the internet for video or at least still images that represent the ideas portrayed in the song. The results is a movie sequence that is richer than any of its isolated components. This can be represented as an algorithm in pseudocode.

```
Begin
ChooseSong
FindImages
Splice
End


function ChooseSong
repeat
choose(Themes[racism|sexism|homophobia|war]) find(Song(Theme[Chosen])) //find song to match theme
if isRadical(song) AND isProgressive(song) AND isAesthetic(song) then exit chooseSong
end repeat
//This does not cycle indefinitely because
//this function can be called as necessary
//It returns only one appropriate song
end ChooseSong

function findImages
repeat
find(Theme[Chosen])
find(Art)
if Art=Example(Theme) then splice
If length(movie)=length(song) then exit repeat
end repeat
end findImages

function splice
movie=movie+art
end splice
```

Of course the splicing function would be much longer if developed for implementation. I am merely trying to illustrate the point, that the Merzbau uses a function to find art, but a guided search function would be possible which then could develop political art.

D. Achievements

My principle goal was to criticise the wars, racism, and sexism that are inherent to capitalism using computer art. I am satisfied with my success in conveying this critique.

The idea of transmitting artistically and politically high content messages through low bandwidth was also, basically, achieved. The work did not however demonstrate much algorithmically generated political art because I was concentrating on putting out an intense political message. Showing the development of historical processes according to economic and social laws did not lead to me proving that we can use algorithms, including artistic algorithms, to influence and accelerate development of society. This aspect of the project was at once most challenging and frustrating to me. Positions that seem to me self evident were not taken as such. Rather than concentrating on arguing positions regarded by others as not only not self evident but also as unprovable I focussed on the content of my message

relying on an indirect proof of the limits of algorithmic art to demonstrate my point. However I remain of the opinion:
*that history develops according to certain economic and social laws
*that we can influence the development of history by understanding these laws
*that these algorithms can be reflected in art.

But rather than demonstrated these positions – any of which could be the subject of a doctoral dissertation - I focussed on the artistic content of my work (popularisation) rather than the scientific content (raising standards).

V. Conclusion

If we were to continue working on the project I would like to more closely link my work to the Merzbau and to combArt. My Bash-Up approach is similar to what the Merzbau does. Only I am doing it by hand. Unlike Merzbau, which develops nearly random art my works are overtly politically driven. Combining these approaches might yield something even more interesting. Another possibility would be to provide a radical art gallery for Merzing. I did provide a library of Chinese revolutionary art for combArt. To explore this further might be interesting.

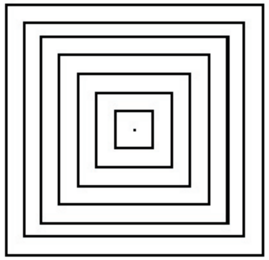
To conclude, TILT, Merzbau, CombArt and iDIA represent four different approaches to art and algorithm. These diverse styles could coexist because:
Letting a hundred flowers blossom and a hundred schools of thought contend is the policy for promoting the progress of the arts and sciences and a flourishing socialist culture in our land. Different forms and styles in art should develop freely and different schools in science should contend freely. (Mao, 1957, 49-50)

ABSTRACT ALGORITHMIC ART DESIGNS CREATED WITHIN iDIA

ARROW

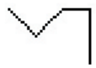
```
on mouseUp
  choose line tool
  repeat with i = 1 to 4
    if i=1 then
      put 0 into x
      put 0 into y
    end if
    if i=2 then
      put 0 into x
      put 10 into y
    end if
    if i=3 then
      put 0 into y
      put 10 into x
    end if
    if i=4 then
      put 10 into x
      put 10 into y
    end if
    add 256 to x
    add 171 to y
    drag from 256,171 to x,y
  end repeat
  put the script of me into cd fld 2
  choose browse tool
end mouseUp
```

Centred Squares



```
on mouseUp
  choose rectangle tool
  set centered to true
  set multiple to true
  set multispace to 6
  set dragspeed to 150
  drag from 256,171 to 306,220
  choose browse tool
end mouseUp
```

Rune



```
on mouseUp
  put 256 into posx1
  put 171 into posy1
  put 256 into posx2
  put 171 into posy2
  put 0 into increment
  repeat with j = 1 to 3
    repeat with i = 1 to 3
      choose line tool
      if j = 1 then subtract increment from posx2
      if j = 2 then add increment to posx2
      if i = 1 then add increment to posy2
      if i = 2 then subtract increment from posy2
      drag from posx1,posy1 to posx2,posy2
      put posy2 into posy1
      put posx2 into posx1
    end repeat
    add 10 to increment
    put the script of me into cd fld 2
  end repeat
  choose browse tool
end mouseUp
```

Pyramid

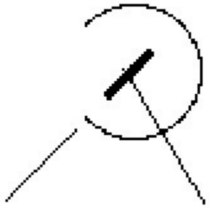
```
on mouseUp
  choose rectangle tool
  set centered to false
  set multiple to true
  set multispace to 6
  set dragspeed to 150
  drag from 256,171 to 356,271
  choose browse tool
end mouseUp
```

These designs, while perhaps pleasing, are also fairly empty of

ATTEMPTS TO REPRESENT POLITICAL CONCEPTS ALGORITHMICALLY

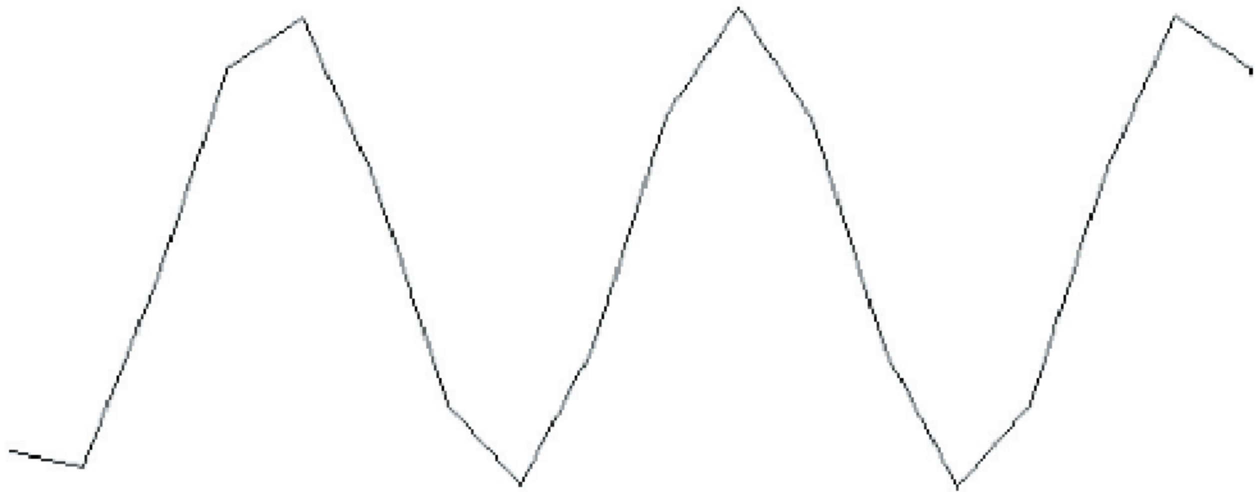
intentional political content.

THE ALGORITHMIC HAMMER



```
on mouseup
  reset paint
  if the visible of cd btn “?” then set the visible of cd btn “?” to false
  repeat with x = 0 to 30
    choose pencil tool
    click at x,75-x
  end repeat
  choose browse tool
  click at x-6, 75-(x-6)
  choose oval tool
  drag from the clickloc to  item 1 of the clickloc + 50, item 2 of the clickloc - 50
  choose select tool
  drag from  x,75-x to 0,0
  type “X” with commandkey
  choose line tool
  drag from  item 1 of the clickloc +15,item 2 of the clickloc -20 to item 1 of the clickloc +45, item 2 of the clickloc +30
  choose brush tool
  drag from x+10,65-x to x+25,50-x
  choose browse tool
  put the script of me into cd fld 1
  set the visible of cd btn “diagonal” to true
  set the visible of cd btn “horizontal” to true
  set the visible of cd btn “vertical” to true
  set the visible of cd btn “erase” to true
end mouseup
```

SINUSOID CURVE TO DEMONSTRATE ECONOMIC CYCLICITY

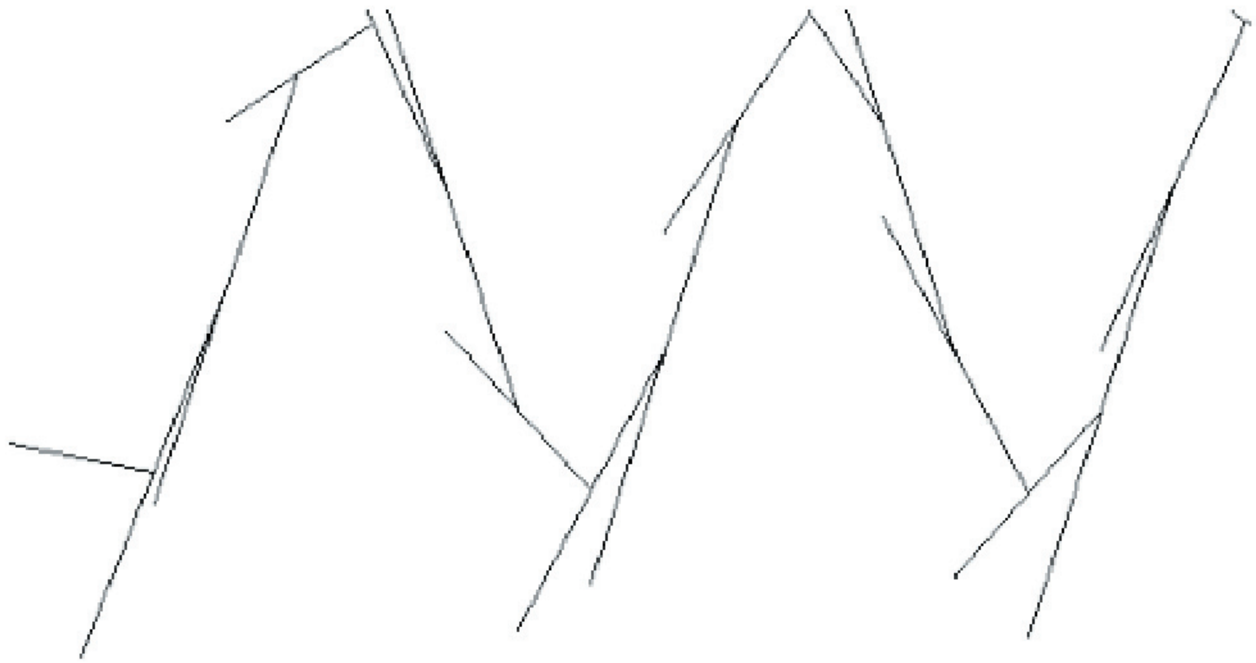


```
on mouseUp
  choose line tool
  repeat with x1 = 1 to 30
    put trunc(sin(x1)*100)+100 into y1
   if y2 is a number and x2 is a number then drag from (x1*30)-
```

```
30,y1 to (x2*30)-30,y2
    put x1 into x2
    put y1 into y2
  end repeat
  choose browse tool
end mouseUp
```

```
    if y2 is a number and x2 is a number then drag from (x1*30)-
30,y1 to (x2*30)-30,y2
    put x1 into x2
    put y1 into y2
  end repeat
  choose browse tool
end mouseUp
```

ARTISTIC VARIATION ON A SINE CURVE

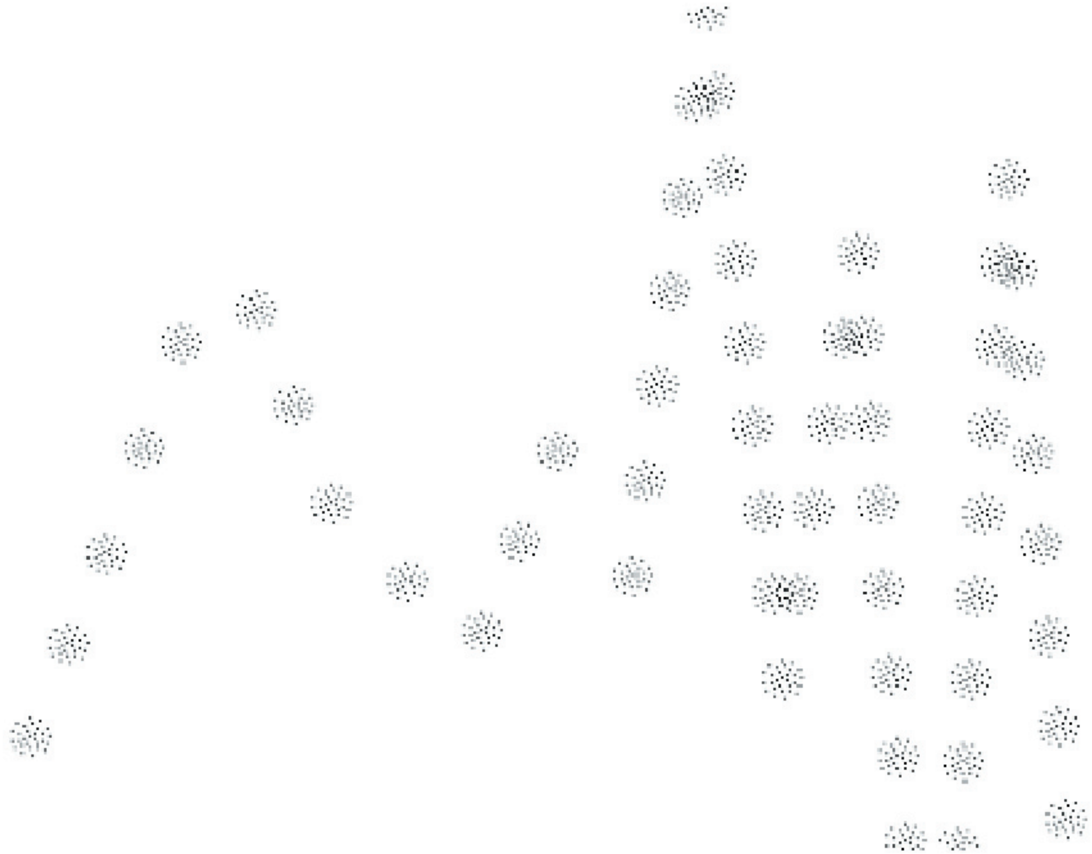


```
on mouseUp
  choose line tool
  repeat with x1 = 1 to 30
    put trunc(sin(x1)*100)+100 into y1
```

AMPLIFYING ECONOMIC OSCILLATIONS TO DEMONSTRATE THE AMPLIFICATION OF CAPITALIST CRISIS OVER TIME (A REFLECTION OF THE FACT THAT EACH WORLD WAR IS MORE DEVASTATING THAN THE LAST)

```
on mouseUp
  choose line tool
  repeat with x1 = 1 to 30
    if amplifier is a number then put trunc(sin(x1)*100)+200+a
mplifier into y1
    if y2>y1 then put x1*x1 into amplifier
    if y2<y1 then put -(x1*x1) into amplifier
   if y2 is a number and x2 is a number then drag from (x1*30)-
30,y1 to (x2*30-30),y2
    put x1 into x2
    put y1 into y2
  end repeat
end mouseUp
```

AN ARTISTIC VARIATION ON THE AMPLIFYING OSCILLATION CURVE



```
on mouseUp
  choose spray tool
  if random(2) = 1 then set the dragspeed to 2000
  repeat with x1 = 1 to 30
    if amplifier is a number then put trunc(sin(x1)*100)+200+a
mplifier into y1
    if y2>y1 then put x1*x1 into amplifier
    if y2<y1 then put -(x1*x1) into amplifier
    if y2 is a number and x2 is a number then drag from (x1*30)-
30,y1 to (x2*30-30),y2
    put x1 into x2
    put y1 into y2
  end repeat
end mouseUp
```

The Y axis in the previous graphs represents the economic performance of the global economy. The Y axis represents time.

These attempts at representing economic functions algorithmically have only limited political signification. The first examples contain no political message (arrow, rune, concentric squares, pyramid). The last examples (algorithmic hammer, variations on sinusoidal curves) could, with text, present the idea of economic cyclicity and increasing crises over time.

One could say that the tools used are simplistic, that the algorithms are straw men or that it is a poor workman who blames their tools. However I am not trying to make a straw man. If I could have expressed political ideas powerfully and aesthetically using computer generated art I would have. Perhaps someone else could use algorithmic art to represent political concepts and someone else could. However, I know of no examples of computer generated political art. Further, the animation tools that were used were also complex. I present these examples to illustrate the limitations on computer generated art as tools of political expression.

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Frieder Nake, Conversation, April 18 2005. (Nake, 2005)

chapter 6

When the University of Bremen started its operation, in the fall of 1971, its educational principles constituted a minor revolution in West-Germany. As is the case with many revolutions, it was energetically supported and pushed forward by a small group of enthusiasts, it was liked by many admirers, and it was hated by a silent minority.

Postscript

Frieder Nake

Postscript

The end is where we start from. Next time

Frieder Nake

When the University of Bremen started its operation, in the fall of 1971, its educational principles constituted a minor revolution in West-Germany. As is the case with many revolutions, it was energetically supported and pushed forward by a small group of enthusiasts, it was liked by many admirers, and it was hated by a silent minority. Its simple idea was taken from the experience of some of the best pedagogues throughout: from those who cared for children and students, and their mental and physical health. For those educators, only the person is important, never the principle.

The problem at hand, not the discipline in the air was to be the focus of education at the early University of Bremen. Students and teachers should come together, in small or middle-sized groups, and use these as their means of working intensively to produce solutions to questions that they felt were worthwile, or even necessary, to answer. Science as such was not interesting, but problems of societal relevance and social need were. If a scientific discipline was important then that would show during the course of dealing with some real problem of relevance. Otherwise, why should one bother? People and their needs, in particular the exploited and oppressed masses in the country and worldwide, were in the focus of students‘ and teachers' activities. That was still the times of great change and ideological battle, times of the Great Cultural Revolution in China, not of the world wide web.

Current times, thirty years later, are times of great changes, too. The world order, dominated so long by European ideology and Western imperialism, and by their fight against a form of state capitalism that called itself "really existing socialism" – that world order is in a frightening process of change. The fluidity and volatility of finance capital, whose chase around the world was theoretically described by Karl Marx, has now become a practical reality. Huge international masses of capital operate nakedly in the most disgusting way but with the moral right of their inherent rule: we have just tripled our profit, managers stand up to announce, therefore we must fire 6000 of you in order to squeeze more profit out of the remaining few. The rest of the world, the majority really, is standing by, admiring the brutal attitude, and getting ready for their unenlightened fundamentalism to fight the rational mind.

This is the time of media! And money, one of the earliest media, is the leading digital medium to accelerate all economic processes. Other digital media can be used as beautiful weapons for ideological offensives against the masses worldwide.

More than thirty years after the start of the University of Bremen, the idea and study form of the project is still an important and distinguishing feature in computing science. Meanwhile, we had to reduce a project's duration from luxurious four to only two semesters. New such programmes have been established leading to the Anglo-American degrees of Bachelor and Master. The traditional and well-established German Diplom is on the down grade.

Some such programmes are offered internationally in an attempt, it seems, to get ready for a new time of tertiary education but without a deeper understanding of what such a change might mean if implemented on a level of principle instead of a fashionable trick.

This report is the result of one such new type of project offered towards the degree of a Master of Science (!) in Digital Media. It was my first project in this programme. A much more difficult task than I had thought it would be, and a lot more work to think about and carry out than in the easy old days. Difficulties you must deal with are the very different backgrounds of students, the language issue, the broad spectrum of expectations, cultural tensions, pragmatism instead of idealism, limited endurance, growing competition instead of solidarity, and more such tensions. The general tendency is away from an assumed, or real, homogeneity to inhomogeneous conditions. They do not, by themselves, constitute reasons for difficulty. Quite to the contrary – they could be used to propel such a project in an unprecedented way. I was, however, not prepared for all the extra aspects.

More than ten years ago, Bo Dahlbom and Lars Mathiassen published an introductory book to general aspects of software. They very deliberately gave it the title *Computers in Context. The philosophy and practice of systems design* (NCC Blackwell 1993). The book is on dialectics. But on dialectics as practice. and our new old projects.I love it. I realized too late that it could make good reading for groups as diverse as those in our new programmes of study, and our new old projects.

I had suggested as a topic the exploration of facets of the contradiction between computability and aesthetics – a wonderful topic, I think, and an important one when it comes to digital media studies. But I was too slow to recognize the peculiar problems and, therefore, chances that showed up because of the international and disciplinary diversity of the group. So the project developed into one of missed chances. To say so, may sound bitter, and it is. I mean it foremost as a critique of my own contribution.

When we started into the adventure of this project, the dozen of students constituted a remarkable distribution of backgrounds. Four came from Pakistan, four from Germany, two from the US, and one each from China and India. Great cultures and nations! Terrifying histories. Great characters, the individuals. An even split into six from the imperialist countries, six also from Asia. Five were women, seven men. Four Moslems, six (most likely not practicing) from Christian or Jewish backgrounds, two from other Asian religious or atheist backgrounds. Several, the majority I guess, should be considered to belong to the political left. The majority had computer science degrees, but there was also a strong interest in design issues. A background in media theory seemed to be virtually non-existent. Programming skills appeared to be well developed, or even professionally applied, by a third up to half of the group.

The project started with the attempt to develop a feeling for the contradiction of art and algorithm, and it returned to this matter for several times. But we did not succede in deeply involving ourselves in digging into one or two specific questions of art history and explore them from the algorithmic point of view. I am convinced that if a mixed group of six did this for, say, three weeks with the task of then producing an extended demonstration, a big step forward could be achieved in seeing the dialectics, the power of difference. If, at the same time, the other six would do the same for issues of an algorithmic nature to be presented from an aesthetic point of view, the ground would be prepared for a long debate of dialectics in general and a number of essays on the particular dialectics of our project.

Similarly simple schemas of organizing a group could be, and were actually, tried. But although participants often did remarkable jobs, we did not get over certain hurdles such that I would have felt: now, that is it, they are now moving forward.

Perhaps, my expectations ran too high as what concerns students‘ motivation and independence when they are working towards a Master’s degree. And even if my expectations were not too high, they were, perhaps, off the track. It looked at times as if parts of this group were reluctant to leave their respective acquired skills in search for new ones. Why should they?

The dozen of students made up for a wonderful collection of characters. Now that the activity is coming to its end, I gradually discover the lost opportunities but I also see how those individuals with their cultural contexts have enriched my experience. I only hope that each one of them gained something, too, from this endeavor in a very untypical learning situation in Germany, a part of the old Europe that would rather want to belong to the new.

As I sit at my home desk, thinking of how to finish and tell those students how I feel, I see them in front of me, one after the other, in some random sequence. They pop up in groups, in situations, with their contributions, their looks, their smiles, their voices, those terribly hard dialects of English. The language, what an experience for an adherent of language to be confined to a language that he does not really master!

As I sit I am thinking
- of a very fine intellectual from the US who, I felt, had much in common with my own convictions, and unfortunately had to leave the project before its end, thus depriving us of the chance to be mediated through his help,
- of one of the last followers of the Cultural Revolution, a very soft and extremely helpful character who was marvellous to accuse of all sorts of dogmatism that he himself would never accept,
- of an extremely calm woman who told us that in her culture women were brought up to speak in a very low voice when men were present, and how much I would have loved to see her change that habit, and stop hiding behind her laptop computer,
- of a female designer who may have had a hard time in our group because the group did not react overly positive to her designs which she worked out with a lot of energy; we should have challenged her more to better profit from her expertise,
- of a software teacher, a very proud and friendly person who must have felt lost in what we did; he offered his services but did not wait until the project as a whole was ready to accept that,
- of a friendly and funny small guy who was interested in formalisms and programs, and even a bit beyond that, and who did not allow doubt to enter his thinking, a great rationalizer of his daily affairs,
- of an enthusiastic creative young woman who produced one idea after the other, tried to bridge national separations but finally had to give in and was, in all her creativity, the one who often raised issues that everybody had been feeling but nobody cared to address,
- of a skeptical and ironic German who almost always was too brief in explaining what he had on his mind, but that he should not have hidden but rather brought to the forefront from behind his Macintosh,
- of another young user of a Macintosh – it was wonderful to have some of this species in the group –, who knew programming quite well, was open to even ask questions about mathematics if he didn't know it himself, but willing to enter new areas even if they were as obscure as Kurt Schwitters' Merz area of artistic nonsense
- of the, perhaps, only mathematician in our group who tried to push the group forward to decisions when it seemed as if we were losing ground; she began to think about the topic of her M.Sc. thesis during the time of the project, and actually wrote first outlines, but did not allow this interest of hers to interfer with project work,
- of the almost tragic friendly man from India who, as an engineer, for the first time in his life had to read about art, found some interest in Mondrian's work, thought about a great project on that, fell ill and had to leave Germany for a while to regain his spirits; he discovered that Mondrian was not doing him good, and found a new group that, as a triad of very different characters did most remarkable things and kept moving forward,
- of the young woman finally from the huge country and culture in the far East from where we once believed a whole new epoch would start; she was, perhaps, the one who worked hardest, tried the largest number of different things, was active outside of the project, always contributed to our discussion, and even though she also belonged to the large group who where always playing with their laptops, hardly ever appeared as if she was

doing something without connection to our work.

What a marvellous group – the Red Guardist from the US and the Chinese girl full of expectation of what her country will soon become in the world. In between a bunch of faithful Moslems and enlightened former Christians: in a way that meant that our Indian friend hat to lead us in the end. Everything I was thinking and writing was, of course, partial and unjust to all the others, and none of the characterizations is unique to any of the individuals, and in fact, they all only together make up those features.

How many of them will continue towards their Master's theses? A curious question for a teacher. And how many of them will, in five years from now, think back in joy to our Friday meetings? In the end, the teacher, under the current educational system, must attach numbers called grades to students even if he knows that doing this is destroying a lot of educational efforts. The ten or twelve have become friends for me. But there was also my good friend, Susi, who shared with me the responsibility of supervision, and who acted much in the background.