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ABSTRACT

This document provides an introduction to the relationship between the current knowledge of focused and creative thinking and artificial intelligence. A model for stages of focused and creative thinking gives: problem encounter/setting, preparation, concentration/incubation, clarification/generation and evaluation/judgment. While a computer can easily generate a list of problems, it must be programmed to decide which problems are important. Preparation, which may be study and practice or the loading of a computer memory, concentration (focused attention), and incubation (unfocused or diverted attention) are essential stages for humans but unnecessary for computers. The remaining stages of creative thinking require decisions, opinions and relevance, which often rely on deviations in logic or sequence, divergent relationships, or emotional reactions--all processes of which a computer is incapable. Suggestions are given for activities and projects that help students understand the "thinking" process by using computers as an analogy and art making machine. Examples are drawn from several popular, pre-technological, technological, and visual art works. An 8-item reference list is provided. (MM)

Thinking, Creativity, and Artificial Intelligence.

by Michael Desiano and Salvatore DeSiano

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THINKING, CREATIVITY AND ARTIFICIAL INTELLIGENCE

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OVERVIEW

This presentation provides an introduction to the relationship between current knowledge of focused and creative thinking and artificial intelligence. The examples are drawn from several popular, pre-technological, technological and visual arts works.

The computer was developed to make mathematical calculations easier, faster and others feasible. There is also research in making computers that can go beyond mathematics into more complicated thinking operations. These include analysis, reason, problem solving and creativity (Vamos, 1993; Reeke, 1988). These areas are concerns of artificial intelligence.

We begin with a model for stages of focused and creative thinking: problem encounter/setting, preparation, concentration/incubation, clarification/generation and evaluation/judgement. Preparation is study and practice or the loading of a computer memory. Concentration is focused attention while incubation is unfocused or diverted attention. These are essential for humans but unnecessary for computers. The remaining stages, problem encounter/setting, evaluation/judgement and clarification/generation are areas requiring decisions, opinions and relevance.

Computers are limited in working with decisions, opinions and relevance in thinking because programmers, as well as psychologists and creative people, only have rudimentary understanding of applicable rules and criteria (Vamos, 1993). For example, a computer can search for a solution if given a precise problem but if the problem is imprecise programming becomes almost impossible. A computer can easily generate a list of problems, but it must also be programmed to decide which problems are important. The highly creative thinker makes an original problem, plan or goal. AI can solve precisely presented problems but it is almost impossible for AI to create significant problems.

The evaluation/judgement stage of the creative process, because of its very nature, requires working with decisions, opinions and relevance. The rules and criteria for evaluation of focused and creative thinking are clearer in the sciences. The evaluation is most often based upon observable and verifiable information. The researchers can check to see if they obtained the correct answer or high correlation. In contrast, the artist considers emotional satisfaction, this is meaningless for computers. More objectively for the artist, there are questions of expressive, formal, thematic and technical intention versus outcome. These are so difficult to verbalize and explain, let alone put into rules for programming.

The essence of focused and creative thinking is the stage of clarification and generation. The first searches for the specific and convergent and the second explores the non specific and divergent.

The clarification and generation stage requires the production of solutions and original ideas. The computer is quite good at solutions to specific problems because it will search out every possibility until it obtains the specific answer. The computer follows a programmed linear and sequential path or circuit, without deviation.

Computer programs can easily work towards originality by generating random words, images, and sounds (Gibbs, 1993). To improve the "aesthetic" of this random output the artist/programmer can provide some rules for the computer. Harold Cohen, working with computer scientists, designed a machine to make pen and ink drawings. He latter refined the program by adding rules that observed the papers border and the overlapping of lines (Campbell, 1983). Cohen is now working on rules for the use of color. A computer can be programmed with rules for generating words and images with very original results (Gibbs, 1993).

There are several art activities and projects for the art classroom to help in understanding thinking using computers as an analogy and art making machines. In groups of about five students have them decide how they can form a production line or act as a mechanical device. An art making device can be made using pendulums, objects rolling down a plane or on a surface, wind, water and wind-up motor toys. Most sophisticated is a remote control toy or one operated from a computer. Lead a class discussion about the difference between art made by man and computer. Have the children make one simple project, first as an artist and then a computer.

INTRODUCTION

Early efforts to make devices and machines centered on movement and latter, reproduction of animal and human like behavior.
An early work to duplicate movement was a mechanical rooster. It can do only one activity, such as a cuckoo clock that sings and pirouettes. It does not respond to any outside stimulus or change

its behavior with time. Other early works are mannequins that have been made to sign names. These were also integrated with sophisticated signature machines that can do up to forty three characters. They have rather complex mechanism similar to that of a music box or player piano. They can combine and repeat a great number of different strokes into a signature. But only those stroke combinations or signatures it is explicitly designed to make. Again there is no automatic response or feedback to external conditions. The only response is the routine established by the maker.

A kind of automatic painting machine was made by Tinguely. Here the brush is attached to an arm that moves when wind currents put pressure on the fan blade like sections at the other end. The results are very much dictated by chance. Some variables are explicitly controlled by decisions made by the artist before "painting" begins. The color, brush size, and the radial movement of the arm are determined at the outset. So there is considerable limitations on the outcome but large variation. Again, results are obtained by chance and not logical decision process. Modern artists, such as Arp and Duchamp, were very interested in works that are determined by chance and seemingly out of the artist's control. However this lack of control was still subject to the initial conditions established. For example media and form of energy, such as gravity. In contrast AI artists want machines that can make open-ended as well as controlled intelligent decisions. Although their is wide latitude in the possible decisions of the "controlled" situation because not every possibility can be envisioned. It is very clear that artists have still have interest in machines that can make art.

I. BACKGROUND TO COMPUTERS & ROBOTICS

You would like to have machines that have more decision making control over the art they produce. How can you build a system that actually has control? We could model it after a system that does have control such as yourself. What components do you use? You have your brain that thinks, sitting inside of your head. You can compare that to a computer, it does the processing. Basically you need a brain or computer, and thinking rules for designing a the computer program. This is the study of artificial intelligence. Finally, you need something that can produce some kind of output. So you connect this brain and mind to a robot.

A brief summary of what has taken place in this field is helpful. In 2000 B.C., the Chinese used an abacus. It was fairly simple, counting in base 10 (meaning ten digits, 0-9). As a historical note, however, the abacus must actually be Babylonian because the Chinese did not have base 10 for some time. Little further development took place for several thousand years.

In the seventeenth century, mechanical calculators were invented by Blaise, Pascal and Liebnitz. Pascal's could add and subtract, while Liebnitz' could also multiply numbers. They were really slow, and often broke down. These early calculators were mainly designed as gifts to royalty, but they were the first step towards a computer type device that could do things that humans are normally required to do.

The other real precursor to the computer was invented by Josef Elias Jacquard, the Jacquard Loom. This was a loom that created weaving based upon a series of punch cards. If you put the same punch cards in again and again, each time you would get exactly the same pattern of weave. This gave control over very intricate designs. While this loom did not solve any problems, it is a perfect example of a stored program. Which is what we have today on computer disks.

We now come to the first actual computer, invented by Charles Babbage in the late 19th century. Called the analytical engine, it's major characteristic lies in that it was entirely mechanical. It was huge, about five feet tall, it broke constantly, and what is worse, Babbage was very temperamental person. Every time he got a new idea he would tear the old machine down and start over again. He ended with seven versions, but none worked to his satisfaction. He had, however, laid the framework for modern computers.

The first real computer was to be used in 1890. In 1880 the United States Census was taken, as it was every ten years, by law. Unfortunately, counting the census results began to take more than ten years. Hermann Hollerith invented a machine that would count punch cards for the census that included race, sex, and age only. With this method he managed to finish in a year and a half. They estimated that it would have taken fifteen years. This was the first practical application of the computer. This punch card approach continued, as did the development of increasing powerful computers. In 1946, the ENIAC was invented, a large room seized computer, eighty feet long, eight feet high, and six feet deep. It ran with seventeen thousand vacuum switches; electrical switches like those found in the radios of that period. The total capacity was one hundred and seventy four thousand watts. Unfortunately, this computer broke down frequently, once a day, thirty times each month. Every time it broke down, the calculations had to be started over again. For this machine, long calculations took three days. ENIAC was built for the war effort in World War II to greatly improve accuracy when bombing the Japanese. It was finished three months after the Japanese surrender.

The last most recent major computer innovation was forty years ago, and was to combine the work of the punched cards of the Jacquard Loom and the computing of the Analytical Engine. This in programs for early computers on punch cards which are read by prongs inserted in the punched holes. The punched card reading provides an electronic output that signals the computer. Modern computers are faster, smaller, more reliable and accurate, but they are essentially more refined versions of the models developed forty years ago. Today's computers are run by programs stored on a disk rather than a punched card.

The computer creates a frame work that artificial intelligence can work with in order to develop programs that respond according to a set of rules. With this as our base, we now want to develop a program that emulates thinking. This is very difficult, because computers can only work with explicit rules. You can tell a computer to run a very logical sequence of rules, and it will complete the assignment. However, without explicit rules, the computer cannot proceed.

You could say "think about this wall" or "think about this painting". The computer will ignore you unless the commands can made explicit by breaking down the process of thinking into logical parts. This hinges on the fact that computers are inherently totally logical. This leads to the problem of turning thinking into logical rules.

People who study thinking and the rules of thinking are in many fields like psychology but most important to us is artificial intelligence . This area of computer science begin in 1946 when Marvin Minsky (1985) invented the field. He began by trying to build a chess computer, one that could play chess against people. This was the closest they could come to what we would consider thinking. In fact, it was simply trying all possible moves, and choosing the best one. Most people, however, would call this "brute-force" methodology a low-level process not at all like sophisticated thinking.

Art, as you might expect, is far more complex than chess. It is the epitome of abstract thought, choices, and decision making. Organizing it into a rule based system offered challenges far beyond the resources that were available at that time. Today, however, there are artists, such as Harold Cohen, who have produced art from computer programs.
Despite the current level of development in thinking and creativity and artificial intelligence we need some method for producing physical output . So we turn to robotics. Many people think of robotics as a new field, it has really been around for several thousand years (Minsky, 1985).

Homer, in the Iliad, talks about Hephaestus who had golden maid servants. They performed tasks and the "look like young girls who could speak and walk and were filled with intelligence and wisdom." Of course they did not actually exist, but it shows that the idea of robots existed as far back as the ancient Greeks. From then on, people have tried to build machines to do tasks typically performed by humans. The Chinese built steam based machines for religious purposes. They had an entirely mechanized Buddha with servants that spun around him. It is also believed that in 890 A.D., the Chinese built a wooden cat that could catch mice. We don't know if this actually happened, but historical records insist that it did.

At this point in history, we have robots that are capable of performing tasks, but we have no ability to control the robot. This, again, is where artificial intelligence comes in. If you link the robot to a computer, you can theoretically get the robot to produce output that responds to its surroundings. If you had a robot that started moving in the middle of the room and simply walked, it could make no decisions about how to proceed and would walk directly into a wall.

Robotics uses a method called "feedback" to allow the robot to respond to its surroundings. Information from the environment is fed back to the robot, which then changes its behavior toward the desired goal. This methodology came of age with the birth of computers because the feedback provides fast paced information that is often very complex, requiring considerable decoding and interpretation. One of the most extreme cases of decoding and interpretation is with the visual images received by underwater robots. Even though the water provides dark and distorted images, the computer can still respond to this information using feedback techniques and steer the submerged robot accurately.

With the addition of robotics we are equipped with the three necessary components to think and act: computers, artificial intelligence programs, and robotics (Minsky, 1985). The remaining task is to put them all together. In producing computer art, you are often restricted to very rudimentary mechanical devices. All you can handle is a pen or marker. At this point, no robot can handle the subtleties of shading. Even using a paintbrush to achieve a fluid brush stroke is too complex for current technology. For this reason and others people generally consider computer art to be of questionable value and not really worthy of appreciation. In evaluating a robot's creativity, however, this should not come into play. You have to get past the lack of dexterity and technical skill, and look for the creativity and innovation. The overall conception and composition of individual shapes and parts of the art work is more important than technical mastery.

Although the problem of creativity with computers is almost intractable, eventually theories will be developed that allow computers to act in a creative fashion. Society has such a desire for human-like robots (Minsky, 1985) that all of this energy will eventually drive us to the development of successfully creative robots. All throughout literature and history you can find the desire for human-like robots. Those that can make and serve breakfast. Even those people who argue that robots aren't like humans, could never be like humans, would like them to be more like us. Eventually we should reach a point where robots are human enough to be creative (Minsky, 1985). To even begin, however, we need a model of creative thinking that can be used by the robot's programmers.

II. MODEL OF THINKING AND CREATIVITY

Wallas (1926) developed a model for the stages of problem solving that consists of preparation, incubation, illumination and verification. For discussing the application of this model to thinking, creativity and artificial intelligence some modifications are necessary.

The Wallas problem solving model does not include problem encounter and setting. This is also a major distinction between problem solving and creativity. Problem solving is related to creativity but differs markedly with regard to inception. In problem solving the problem explored can be given, as in psychological testing, or known to exist in a field, like the importance of the oz layer. The creative endeavor is marked by a very indefinite beginning that is most often established by the individual. Some examples are Calder's mobiles and Rauschenberg's flag paintings. With AI and computers the process is seen to be more like problem solving because the problem is provided by the human operator.

A. PROBLEM ENCOUNTER / SETTING

This initial stage precedes preparation and deals with encountering and taking on problems in s field or discovering a novel problem or direction to be explored. This initial stage for art is very particular. Many of us know that art students are given problems to be solved or worked out by their instructors. This makes art students very different from profession artists who set their own problems. This is a very significant difference between professional artists students and Sunday painters. In the history of art there have been some problems to encounter. During the Renaissance a preeminent problem in trying to gain a better understanding of the world was the representation of reality and realistic space. Many artists approached this problem as scientists, with grids, mathematical proportions and mechanical devices. In contrast, twentieth century art problems are less concrete and most often come from the culture or art itself. These art problems must be discovered by the artist through sensitivity to contemporary culture and art.

B. PREPARATION

The first stage of the Wallas (1926) model is a period of preparation. goes to school, takes in lectures, works in a studio and studies. It is a very intense intellectual situation that requires a lot of time and hard work. It is believed that it takes an artist ten years before reaching a point where they are make a significant breakthrough in their creative output. This works out to be approximately ten thousand hours. (Ten years x 5 days X 50 weeks x 4 hours). Many people do not realize the extent of preparation d by those who succeed in making breakthroughs. This is particularly true in the visual and performing arts because the stereo type of these is that they do not work very hard.

C. INCUBATION / CONCENTRATION
To the incubation stage in the Wallas (1926) model can be added a distinction between concentration and incubation. In focused thinking you must concentrate by focusing your energies in place. Concentration is applied, directed toward the solution of a problem or part therein. In creativity it is quite different because it is the inattentive or wandering mind that comes up with novel ideas or problem setting.

Incubation is a turning away from the problem. We divert our attention from the creative endeavor. We must not think about our work, putting it outside current activities. Putting it on the back-burner, subconscious, unconscious. If you concentrate, put pressure on yourself, and constantly think about a solution, the answer usually doe not happen.

D. ILLUMINATION: CLARIFICATION / GENERATION
Illumination is the stage when the answer comes to the thinker. The distinction here is that with a focused thinking problem you are trying to make it clear, complete the train of thought or understand. You are looking to clarify what is already present. But with creativity, where you want to come up with something new, that does not rely on existing things, you must generate a novel possibility.

E. VERIFICATION: EVALUATION / JUDGEMENT
Wallas (1926) applied his model primarily to science and needed a means for deciding the value or correctness of a solution. In science, quantifying, putting a numerical value on something, enables very fine distinctions to be made. At the very least quantification permits being able to state an outcome is significantly different. With art the merits of the outcome are not quantitative and requires more open ended thinking operations for making judgements. This is much more subtle and instead of being quantitative is qualitative, in that you must reason s way through it without the use of numbers and their available operations. In scientific evaluation rules can be established to weigh or compare outcomes. However with judgement the process leading to the conclusion appears complex. Their are education programs that work toward improving judgement, particularly in considering tracts of information or propaganda. In literature where the medium is words of rather specific meaning judgement is still frequently difficult and open to interpretation. In visual and performing arts where the medium is far less intellectually organized than with the use of words, judgements are difficult to explain and justify. In the creative arts, rules for judgement

are few, if any, and to teach better judgement we most often resort to examples and practice.

III. FOCUSED THINKING & CREATIVITY OPERATIONS

The knowledge of operations for thinking are essential to understanding and emulating thinking with the use of computers. These thinking operations are a central concern of cognitive psychologists. This is a very different position than the behavioral psychologists who believed thinking operations could not be observed and were beyond the scope of understanding. The behaviorists concentrated on observable behavior and considered the mind to be a black box that could only observe what goes in and comes out. They hypothesized the mechanism in the brain to be association, driven by a kind of Pavlovian stimulus response mechanism. In contrast, the cognitive psychologists theorized a number of possible thinking operations taking place in the brain. mechanism could be a simple stimulus-response similar to that proposed by the behaviorists. A more complex mechanism utilized information filters in conjunction with memory storage that permitted manipulation of information in the memory space. The cognitive operations are discussed below.

A. ANALYSIS

To divide the stimulus or problem into its components so that they can be inspected separately or put together in various ways to better understand the whole. Visual analysis is used extensively in art. Students draw portions of objects and scenes and diagram and separate out or concentrate on parts.

B. LOGIC

Formal logic is derived by rules and can be used by computers to make conclusions. For example, if All men are mortals and Joe is a man ten Joe is mortal. However, formal logic is something we don't use in art. Logic can be withdrawn as a useful operation for work in computers and art because we do not generally formulate our art styles in this manner.

C. REASONING

In general reasoning means a methodical, systematic or algorhythmic approach to obtaining a conclusion. As is in means ends approach. Let's make a distinction between different kinds of reasoning based upon the medium used in the approach. Some speak of visual thinking that is a form of reasoning. Although it may not be highly regarded in some circles we know how important visual reasoning is to art making and our thinking in general. Lets also distinguish between the kind of reasoning we would use in trying to solve a mystery story. You read the story and try to figure out who had a motive and there whereabouts. Contrast this with reasoning how to achieve symmetry in manipulating a collage. It requires that we manipulated shapes and consider center or folding line that are not tangible. So we have reasoning in art, but it is just very different than with verbal media. Here is an example where verbal and visual reasoning may be closer together. If A is greater than B and B is greater than C. What can you say about the size relationship of A & C ? Obviously, A is greater than C. The reasoning involved in this problem can be approached both verbally and visually, but it an extremely elementary activity for art.

Computers can manipulate images into balance and other kinds of visual concepts if their are rules available. They can also, with the aid of visual perception inputs, like a video camera, match items to stored images and patterns. So reasoning has potential for use with AI and art.

D. PROBLEM SOLVING

In general, problem solving subsumes the other thinking operations. The goal is to obtain a solution to a complex issue by using other thinking operations such as analysis. How do we arrive at a solution to a problem? Either a systematic approach, as in the scientific method, or a culling and reorganization, trial and error approach can lead to a conclusion. Problem solving in art is valuable because once the problem is established we can systematically or pragmatically approach a solution. As with Sol Lewitt who can produce hundreds of variations on a simple geometric configuration before choosing the image to be executed. These approaches are not popular but they do reflect on the thinking style of the artist. Problem solving for art and AI is valuable because it bridges the systematic and intuitive approaches.

E. ASSOCIATION

What produces the bringing together of the new idea or image? We can think of it as association which is relating thing to another. In free association clears their mind of specific thoughts and allows ideas to come from many disparate areas of information or imagery. A very divergent group of responses can result.

Association can result in convergent responses if you are asked a question that is satisfied by specific answers or any of a several possible answers in divergent thinking. How many fingers do you have? is convergent; while who discovered America is less specific and divergent. Many associations are habitual and can be triggered by frequent stimuli. If you are asked to buy a container of milk you may immediately think of or reach for your my.

This kind of internal stimulation of associations can also be spontaneously produced by external stimulus. A color, shape or sound can suddenly produce a memory image. This can happen during attentive moments but is more likely during periods of low concentration or distraction.

What of the connection between association and incubation. The incubation period leading to creativity is fostered by lack of concentration on the issues and a state of reverie. This mental state enhances free association and can be prompted by incidental internal stimulation or external stimulus encountered by chance. For some artists, like Chagall, reminisces, trips to familiar old places or life among memorabilia stimulate a cascade of creative associations.

Again in making a distinction between focused and creative thinking the former is convergent, a more attentive approach and often with a known answer. While creativity is divergent, and nonspecific with little or no direct attention. Therefore association can be related to both focused and creative thinking.

F. SYNTHESIS

Synthesis is very important to the creativity of those who produce both words and images because it can explain bringing together things not together before. The difference between synthesis and association lies in both the initiation and control of the content. Association is the generator of initial content and raw material. It works most creatively when out of attention. Synthesis combines material, content or subject through concentration and effort. The content can be in any medium, visual, auditory or other senses. Artists can combine images in various media, taking parts from each or in their entirety.

This is often misunderstood because many people are not frequent or strong imagers. On the part of the low visual imagers this approach to thinking is rather secondary or inconsequential. For the strong visualizer it is an essential tool for thinking. And for the artist visualizing is all part of thinking, drawing and constructing. These images can be manipulated and synthesized to bring together new images and ideas in s imagination or on paper. An example would be to behold the surface of a Pollack painting and the precise shapes of Calder and synthesize them into a new image. This is of the visual artists way of creating.

G. EVALUATION & JUDGEMENT

Unfortunately for clarity some terms are used both to describe stages and operations. The use of evaluation and judgement as operations is discussed here. Evaluation and judgement are those things that enable you to come to some kind of decision. How does this occur? You need to have some basis for it. Some may ask, how do you like this? and you respond I don't like it! Then you are asked, why? Can you provide answers, make and informed judgement.

These are the thinking operations we use inside of our head. It is very difficult to explain them. We have seen that ways to facilitate evaluation and judgement is with quantification and qualification. In both cases the resulting approach is a comparison. When comparison requires quantification, the rules of mathematics and statistics are essential. However when comparisons involve qualities the rules are far less specific and in art frequently little understood. We can use the elements and principles of design to make qualitative comparisons. But thematic, symbolic and contextual qualities are not presented as hierarchical rules or even rules. Now imagine how difficult it is to translate the knowledge of these operations into written statements for use by computer programmers.

IV. ARTIFICIAL INTELLIGENCE - THINKING & CREATIVITY

The primary way that programmers have begun to look at the task of emulating cognitive operations is to break the operations down into smaller, more specific and manageable parts. If you take the task and make it simpler, the rules are less complex as well. Computers are very good at making calculations and following logical rules.

For example, imagine a program confronted with the problem of writing Haiku poetry. For starters, it would need a vocabulary and the form of a Haiku. The program might ask to choose sets of words from different lists, use one for each line, and arrange them so that it begins with a verb and ends with a noun. Is this thinking? Is it creative? The problem becomes of boiling down the very abstract idea of a Haiku into a set of specific rules. In the same way, we will consider breaking down each of the operations for human thinking into sets of rules, bringing creativity and thinking into the context of artificial intelligence.

A. ANALYSIS

Computers have a limited ability to do analysis. For instance, a word processor can often analyze your grammar, or spell check your document, another simple form of analysis. Fortunately for programmers, grammar follows some very explicit rules. Shift the focus to art, and it is an entirely different story. A computer can recognize, with a great effort, a limited number of shapes. It can look at a shape and say that is a circle and that is a square. In this way, the computer is capable of analysis. However, if you were to take the analysis further and work on a wide range of possible shapes, including different ovals and rectangles, it is almost impossible to set up a program that can distinguish shapes with great similarity.

In art, where the possible shapes are endless, programming primitives for each and every shape is impossible. It is possible to have complex geometric shapes and many irregular shapes categorized, but having a computer identify which it is looking at is not currently possible. For instance, while the computer could differentiate between a square and a circle, it would have many problems differentiating two people's faces. In fact, a major thrust of current research is to get recognition of more complex shapes and objects. In conclusion, analysis is limited when applied to the complex objects that occur in art.

B. LOGIC
On the up side, formal logic is something that computers are very good at. On the down side, it is not very useful in art, unless designing complex patterns as in textiles.

C. REASONING
The prototypical example of reasoning is the process behind trying to solve a who-d-it mystery. In fact, a computer can do this fairly well if the story is "read" to it in the proper manner. (Currently we lack the ability to simply read to a computer. Even when typing, we must adhere to a certain structure that highlights the salient points of each sentence or section.) Nonetheless, if a computer equipped with the appropriate program was "read" a bedtime story or a who-done-it, it could do a fairly good job of understanding. That is, be able to answer questions about the story.

Given explicit rules, a computer could even perform a task in which it must balance visual symmetry in a picture. Given a three dimensional work space it could distribute the objects so that, even if it is not aesthetic, it is not cluttered or clumped. But this is still far from what we would consider aesthetic reasoning.

The question becomes, then, whether or not we can break down painting and the associated aesthetic reasoning into more explicit rules. Using the few rules that we have for composition, we could say that the objects must stay away from the edges, or avoid piling them in the center. But these mediocre, simplified rules pale in comparison to the ideas that would be applied by a second grader.

D. PROBLEM SOLVING
Problem solving is mostly about an overall strategy for coming to a solution in a given environment. It may involve several of the operations described, like analysis and reasoning. However, problem solving is very specific to the activity or task at hand. If a computer is problem solving a chess game, it could review all possible moves to find the best one or it could select from a repertoire of moves made by masters. There are computers that can compete on the grand master level, the highest world-wide ranking.

Unfortunately, if the task is not so easily defined, or the number of possible "moves" is infinite, such as in art or writing, the outlook is much more grim. Say there is a story that you would like to compare with each of Shakespeare's work in order to decide which work it is most like. What rules would you need to achieve this goal? It would be hard to know where to start. In fact, they have managed to do this with a program that assembles a table describing the characters and their interactions. If given the story line and the properly encoded text, it can pick out Romeo and Juliet as being the story most like the West Side Story. This program, however, took seven years of research and a large team of programmers.

If we wanted to do problem solving involving visual art, we would first have to determine possible dynamics and relationships between the different aspects of an art form, such as painting. This is a far greater task than anything that would need to be done in the field of writing. Art is much less restrained, just by virtue of the existence of a grammatical structure in writing. If we could manage to get a tight structure or specific rules for art down on paper, perhaps then you could consider having a computer do problem solving in the world of art.
One of the ways that psychologists and cognitive scientists go about finding these rules is through introspection of themselves and others. This involves looking into how is producing their art. One can still learn a great deal about the mental processes being investigated.

E. ASSOCIATION
Association in the context of art is a way of explaining the source of new ideas. For example, a elaboration or new work of art can be made from two existing works by combining qualities and elements from with the other. The question arises, then, whether we can always associate the problem we are currently working on to previously encountered. The hope is that we can find a structure that allows us to associate the characteristics of art work with those of another. Again this hinges upon setting a paradigm for describing art work in a rule based manner. And again, this is a very difficult problem.

F. SYNTHESIS
Synthesis is the creation of an art work from things that you already know, not necessarily previous art works. The problem here is again of framework. We need a framework to work in. When Einstein discussed his work towards the theory of relativity, he said that he pictured himself catching up to a beam of light, and thinking about what would happen. This thought process contributed to discovering his revolutionary theory. As a computer does not have imagery, a computer has to work with a propositional description of those images. As you can see if you try to describe imagery in a propositional manner, it becomes an intractable problem to manipulate all of the information available. As it has often been said, a picture is worth a thousand words So synthesis can be accomplished by bringing together words or images from a provided source. But an innovative leap to another realm of words or images is impossible.

G. EVALUATION AND JUDGEMENT
A computer with an artificial intelligence program can do evaluation and judgement if you can give a quantitative way of doing this evaluation. It can tell you which letters or objects are larger, or which of two paintings is brighter. If you could define aesthetics in terms of a set of rules, artificial intelligence could tell you which of two paintings is more aesthetic. For example, if you ruled that brighter is better than dull, larger better than smaller, warm colors better than cool colors, or complex better than simple.

Beyond these rudimentary descriptors this task has never been attempted, much less accomplished. The problem, then, with artificial intelligence is that it can do anything you can program it to, but it cannot establish its own rules or criteria for judgement. This is the same problem that artificial intelligence has with problem formation. A computer could produce a work of art using existing rules, but it could not look at art and answer, or even ask, the questions like "What is art?" or "What is art work lacking?"

V. ARTIFICIAL INTELLIGENCE & ROBOT ART
Jazz improvisation long considered to be highly creative is emulated by a program built by Johnson-Laird (Matthew, 1994). His program manipulated chord sequences or base lines and melodies and fed them into an electronic music synthesizer. The resulting improvisations captured the spirit but were not exciting examples of the art form.

In the visual arts drawing programs or software are used by the computer artist to manipulate images. It is the direction and choice of these manipulations that are left to the computer artist. This is the most creative part of the work. Some artists have designed software that can control the manipulation of the images by programming rules for image transformation or mutations (Gibbs, 1993). These image generating programs can produce some startling results but can always sense they belong to a particular family or species.

A. ROBOTS
There have been several attempts at creative use of robots. The Wabot is a very sophisticated robot that is programmed to play a piano. The greatest level of sophistication is in the manipulation of a standard piano keyboard. The Wabot has two hands with five fingers on each. The computer program and hands are connected by an electronic interface that conducts the information from the program to the hands. Like the player piano the Wabot can not create music or listen to music and learn to play.

B. AARON
Harold Cohen is working on Aaron, a computer based drawing robot, for over twenty years (McCorduck, 1991). The most interesting

robot used consisted of a pen mounted on a wheeled vehicle the size of a blender. Aaron developed through several stages of drawing landscape and figures to complicated compositions that incorporated both. By establishing rules for Aaron to follow drawings of specific types of imagery can be made and never have the same work repeated because of the unspecified actions that can be taken (Matthew, 1994).

Cohen's Aaron is programmed so that it draws on a paper sequentially. When watching it work one might think that it is doing an impressive job of visual balancing. In fact, Harold Cohen only programmed it so it puts objects in the first empty space that it finds. It works, and sometimes the results are aesthetically pleasing, but it is a far cry from anything that a human would do while executing a drawing.

Improving control was very necessary for the next phase of his work, referred to as Phase Three by McCorduck (1991). In this phase Cohen included rules for layering and occlusion, only one object occupying a single space. This allowed for realistic, even possibly artistic effects. In this phase he had several series, including the jungle, acrobats and balls, and the bathers. For each of these he introduced rules for each object. A tree would be defined as something that is taller than it is wide and has small closed elliptical shapes at the top.

These rules included rule sets for people. In his work, people have two arms, two legs, a chest and a head. Even simple definitions like this had to be qualified. He had to include rules of balance, or the figures would appear to be falling over or flying. This all took six years of work. The accomplishment, however, is to have proved that it is possible to have models that computers can follow to produce realistic work.

Occlusion also allowed Aaron to draw backgrounds and scenes with the illusion of three dimensionality. Later on he developed rules that allowed overlapping forms that increased the sense of three dimensionality. Some of these works included rock-like formations that were drawn by the robot, and then hand painted by Cohen.
At point in this stage his figures became somewhat cartoon like, and he felt uncomfortable with the. Although these cute figures are part of the record of Cohen's development, he did not exhibit these works.

At the end of Phase Three, Cohen attains a very realistic three dimensional space in which humans can interact with each other. hand can cover another, and in other cases figures might have interlocked arms. However, the drawings are still flat and do not exhibit the volumes and masses of actual figures.
The final phase, or Phase Four, has both the three dimensional space of early works and the suggestion of volumes and masses for the figures. There are scenes of dances which could be mistaken

for works completed entirely by hand.

After these great accomplishments with mass and space, Cohen has set forth trying to have his artificial intelligence programs and robots use color. This requires establishing rules for the domain. Cohen has found this to be even more difficult than the rules for form because color is structured much more loosely, and governed by abstract aesthetic and emotional guidelines.To some it would appear that the personal involvement of the artist, in this case Harold Cohen, would be lost in such rule ridden endeavors. However, interesting story involves a gallery owner from work who was familiar with Cohen's pre-Aaron work. The gallery owner came to San Francisco on business and saw a computerized drawing on the wall of a friend's gallery. The work looked familiar to him, though he realized that Cohen hadn't worked in several years. After inquiring, he realized that the style was, in fact, Cohen's. This indicates that Cohen was able to program his own personal style into the work.

C. RULES & ART MAKING

An analogy could be made between different forms of music. Some music is passed from musician to another by listening to or playing with another. Classical music relies on the writing of music in a manner that can be understood by all those able to read music. Both the unwritten and written music are art forms, even though the latter has been subjected to very rigorous rules that can be inscribed explicitly. Trying to write rules for computer art right now is much like communicating a musical piece without any musical notation.

As it has been seen, establishing rules can be difficult, but once this is d, a computer can follow them without error. In contrast, getting humans to follow rules with such precision can be very difficult. But, for now, there is nothing to be afraid of. We are much more intelligent than any computer. A computer cannot comprehend working in the visual arts. It cannot even comprehend many things not as subtle as visual art.
However, must remember that this is also a matter of training and specialization. A Sunday painter, who does not go to school or practice tirelessly, does not have these skills. This inexperienced person should not believe that they have as deep an understanding as the seasoned professional. Likewise, computers have years of work ahead of them before they even become amateurs.

VI. EXERCISE

(This exercise was done by the audience.)
This is a rule based exercise. Using a small sheet of paper, about 5 1/2 x 8 1/2 inches. Take the paper and begin to fold it at an angle to the edges making sharp creases so that they fold show up clearly when the paper is opened. Repeat this folding process at various angles twelve times. Flatten out the sheet of

paper so you can draw upon the surface. Draw on the paper in any medium available and follow theses simple rules. Starting at an edge draw on a crease. Go right at the first junction of creased lines. At the next junction go left. Continue drawing in this alternating left and right direction until the paper's edge is reached. When you come to edge select another crease that begins at an edge and repeat the drawing process just described.

After ten minutes most of the audience finished and is asked to hold their work aloft for all to see. There is a great variation in the results. Some are very geometric other linear, and some are tightly gathered and others very open. These are the results of rule driven exercise that a computer could follow. A computer can be programmed to go left and then right, at different intervals of time or distance. It is also possible for a robot consisting of a computer with visual input to follow a line like the creases used in the exercise and move a pen right and then left.

It would be possible to make a program of rules that results in more open or densely placed lines by decreasing or increasing the number of folds respectively. Or the robot could be programmed to randomly follow the lines on the surface regardless of direction.

Which of these drawings made by participants using a rule driven approach is art or artistic? The results of this rule driven exercise are aesthetically pleasing in some cases. A robot following the same creases with a pen would result in the same drawing. However, the robot would not be able to evaluate or make comparisons between drawings unless more rules are provided. Rules for symmetry, overlapping and density of line placement could be programmed as criteria for evaluation. To choose which is the most beautiful or artistic would require providing rules not currently available.

VII. CONCLUSION

Establishing rules can be difficult but once this is d a computer can follow them without error. Computers can not comprehend or work in the visual arts if this means developing or initiating the idea and making evaluation and judgement.

This need for background information in order to understand and create also explains why some people can not understand and appreciate visual art? They do not know the rules or context to use in thinking about works of art. It is also a question of specialization. Many people do not realize how many years of experience artists have in arriving at their knowledge and skills. To make computer art with artificial intelligence requires either development of extensive acceptable or arbitrary rules. If the individual artist makes these rules then they are creating a style of expression where none existed before.

VIII. PROJECTS & EXERCISES

(Briefly discussed as a handout.)
A. Sketch/Describe An Art Making Device
B. Sketch/Describe An Art Making Robot
C. Draw Like A Robot
D. Draw From Rules (by self or others)
E. Repetition Of Templates
F. Classmate dictated drawing
G. Hand-colored Photocopies of A - F (above)

REFERENCES

Campbell, L. The machine that Learned to Draw. Art in America. 71, 205-207.

Gibbs, W. (1993). Creative Evolution. Scientific American, 269, 20-21.

Matthew, R.(1994). Computers at the Dawn of Creativity. New Scientist, 144, 30-34.

Minsky, Marvin. (1985). Robotics. NY: Anchor/Doubleday.

McCorduck, P. (1991) Aaron's Code: Meta Art, Artificial Intelligence and the Work of Harold Cohen. NY: Freeman & Co.

Reeke, G. (1988). Real Brains And Artificial Intelligence. Daedalus, 117, 143-173.

Vamos, T. (1993). Computer and the Thought Process. Act Neurochirurgica [Supp], 56, 96-99.

Wallas, G. (1926). The art of thought. NY: Doubleday.

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