THE COMPUTER AS AN ARTISTIC TOOL—AN ATTEMPT TO PROGRAM AESTHETIC CONCEPTS

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Abstract

This paper very briefly references historical precedents justifying the use of the computer as an artistic tool, major problems involved in such use, and several successful computer applications in the fine arts area. An outline of the author's own efforts to utilize computer resources for artistic purposes is then made.

The research involves the algorithmitization of basic design concepts - initially the idea of "balance". The primitive of the system is "line" which is also a fundamental design element. (Lines may be straight or curved.) Drawings are produced by concatenation and juxtaposition of lines according to the rules of symmetry (or asymmetry) and the achievement of "balance" throughout the entire picture plane. Works produced are then evaluated by "educated eyes" as to their artistic merit in order to further formalize the concept of design being dealt with.

L'ORDINATEUR ET LES ARTS – UNE TENTATIVE DE PROGRAMMATION DE NOTIONS ESTHÉTIQUES

Résumé

Cette communication énonce brièvement les antécédents historiques qui justifient l'utilisation de l'ordinateur comme outil de création artistique, énumère les principaux problèmes que soulève cette méthode et donne plusieurs exemples d'application heureuses de l'ordinateur dans le domaine des beaux-arts. On présente ensuite dans les grandes lignes les travaux de l'auteur visant à utiliser les ressources de l'ordinateur à des fins artistiques.

La recherche consiste à transformer en algorithmes les notions de base, avec au départ l'idée «d'équilibre». La notion première du système est celle de «ligne», qui est aussi un élément de conception fondamental. (Les lignes peuvent être droites ou courbes.) Les dessins sont produits par concaténation et juxtaposition de lignes suivant les règles de la symétrie (ou de l'asymétrie) et par la réalisation de «l'équilibre» dans l'ensemble du plan de l'image. Les oeuvres produites font ensuite l'objet d'une évaluation experte afin d'en déterminer la valeur artistique, de façon à donner une forme plus précise à la méthode utilisée.

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A. Historical Background

Science and technology have always been an integral, although often very subtle, influence in the area of Fine Art. For example, in the area of painting, tempera (wax based) and fresco (plaster based) work on walls generally ceased with the development of oil paints which allowed for the production of a more mobile work and also introduced the idea of 'wet on wet' painting due to the slow drying nature of the paint. The science of oils involves the use of many glazes and varnishes -- the impact of which must be known to the artist in order for him to choose colors because the color and tone of the work are very much affected by the preserving process. More recently many artists have returned to a quick drying process using newer acrylic paints and again the process of applying color to a surface has evolved. In the words of historian Edward Hill:

> 'A painting represents a fragile surface of pigments of various chemical origins suspended in an aqueous, unctous, or synthetic resin binder, adhering to a plane support. With poor science, cracking, yellowing, bleeding, deterioration of ground can seriously alter the painting image and thereby the artistic intention.'[1]

Two important scientific inventions proved catalytic in the spread of aesthetic ideas and therefore in the development of art -- printing and photography. Thus the invention of the printing process in the mid 1400's allowed the first large scale communication among artists and between artists and the public:

> 'Just as the invention of printing hastened the exchange of ideas without which the Reformation might never have come about, so the printing of images ensured the triumph of the art of the Italian Renaissance in the rest of Europe.'[2]

Printmaking itself became an art form, particularly with the development of lithography in the late 1800's and the introduction of poster works (Toulouse Lautrec).

The impact of photography only started to be felt in the 20th century and recently it too has become an art form in its own right. Art historians claim the photograph deprived painters of a need to reproduce and preserve reality and pushed them into further exploration and experimentation with art itself. The camera helped to discover unexpected views and angles, and introduced unpredictability as a valid artistic output. New landscapes, such as microscopic organisms and outer space, are exposed by the camera and eventually incorporated into artistic images. Photography and printing together have increased public awareness of aesthetic concepts and artistic trends since they allow relatively accurate reproduction of images and ideas for mass distribution. Today television and film extend the innovations established by printing and photography. Film has created and is

developing its own artistic realm, where dynamic movement and aesthetic coherence of people and/or images is important. Television provides instant visual communication between most parts of the world and furthermore inflicts very important and controversial effects on our culture and thought patterns. Newer media still are emerging and a technology for the artistic future is already to be found institutionalized in our social and economic systems, namely computer technology. Not only is the computer a further innovation in mass communication, or yet another potential art form, but it provides the possibility of extending our abilities to structure and organize information; it provides an opportunity to formalize knowledge and to establish new metaphors for understanding ourselves and our world.

> 'Often the heuristic value of a metaphor is not that it expresses a new idea, which it may or may not do, but that it encourages the transfer of insights, derived from one of its contexts, into its other context. Its function thus closely resembles that of a model.'[3]

From this it should not be inferred that the machine may eventually replace the artist -- not a very exciting concept -- but rather that it may help in organizing and testing theories of art, just as Heuristic Dendral[4] helped in ordering, evaluating and formalizing theories of mass spectroscopy without replacing the chemist or physicist but rather broadening their knowledge.

As with many new developments, the use of a computer in the area of art is viewed by artists with some suspicion and fear. The sterility of machine produced images and a supposed encroachment onto the creative territory of 'artistic intuition' are two perceived problems. To overcome such feelings it is necessary to provide a flexible interaction between artist and machine in any artistic system any a judgement of merit from within the system should provide an extension (or an innovation in) artistic intuition, not a restriction upon it. Research has, within the last several decades, begun to meet such demands, particularly in the development of interactive systems. Ivan Sutherland's SKETCHPAD[5] has provided the basis for graphic concepts, Charles Csuri and James Schaffer[6] pioneered the area of figurative computer graphics, Nestor Burtnyk and Marceli Wein[7] developed key-frame animation, which was successfully used by artist Peter Foldes to produce the film "La Faim", while, finally, Kenneth Knowlton[8] and Leon Harmen, and Waldmar Cordeiro and Giorgio Moscati[9] have made much progress in the area of digital picture processing. The formalization of aesthetics is a more difficult problem, but it has been tackled by a few -- notably by the German school of philosopher-mathematician Max Bense;[10] using the work of G.D. Birkoff to apply information theory to aesthetic formalization (Frieder Nake[11] and Abraham Moles[12]) and by the Stanford team of George Stiny and James Gips[13] using Shape Grammers to generate aesthetic objects by computer.

In order to begin exploration of the formalization of aesthetic concepts via a graphic system, a working interactive system must first be available. It is toward this end that my current research is directed and an explanation of it is now given.

B. Initial Investigation

1. Problem

The work is being carried out in cooperation with a professional artist (Gerald Hushlak) who has the final say in aesthetic judgements of the drawings. Our initial concern was an investigation into what could be produced using the resource available -- a Calcomp plotter. At this time the primary objective was to develop an aesthetic arrangement of marks equated to an artistic sensibility rather than to the mathematical or technical prowess of the machine. The arrangement of marks was intended to solve the same types of problems as those that the artist would work on in his paintings. In particular, such arrangements comprised systems of modular structures, with stimuli ordered so that the surface readability of a given drawing changed as the observer's distance from it varied. (Note that Western culture generally reads symbols from left to right.)

2. Methods Used

A drawing was generated as a series of modules repeated over the picture plane using a straight line to mark each data point within a module. A module is a set of x,y coordinates generated by digitizing a form -- we chose sections from aerial photographs because of their 'structured randomness'. The straight line whas chosen because it is a fundamental shape, without prior restrictions or labels, and because it gives direction and so helps to manipulate left to right readability. Lines much over .55 inches tended to create 'mud' -- a form of graphic noise -- within the picture and were, therefore, avoided. The variables within a drawing were:

a) Density - The denseness of a module could change from one module to another several times over the drawing (Eg. lighter to darker to lighter) but only in a single direction (vertical, horizontal, diagonal).
b) Line - The line marking each data point could change length or direction from module to module.
c) Size - Modules could be scaled up or down or omitted altogether.
d) The distance between successive modules could vary.
e) The image size could change from drawing to drawing.
f) Color - Color was restricted to the ballpoint inks red, green, blue, and black. Due to the restriction of manual pen changes, all lines of the same color had to be plotted at the same time, therefore each drawing was divided into blocks to coincide with pen changes and the density and line parameters could also vary from block to block.

A basic program framework was developed and modified according to the demands of each drawing. The system was not interactive, it used batch processing on the CDC, but parameters could be changed by the artist if there was a feeling that a drawing did not 'work'. Initially the drawings consisted only of the modules. However, later, we added a covering of black lines to each drawing in an attempt to create a more subtle image and (again concerned with readability) in an attempt to draw the viewer closer in trying to decipher the modules below the covering. Several different coverings could be used within a single drawing. In using these coverings we discovered pleasing optical effects

which were primarily caused by the plotter's incremental nature. Increments would occur at the same point in adjacent lines, if the lines were slanted at other than 45 degrees, and thereby cause a subjective line to form in a direction other than that of the objective plotted line. Plotted lines were somewhat irregular which was also pleasing.

3. Results

The result of the project was a series of computer drawings which showed that the work was successful from a machine-aesthetic point of view. It was possible to produce aesthetic arrangements of marks, by varying the parameters, and several of the resulting drawings have been accepted by international jury-assessed print exhibitions. The solving of the readability problem was also successful since viewers, when they took time to study the pictures, were drawn toward the images as intended and noted varying levels of readability. Interestingly enough, many viewers did not realise that the drawings were machine produced.

4. Discussion and Conclusion

The project has been very fruitful in providing insights into machine potential and also in exposing some aspects which cause hardships. On the positive side - the unplanned optical effects and accidents in some pieces were provocative in stirring new ideas for use in future drawings. Working with an artist, naive in the area of computer science, also proved stimulating because, from the artist's point of view, each drawing was created by an intuitive manipulation of parameters rather than with preconceived notions of coding problems or machine limitations. The intuition was frequently grandiose, and restrictions required explanations, but, for the most part, the naive user was instrumental in expanding the boundaries of the project.

Most of the problems stemmed from the human intervention needed when using various inks and from the inconsistencies of the pens themselves. One of our initial ideas was to use the computer and plotter as an alternative to traditional printing processes, but the problems encountered with pens have led to a temporary shelving of this idea. The difficulties lay mainly in control of ink flow. Particularly when using liquid ink, the barrel of the pen solenoid had to be absolutely clean, and the initial fine adjustment of the pen above the paper precisely correct, or the pen did not lift at the ends of lines. Any leak of ink into the barrel of the pen solenoid from the pen also caused this dragging to occur. Both ballpoint and liquid ink lacked consistency during the life of the pen. This was tolerably controllable for liquid ink using the strategy of refilling after every plot. However, the ballpoint ink sometimes changed from dark to light within a single drawing. The use of pressurized ballpoints may counteract this but a special barrel is required. Occasionally there was a variation in the "same" color of ink from pen to pen and the ballpoints frequently built up ink in the nib causing smudging. With the need for manual pen changes, there were other problems. Thus the pen might be left in the down position upon restarting, or an incorrect color might be inserted prior to drawing, or a pen which had run out of ink might go unnoticed, unless the plotting was constantly monitored. The process was simply too tedious and time-consuming to be feasible and, with the cost of a plot under the supervision of a technician running from $30

to $60, the economics were not encouraging either. Perhaps more modern equipment with automatic pen changing mechanisms might alleviate some of the problems but would also be costly and the best solution is probably to generate single frames on the plotter and transfer them to traditional printing processes. In this way only black ink need be used for plotting and the colors available for lithography or silk-screening could be utilized in the actual production of an edition. A further consideration was paper quality. What was really needed was a flatbed plotter onto which drawing paper could be placed. Drawings produced by the system had to be matted for display and, even then, frequent pressing was needed to prevent wrinkles developing in the paper. In fact, the work is best displayed under a plastic film lying flat on a table rather than hanging on a wall. Drawings were plotted both under personal supervision and under the supervision of a technician. Although it saves the artist's time to have someone else supervise the plot, it was found that viewing the plotting process is very useful in determining the causes of pleasing accidents. Also time can be saved by stopping the plot if a drawing has not developed as desired.

The conclusions drawn from the project are:

a) that, although drawings are artistically very satisfying, their production does not utilize the potential powers of the computer, apart from its ability to calculate, to remember positions and to draw without fatigue;
b) that the plotting process is not yet suited to the production of editions of prints; and
c) that human intervention in the plotting process should be avoided.

In order to expand the machine's powers and to further the development of an interactive system, the next stage is to take some aspect of the process that is currently under the artist's control and place it under the machine's control. The artist should guide and constantly reassess the decision making done by the machine but should avoid involvment with the actual plotting process. The area of Design has thus been chosen for investigation with the specific aspect of *balance* for initial experiments. In the final section, therefore, we look at some of the terms and problems involved in this new work.

C. PRESENT AND FUTURE RESEARCH

A work of art consists of the treatment of a subject matter by manipulation of form and content. Content refers to "the essential meaning, significance, or aesthetic value of an art form. The psychological or sensory properties one tends to 'feel' in art forms as opposed to the visual aspects of a work of art."[14] To develop algorithms for content involves the formalization of aesthetic criteria and this will not be considered until we have established a system to deal with the 'visual aspects' of the art form.

Form is "The arbitrary organization or inventive arrangement of all the visual elements according to principles which will develop unity in the total work of art."[15] The elements, as found in design texts, are: *line, shape, value, texture* and *color*. *Line* creates *shape* and possesses *value, texture* and *color*. Therefore *line* is chosen as the primitive of this system (lines may be straight or curved) and *line*

will be attributed varying degrees of value and texture. *Color* will be ignored for the present because of the optical, structural and emotional complexities which need to be considered in its use. The artist-user may change the pen as desired but such changes will have no effect on the system. *Value* refers to the quality of lightness or darkness given to a surface or area. In this case a line's perceived value will be manipulated by its width at low values and by the spacing between lines at high values. An area's value will be a combination of the values of the lines it contains. *Texture* is the surface feel of an object, or the representation of surface character, and the texture of a line in the system will indicate the degree of smoothness between its end points, surface (area) texture again being a combination of the texture of the included lines.

The principles of organization for the development of unity are: *balance, harmony, variety, proportion, movement,* and *space*. *Balance* is actually a weighting of tension established by a combination of *harmony* (achieved by rhythm, repetition and dominance) and *variety* (achieved by contrast and elaboration). *Proportion* relates the elements to each other in terms of size, quantity or degree of emphasis. *Movement* implies visual paths (horizontal, vertical, etc.) within the picture plane. *Space* is an indication of distance within the picture plane. In this system balance is, as previously noted, the principle selected for experimentation. Movement will not be an initial concern, although the lines will have an arbitrary direction. Proportion will be considered only as it relates to balance and the space of the drawings will be assumed to be *shallow*. Thus no point or shape is so remote that it does not take its place in the pattern of the picture surface. Shallow space is a contemporary artistic concept and was the nature of space being dealt with by the initial drawing system. It is also easier to work with shallow space to start with and three dimensionality may be considered later.

The lines (shapes) to be used in a drawing may come from several sources:

a) user entry via a data tablet,
b) a stored set of lines found effective in previous runs,
c) the random breaking up of one of the modules used in the initial system -- the module is a set of data points which would be arbitrarily collected to form a set of lines or shapes.

Lines will be encoded according to Guzman's[16] point-slope method (1970). However, the need here is not to match lines, but to generate and manipulate them and, therefore, the factors he uses to represent the true orientation of a line will be replaced by variables indicating the line's value and texture (later possibly color too). The artist will decide upon the picture plane and it need not be rectangular. An image plane may be specified within the picture plane or the two may coincide. In either case clipping may be necessary. The image plane will be divided into regions, again by user selection, according to a previous pattern, or by random selection. Then the set of lines will be randomly (or selectively) distributed throughout the image plane.

As in Guzman's system, models will exist here. They will contain information pertaining to balance criteria -- horizontal, vertical, radial; symmetrical or asymmetrical. The user will specify the allowed deviation from perfect balance and requests will be made

for manipulation of the lines or regions, in the image plane, within those limits. Variations of lines' attributes (texture, value and position) may be requested and, when satisfied by the system, consideration will be given to their effect upon the entire image plane. If the request alters the degree of balance being maintained, it will be reported to the user, who may then take action himself, or request the system to do so. Special lines, such as grids, hatching, and basic geometric shapes, will be available for use by request.

Weightings will be calculated for each region within the plane and will consist of a count of the number of lines (shapes) within a region, modified by their various textures and values, together with a factor relating to the position of the region. Since an image appears more out of balance if all marks occur in the top half than it they occur in the bottom half the regions in the lower part of the image plane will be given more weight than those in the upper portions. Combinations of the weightings will then be evaluated against the balance models to determine if the required degree of balance is being maintained. The user will decide when a drawing is finished. Finished pictures will be shown to other artists, and to people educated to deal with aesthetics, to obtain evaluations on their artistic merit, within the limits of balance. Criticisms made by these people will be used to modify the system's balance models. Once the balance criteria have been developed, color and space variations may be introduced.

In the initial system the artist maintained complete control. In the newer one the machine will have some decision making capabilities, but the artist will retain a veto power. In this manner, perhaps, users will not feel stifled by the system, but instead will be provoked by the alternatives offered which they may not have thought of. In the constructive evaluations of the final drawings, it is hoped that aspects of design may be formalized not only for future use by the system, but also for use by the artists themselves, thus providing further evidence for the belief that a simbiotic relationship can and does exist between science and art.

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