The Visual Computer

Intimate machine interaction

An illustrated definition

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It is argued that current digital media offer exciting new opportunities for experimental work based on sharing responsibilities and tasks between man and machine. The artist can get a better in-depth understanding of his individual exploratory behaviour through navigating in behaviour-rich problem domains. Interactive methods are instrumental to introspection and flexible enough to control and explore many different types of dynamic systems.

Key words: Computer graphics – Interactive systems

The simplest approach to computers in the arts is automation. The artist formulates a basic idea into a mathematical or logical description (=program), the program 'remembers' and finally executes. The artist's objective is to generate final output. This can be called an object-oriented attitude towards the medium.

My first attempts to use computer programs (in the early 70s) explored this type of mechanistic automation. All types of generative systems, some based on controlled randomness, some more deterministic in nature, were developed. A first step towards giving a system a more important autonomy was to make it self-modifying. For instance, the limits of a process might change according to how the process behaves; it does not matter whether this behaviour is stochastic or deterministic. A process might itself change the parameters it uses until some final condition is met, or, for instance, until all available energy is used. Many of these works used a modular, geometric vocabulary.

Most of these early experiments were realized and shown as series, i.e. as grouped sets belonging to the same family. A special type of combinatorial logic was used, for instance showing all four possible progressions of two parameters. The program-determined evolution used the concept of 'relative' values (possibilities) and 'absolute' values (certainties) and gradual evolution between them. Doing things this way, it is obvious that a system allows for [(no. of parameters) exp 2] number of possible states, and consequently the same number of drawings. These are called 'closed' series since it is both necessary and sufficient to regard them as a multipart single construct. Also, it is meaningful to note that much of the significance of these works is resident in the difference between individual members of a single family, and the difference/similarity between various families on a larger scale.

A more open-ended approach gradually emerged from these experiments: a tendency to search for powerful strategies to generate pictures rather than the manipulation of predefined vocabulary according to a set of previously stipulated rules. Digital technology clearly provides the practical and economic means to do so. It is no longer a matter of thinking about visual structures but of finding a methodology to think about action and interaction. Indeed, interactive techniques constitute a means to explore the dynamics of more complex generative procedures. The artist is engaged in a circular, iterative process: to analyse an initial idea, design a program, implement the program, test it and interpret its output in order to decide

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what to do next: modify the program or make a 'snapshot' (i.e. hardcopy) of the current status. The artist gets constant feedback, so he is actually learning about what he is trying to do. He is free to gradually add complexity according to (possibly varying) requirements and constraints. Designing such programs is planning for change.
This new attitude is engendered by a swing from mechanistic functioning to the creation of animated behaviour.

2 Characterization of interactive methods

Definition

Interactive problem solving can typically be described as a special form of process control. The situation can be modelled as a complex feedback system receiving input information on many levels and of many types simultaneously, together with an active process where some internal activity is going on and an output stage. These three stages can be seen as active objects, as continuous transformers of information. In many ways, such a system exhibits far greater complexity than a simple stimulus/response model because of a complex multidirectional network of continuous control and self-control.
Actually, the total situation is clearly characterized by two interwoven processes, one internal, the other external. The internal process was invented by the user and is described in a program. The external process is resident in the programmer's mind. Since these two processes interact, the user and the programmer have to be the same person. Very often, there is no way of telling who is controlling what, or, more precisely, at what source new control decisions originate.
Let us take a closer look at the individual building blocks of this simple model.

The process

First, the programmer has the intention to get some type of activity going. Therefore, the process, as a dynamic system, is a formalized intention.
The process can range from a very simple system to a hierarchy of nested subsystems of arbitrary complexity. There exist various types of families of systems. Consider, for example, the activity that conflict resolution programs exhibit, in systems which represent hypothetical worlds or programs that combine a frequency- and rule-based approach to problem solving in artificial intelligence. Some examples are given below.

The input

Once the process is defined and formulated in a program, it is ready to accept input data. The first set of parameters define the limits of the problem domain but do not account for the process definition itself. They often put constraints on the flexibility or somehow limit the potential of how the process behaves. These are the behavioural parameters.
Second, there is a set of visual attribute parameters. These allow one to adjust the way in which the output of the process is perceived as a physical fact by the user (see the examples below).

The output

The artist has a responsibility to select strong physical 'carriers' which exhibit considerable coherence with the idea to be conveyed by the process. It is important to note that objects are generated from ideas. These objects are only one form of output. Eventually, a program might itself change some input parameters through interpretation of certain output. More importantly, the program might decide to change its own logic according to generated information if the process definition allows it to do so.
The complexity of the perceived image can be in sharp contrast with the complexity of the underlying generative principles, and this is a positive fact. Clearly, abundant visual complexity is a poor excuse for simplistic process definitions. Furthermore, it is quite easy to mystify, especially when using advanced technology in the arts. The challenging task is to formulate output using a simple, compact and straightforward visual language. It is easy to be complex but difficult to be simple without being simplistic. Consider the really convincing examples of successfully achieved compactness in some quite minimal art in the American tradition and in fundamental painting in Europe.

The purely visual aspects will determine the initial response of a viewer and define the degree of resonance induced by perceiving a work. This first contact is essential as it will determine whether the viewer is ready to penetrate, looking for an underlying meaning, or whether he will be satisfied by merely scratching the surface. Moreover, activity continues 'outside' the physical work as every single individual brings his own context-dependent algorithms to decode the message.

The interpretation

The output reflects the type of activity and dynamic range of the process. It is interpreted by the user according to a collection of criteria. Some of these criteria are well defined, others are poorly understood because they function on the subconscious level. But to be practical, we might ask: does the output meet the intentions formulated in the process? Is there something new discovered just by activating the process? Or, perhaps the process under current consideration doesn't lead anywhere at all. In fact, a process can be a dead-end street because there is not enough dynamic potential in the initial idea, or because the process behaviour is too simplistic or too chaotic so that no meaning can be derived from the results: the minimum required relationship between input and output got lost or was too ill-defined from the start.
Even in the case of very simple algorithms, the user is often surprised about side effects in the program's behaviour. A program nearly always implies something more or different than was expected. Working in an open-ended system means that side effects get a substantial chance of being more closely examined and may steer the interaction to a new focal point.

Learning

There is an important cognitive aspect when working towards idea amplification by delegating decision making to a machine. The artist learns about his own approach to problem solving. This process also suggests problem domains which might hide considerable dynamics and interesting activity, but of which the programmer was not aware in the first place. Some work may consist of a system where the programmer as well as the system learn both from their independent functioning and from the continuous intimate man-machine dialogue, i.e. by comparing reality with expectations.
In a way, systems with little behavioural potential learn because they are being told something explicitly in a program. Systems with a great behavioural potential learn from discovery by executing a programmed action. Knowledge increases by discovery, by guided accidents, so to speak. Could this be conceptually equivalent to the idea of 'found objects' in art?

3 Attitudes and motives

Dual activity

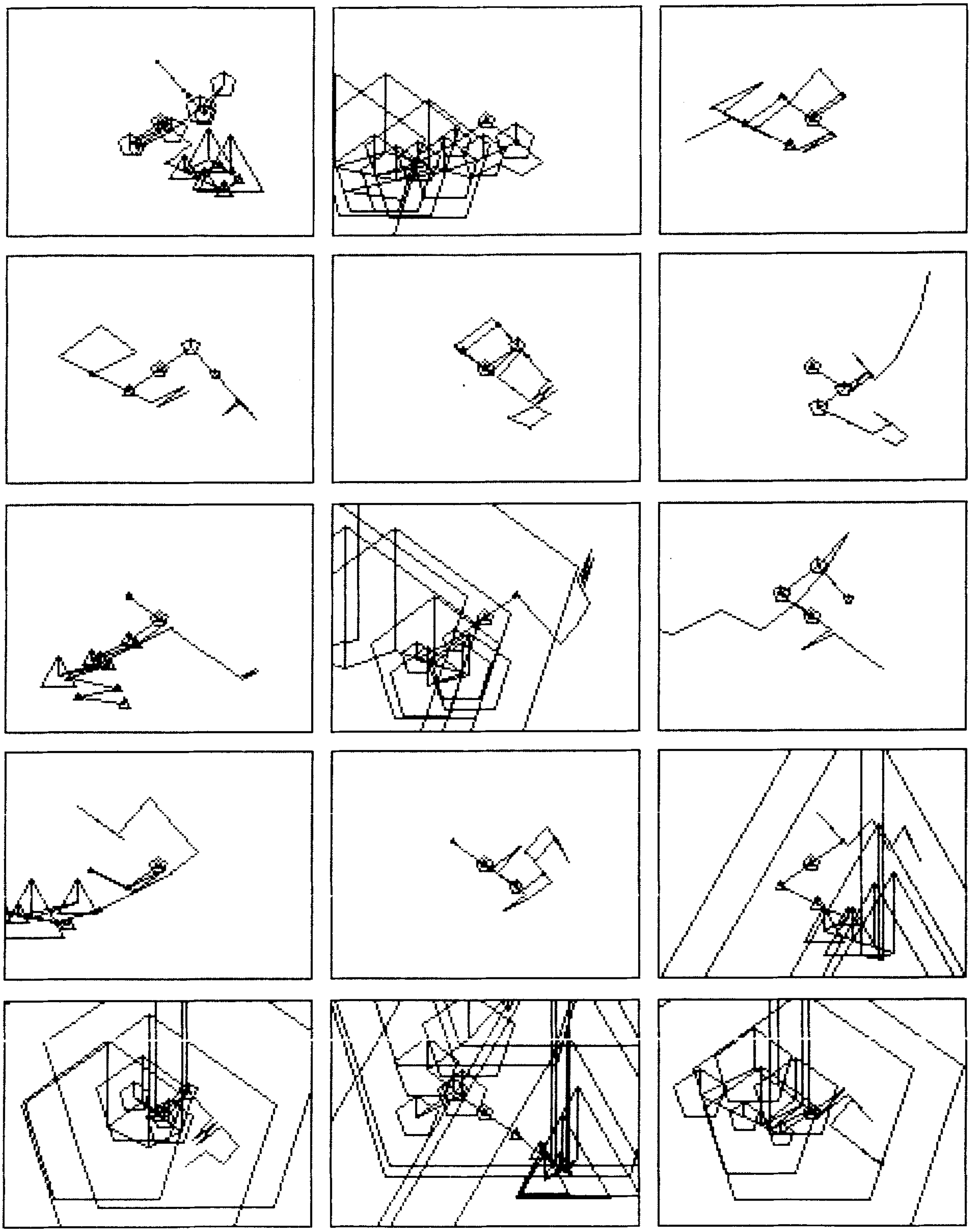
From the above it is clear that interactive methods can be described as a special form of 'activity' on two levels: activity produced by algorithms and the communicational activity present in the man-machine dialogue.
Since this process outputs continuous visual feedback, it constitutes a method to handle purely conceptual ideas in a very concrete way. Also, this activity can be described as related to navigation. It is typical for experimental and exploratory behaviour to gradually narrow a problem domain through interactive examination of idea potential. This is a process of continuous correction and reformulation of ideas and implies that all output is intermediate output. This means that the artist is the first to see his work – and this of the utmost importance. Also, the artist is the only person ever to witness these intermediate stages in the development of a new work.

Dual time

Activity is something which develops in time. First, on the microscopic level, the chaining of decision making in the program, i.e. the tracing of some artificial behaviour in a single work. However, time seems to appear amplified in works that express themselves as a physical series showing stages in the development of, say, a cellular automation. Second, larger programs are under continuous development and it is not uncommon to talk about the 'age' of a system.

Ideas

Some artists borrow ideas from critical examination of nature. They inspire themselves by real ex-



Figs. 1–15

amples in the physical world, and react according to perceived information. This is a form of re-creation of something which already exists, but which is seen from another point of view, with added personal interpretation, visualized according to current aesthetics, or realized with media-dependent objectives. It is a view of reality coloured and filtered according to, for example stylistic criteria imposed by local trends.

As from the start of the century, many artists have been inspired by emerging technology, both as a source of new, merely pictorial elements and as a source of new ideas with which to work. Examples of the latter include 'speed', 'movement' and other qualitative descriptors.

More recently, many artists have borrowed ideas, working methods – such as simulation and general automation – and new materials from the scientific community. Simulation is a proven scientific method to examine reality by building and consequently testing the validity of mathematical models of it.

It is my specific intention not to borrow from nature but to generate ideas based on my own imagination. This implies designing systems which do not have any – even remotely related – real-world equivalent. Since these systems amplify imagination they can be said to 'suggest' new ideas to the artist. So, the essence of this man-machine relationship is within a process of constant reorientation by the artist. This type of attitude is not object oriented; it would be naive to think that the resulting physical works are by any means the whole story. However, they do have an important function – they provide physical evidence of the artist's intentions and mental behaviour. It is correct to say that the works constitute their own documentation.

It is clear that in such an imagination amplifier, many ill-defined ideas get a chance to develop. By the way, the artist does not have to be aware of all the implications of his basic ideas, as the system will act as an assistant to sort things out and suggest a number of alternatives and avenues for further exploration. It is exactly this ability to 'worry about' poorly understood, incompletely defined and ambiguous and fuzzy ideas that information technology offers which makes it possible to gain deeper insight into oneself. The machine acts like a conceptual mirror and magnifying glass: it reflects the consequences of decisions and is instrumental for detailed introspection.

4 Examples

1 L&H (1979) (Figs. 1 to 15)

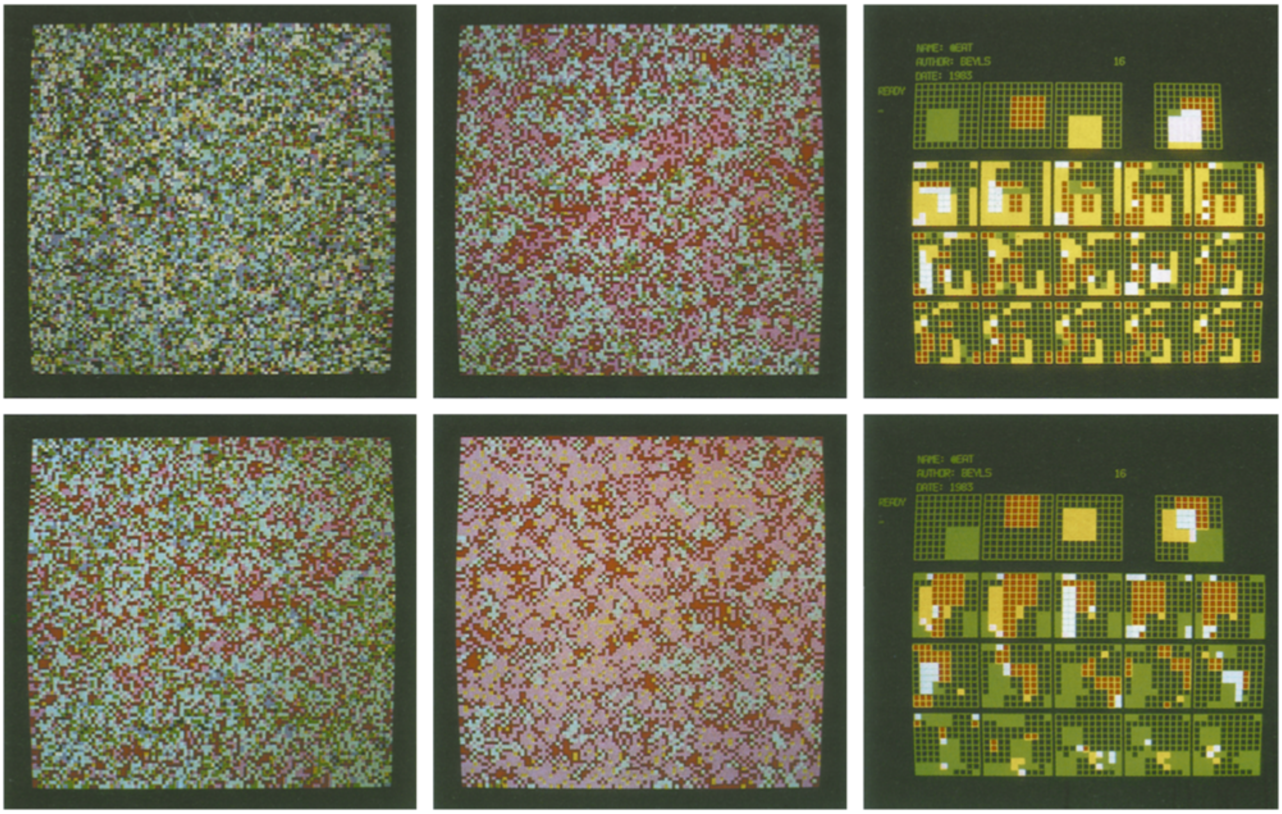
This program is about two organisms interacting according to simple rules. Both start in the middle of a rectangular area and are represented by different-sized polygons. Their behaviour is guided by both independent and interrelated parameters. New positions are selected as deviations from previous positions. Both organisms will determine each other's life cycle because they grow or fade according to their absolute position and the relative distance between them. This accumulative process might lead to amplification or mutual destruction.

2 Gradient (1981) (Figs. 16 to 19)

A cellular system is represented by a two-dimensional matrix, initially filled with random numbers. These numbers refer to a look-up table to assign 64 colours to as many values. Every single cell is transformed according to its neighbourhood and the same procedure is repeated throughout the sequence. The absolute value of the difference in value (=gradient) for every cell and four of its neighbours (up, down, left, right) is computed. Then, the position of the greatest gradient is taken and the value of that cell is changed to the gradient value. This procedure constitutes a peculiar growth which spreads throughout the matrix. Notice that only four consecutive generations are shown.

3 Eat (1982) (Figs. 20 to 21)

This hypothetical world is, on this occasion, inhabited by only three organisms, each one built up from 25 identical cells. There is a limited space for the organisms to move in. Their initial position is selected at random. A unique colour code allows easy reference to single organisms and overlapping cells. The program imposes a sequence of actions: A eats B, B eats C and C eats A. This is clearly a kind of conflicting situation. For example, if A eats part of B, then A gets bigger and B gets smaller. This implies that the chances of B overlapping another organism decrease. Simultaneously, the mobility of A decreases and the chances of it colliding increase. Again, this situation remains unstable until a single organism survives.



Figs. 16–21

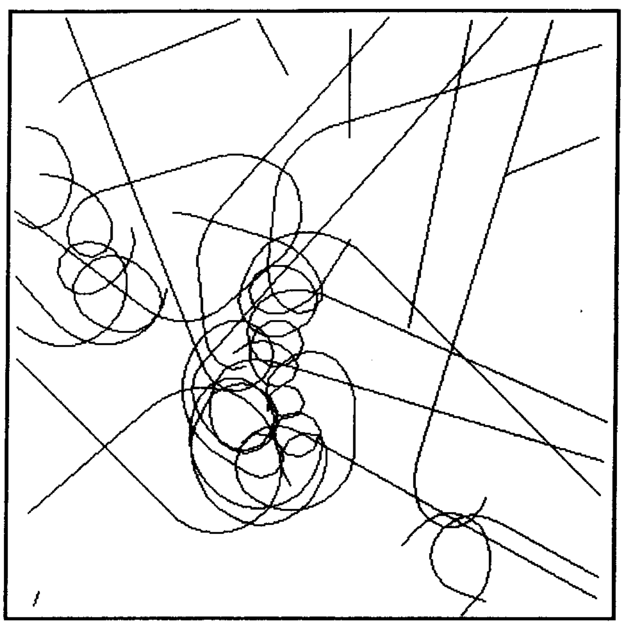


Fig. 22

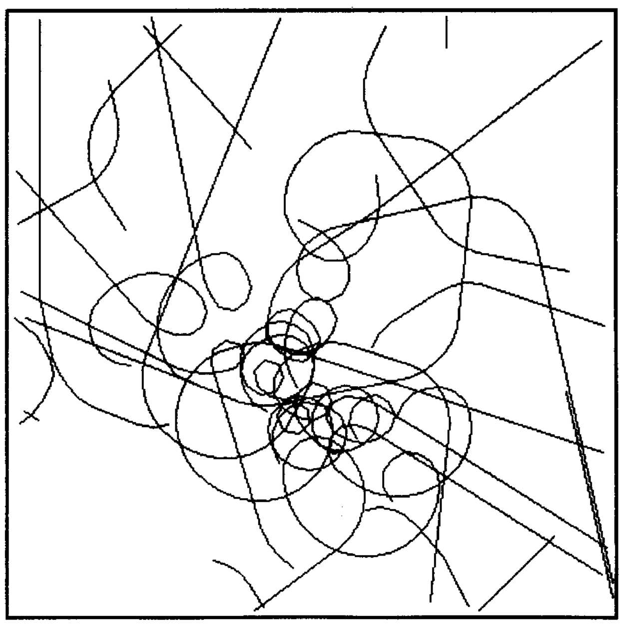


Fig. 23

4 *Actors (1983)* (Figs. 22 to 23)

Message passing is a computational paradigm used in A.I. Messages are passed among basic computational entities, called 'actors'. This idea is extended further to create families of actors which influence each other according to a set of constraints and according to context-dependent descision making.
An example with actors moving in a square field:
- when any two actors happen to be close enough to each other, they increment the angle at which they move.

All actors have limited resources; they must exchange information sometime; if not, they will die from isolation.
This example is very basic; our aim is to develop a more complex and general algorithm, with diffent types of families of actors and various kinds of context-dependent behaviour. This program was written in LISP with the appreciated assistance of Ludo Cuypers.

Conclusion

One of the most exciting facts about interactive systems is the inherent mechanism of self-reflection, a system that encourages asking questions about behaviour and problem solving. As a further consequence, good works raise questions in the viewer's mind, still better works manage to induce fundamental questions. Intimate interaction also facilitates learning through discovery. Circular introspection allows for a deeper understanding of 'activity', in the man–machine dialogue on the one hand and in program activity on the other. Interacting with machines can be an extremely instructive experience, to the point where it might teach us something – or bring us new awareness – about the way we interact with other humans.