From Turing Machines to Dynamic Networks: the future of computational art systems

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Abstract. The paper briefly considers the conceptual and actual developments in art as a result of advances in computation and communications. It postulates various advances and developments that might take place in the future and expresses the view that, in the long term, computation itself, as introduced by Alan Turing will prove to have changed art practice in the most profound way.

1 INTRODUCTION

As I discussed in an earlier AISB conference paper [6], the most important contribution that Alan Turing made was in his 1937 paper [13], in which he proposed a full account of computation illustrated by what has become known as the Turing Machine. As Jack Copeland put it: this paper "contains his most significant work. Here he pioneered the theory of computation, introducing the famous abstract computing machines soon dubbed 'Turing machines'" [3:6]

Turing's contribution was his most significant to art as it was to our culture and our lives more generally. This abstract machine was shown to be able to compute anything that could be finitely defined, given a particular point of view. This point of view was subsequently taken as the received position and pointed directly to the possibility of constructing real machines. These machines became known as 'computers'.

Crucial to the Turing machine was the concept of computation and the finite definition of processes that could 'calculate' any 'computable' number. These concepts arose out of a long and difficult journey that had taken place in philosophy and the foundations of mathematics in which, for reasons that we will skip in this short paper, even the reliability of arithmetic had been called into question. The history is briefly summarized, with references, in [4].

For art, computation introduced a wholly new possibility: that of defining a making, designing or construction process in a finite way that could lead to an automatic method of making the artwork itself. The possibility of automata making art became a reality. A certain mystery could be removed from aesthetic dreams.

In many ways the idea of automata making art could be seen as an answer to the constructivist dream of replacing 'composition' by 'construction' [8]. In 1921 the constructivists had turned their back on 'composition' and the strong concentration of the arrangements of colour and form that made up the appearance of the final art object. In stead they advocated a constructive approach in which, by one means or another, the artist defined the construction of the work and left the final appearance to be determined by the consequences of that process.

In his 1937 paper, Turing recognized that a human could influence the processes defined for his machines to follow. In other words, he saw that an interactive version of the Turing Machine was possible, although he chose not to deal with it within that paper. This is much like the interactive computer of today.

2 COMPUTATION

From a conceptual perspective, by far the most important development of the twentieth century relating to computers is the idea of computation itself: the idea that we can finitely define procedures for generating anything that we might claim truly exists. Crudely put, this is the idea that we really need to either show it or show how we can generate something before we can have faith that it certainly exists. As mentioned above, this idea had a resonance for certain artists and the implications are still being worked out.

At the centre of the exploitation of computation by artists is the use of computer programs, code, as a core element of their work or as the medium itself. It is surprising that code receives rather little attention in much of the literature on digital art and yet it is arguably the most important aspect. The early computer artists wrote code as they had no other alternative and many digital artists still do. In fact, new programming languages and environments have been created by artists for artists, for example Max/MSP [8] or Processing [12].

Perhaps the key point about code is the need for clarity. As Manfred Mohr put it "if you have to program, you have to order your thoughts, you have to really crystallise exactly what you want to do" [11]. This can be seen as a strategy for exploration, for moving on. Harold Cohen expressed this point very clearly, "after 20 years of painting I thought I didn't know anything more about image making than I had when I started. And I thought rightly or wrongly at that time, I thought I saw in computing a way of learning something much more objectively about images and how one goes about making them." [2].

This exploration through code has a long way to go. To take a simple example, colour is central to my computer-based art and is most certainly an important, long-standing, part of Harold Cohen's. However, not very many computational artists have yet investigated colour deeply through code. So, there is much to be done. Indeed, within computer science itself, code representations of interaction, which is a strong area of interest for many artists, is not yet a fully developed topic.

Perhaps the most unexpected development has been the incorporation of code into the final presentation of art works as we now see in Live Coding, where musicians develop their code during a performance and display it to the audience to accompany the sound. This is a new area and there are many challenges ahead. As live coder Alex Mclean said, "the challenge is to develop new languages which are more easily understood. For music I think that means just making more declarative languages that are more about the structure of music

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and something more like a human language, than something that's more about the nitty-gritty of moving data around." [10].

In relation to computation, I suggest then that we can expect many developments in the near future. On the one hand, an increasing close exploration of the elements of art forms, from colour to time and space, remains to be conducted through the use of code. On the other hand, particularly as the public becomes more educated about computation, we can expect to see mare explicit code in artworks and, perhaps, the development of computational elements in the language of art criticism and analysis. Finally, the problem of the conceptual/physical relationships within artworks will continue to concern us as the increased emphasis on the essentially abstract code challenges the concrete reality of the artworks that we see, hear and touch.

The next two sections will briefly review communications and computer applications and their future in the arts. However, in this paper I continue to assert that computation, as introduced by Turing, remains and will remain the most significant conceptual advance for the arts in relation to computing.

3 COMMUNICATION

Perhaps the most important application of the computer has been its use as a controller of a telecommunications network. By the early 1960s computer networks were being formed and in 1969 ARPANET, the precursor to the INTERNET, was demonstrated [1]. The integration of computing and communications that followed has taken communications beyond the role of an application of computing to become an integral part of the conceptual and actual computational world in which we live.

With the addition of GPS, artists have a complex, flexible and highly innovative infrastructure to both enable and inspire new work. Distributed and multi node location based work is with us already. In my early work, in the 1970s, I made artworks around the concept of human-to-human communication across networks and with modern technology such art is easy to build [7]. What are the future directions?

The art systems concept that was first proposed in the 1960s is now with us, but new possibilities are emerging. For example, collections of artworks interacting with one another are being made. In such cases, the interacting set can be dynamic and changing as well as distributed around the world. A second development from the early systems art position is the movement beyond simple action-response models of interaction to ones in which the interaction leads to changes in internal states, and hence future behaviours, as well as direct response [5]. The direction is interactive art beyond the game paradigm.

So the future will be one in which we go beyond interactive art that employs human-machine communication to art that also involves more human-human interactions through the technology and interactive art systems in which art works also interact with one another of local area networks and over the internet. Issues of time differences, disparate physical contexts and dynamic living networks of artworks will offer particular challenges.

4 APPLICATION

Only the limits of human imagination limit the application of computer and communications technology and the only confident thing to say in this context is that we cannot predict the future. We might, however, note a couple of examples of current applications that are being explored by artists but that show every sign of becoming more important as time passes.

Consider augmented reality. This is now a very real technology that has, as it were, hit the public through, for example, Google Glasses. The mixing of the real and the virtual, including the overlaying of the actual with abstract or linked forms and information seems almost designed for the artist and we can certainly expect this kind of art to grow significantly.

Another generic application is the modelling of dynamic systems. Expressed in that way, not many artworks may come to mind, but if we think of the modelling of living systems, particularly medical and biological ones, then we see that this is already a thriving area for art, particularly where artists are working with scientists. Perhaps the growth that we can expect will be in interactive work where the models can be used in the "what if" manner that scientists, planners and others use in order to explore possibilities. Probably this area will seriously grow in the near future.

However, as discussed above, we will see new art using new computer applications that none of us have yet even dreamt about.

5 CONCLUSION

So, what might the future hold for computational art? The predictions made in this paper can be summarised as:

- The computational exploration of more elements of art
- More explicit use of code in art works and art criticism
- Increasing concern for the conceptual element that code embodies in art works
- Interactive art beyond the game paradigm
- More distributed human-human communication based art
- Dynamic networks of art works interacting with one another
- The full development of augmented reality as an art form
- Interactive "what if" models as artworks, particularly in relation to medicine and biology
- Many more artworks exploring new, as yet not invented, computer applications

As with all predictions of the future, the most likely outcome will be that mine are wrong, but they are the best that I can do. At least they may represent one view of the hot areas of computational art practice that are alive today.

Notwithstanding these particular predictions, I conclude by emphasising the point made both in the introduction and at the end of section two. Alan Turing's great conceptual contribution, of the formally defined process of computation that underpins all of computing, was a very significant to our culture. Its implications for the arts are considerable and not fully played out yet. Whilst application oriented advances, including those mentioned above, may well be the most common and popular ones that we will see growing in the near future, and whilst digital communications is undoubtedly expanding the nature of art, I suggest that in the long term we will find that it is computation itself that will prove to have changed art practice in the most profound way.

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