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Computer Science and Fine Arts

1.1 Why Use Computers for Arts?

"Why use computers for arts?" "What are the advantages of digital arts?" These questions seem to assume computers are already applicable to arts. But is the computer by its very nature a kind of art creation tool? Only if this answer is affirmative can we go on to discuss what sorts of artistic results would the computer be able to generate and the advantages. It turns out that for many practicing artists, a large part of their artistic talent or training is about how to make use of literally anything on earth that happens to fall into their grip to do art creation. Of course, the computer is included. But an artistic genius could still produce wonderful artwork even when the tool is inferior. So the real question is whether the computer is really a good or suitable tool for art creation for all.

1.1.1 Computer as an Art Tool

Whether the computer can be labeled as belonging to a certain class requires a definition of the class. For our inquiry here, the class is the class of artistic tools. We have a very challenging problem here since even the definition of what is art and what is not has never been widely agreed upon and is likely to remain so into the future. In the absence of a given definition, we venture to suggest some criteria for what might be considered a suitable tool for art creation.

An art tool is some kind of a metaphor which

(1) has certain material shape and is specially designed to serve a purpose;
(2) lends convenience to the creation of novel artwork;
(3) supports certain generality in its functionality so that when suitably applied, it could produce a range of different results reflecting the different traits of the individual users.

By the first criterion, an art creation tool is either from nature or artificially designed and manufactured and it must be easy to hold on to physically.

It must have a shape, volume and mass. This excludes anything that is not at all tangible, which exists perhaps only in spiritual or psychological realms. The second criterion postulates that an art creation tool is not just any tool but one that can promote, encourage and facilitate the process of art creation, as well as the exploration of new interesting artistic effects. So an art tool has a very clear functionality and it must be artistically useful. The third criterion says an art creation tool must have a reasonably wide applicability. It must be able to produce a multitude of results, including some new, previously unseen ones. Therefore a pre-programmed electronic device or digital recorder which can only play recorded music cannot be called an art creation tool since it does not permit variation of its end effects. But an electronic piano is an art tool since it allows users to generate different music under their control. Given these criteria, we can now try to answer the question of whether the computer as a tool qualifies for art creation or not.

First and foremost, a computer is purposely designed and manufactured to achieve certain human intellectual goals. It has its own unique form of existence and way of functioning. Its outputs, though in digital formats, always have a certain clearly-defined representation and can be universally accessed through that representation, without regard to the machine and people operating it.

Second, modern computers have enabled many new ways of creating old and new types of information which are artistically interesting, some of which would be difficult to achieve otherwise. For instance, some sound effects generated by an electronic piano can never be produced by any acoustic instrument. In movie production, computer-generated effects such as the massive repetition of some patterns commonly found in recently-made hi-tech films by Pixar and the like would be prohibitively expensive and labor intensive to achieve, if at all feasible. At this juncture we feel we should touch on one important feature of computers which has effectively facilitated the art creation process and yet is not as widely recognized and appreciated as it should be—machine intelligence. Not many would oppose the point that even the most creative people are under the influence of history, society, education background, family, and so on, and no one can be completely original in the absolute sense. In comparison, although a machine's intelligence is also affected by its input knowledge, simulated intelligence in a computer is very different in nature from human intelligence. We do not imply that machines are more intelligent than human beings, which as a matter of fact is far from being possibly true in the foreseeable future. What we really want to say is that because of the different ways of thinking leading to the two types of intelligence, we should let them be mutually promoting and stimulating. This is especially important for art creation activities where the artists are constantly, sometimes desparately, in search of original ideas which really would require intelligence in multiple dimensions. In this regard perhaps it might be more beneficial to train a computer to be an imagining artist than a disciplined and self-motivating engineer. And instead of the self-aggrandising goal of attaining a powerful level of machine intelligence to completely replace human intelligence in art creation, it makes more sense to gear computing intelligence to cooperate with biological intelligence. Like man-made organs being transplanted onto human bodies in order to save or improve lives, the human faculty of creativity may function to its fullest extent when complemented by machine intelligence.

Lastly, for the third criterion, computers would never lack variational possibilities. In fact the computer has too much variational space in which to exercise its power. That can be easily seen for instance in the field of computation complexities which deal with the extreme technical difficulties caused by too large a problem space. There one important task is to try to reduce substantially the variational possibilities in the problem space. Now in the realm of computational art, as opposed to preferring a reduced space, the huge space (of possible ideas satisfying an artistic requirement or ambition) is wonderful news to the artists.

By the above analysis we can now safely conclude that the computer should be an ideal and suitable tool to be used in art creation, despite the fact that it was originally designed for scientific computing and information management tasks.

1.1.2 Computer as an Exceptional Art Tool

Additionally, one may want to include a "skill" dimension in the set of criteria. That is, *the tool's performance should reflect proportionately the skill level of the user, and produce a result that is commensurate with the skill of the user.* But on the other hand, unlike other tools we all have seen and used so far, the computer can sometimes produce a professional result for a novice user. This is where machine intelligence comes in, and with machine intelligence the computer is fundamentally different from all other (art) tools. It can be intelligent and completely autonomous where the word "autonomous" means that the computer can perform certain acts that may not be requested by the user or attainable within the user's skill set. Going for the extreme, we can even have a computer generating a piece of art completely without a user. Several chapters in this book actually discuss work done under this category, in particular the chapters in Part IV.

In summary, the computer not only can qualify itself as a standard art tool in the conventional sense, but also distinguish itself as an exceptional art tool which can help people to accomplish art creation tasks not originally reachable by their own skills as well as perform art creation autonomously with or without guidance from a user.

1.1.3 Computers as Mind-talkers

We feel that in digital arts computers can play a special role between a human artist and a tool—in "talking" with the human artist in the digital art creation process. In this sense computers are like a mind talker accompanying the artist throughout his journey of idea seeking, exploration, refinement and development.

Such a role for the computer has recently gained some noticeable recognition in some fields of computer science, in particular computer-aided design and human computer interaction. Some interesting discussion has taken place over the term CAD. Historically, it stands for *computer-aided design*. However, people now realize that in the past CAD [Sum74, TLM83] actually was all about computer-aided documentation and expression [Dur02]. Upon such a reflection, more people become motivated to study what they call the real computer aided design systems, in which the systems are not to create designs automatically or semi-automatically, but more to inspire the designers to innovate. But when these intelligent suggestions or inspirations become more substantial, human intelligence and machine intelligence crash into one another, giving rise to a design which may be beyond the reach of either type of intelligence.

For painting, sculpture, graphical design and some other forms of digital arts, there are situations where the features or structure of the artwork may not have been completely conceived before the artist sets out to create them. Admittedly there could be many factors affecting how the artwork eventually emerges, which include the tool factor. The artwork may be a cross product of the artists' skill set, creation motivation and the peculiar functioning of the tool, where the versatility and variability of the tool may have a very strong bearing on the art creation.

It is feasible to carefully design a computer system so that it can suggest different "voices" based on machine intelligence when collaborating with human artists in their search for innovative art creation ideas. In these scenarios, the computers may appear to have its own mind, which actually descends from the mind and talent of some human beings. This brings out the issue of consciousness and unconsciousness and the display of human talents in both states.

Traditionally computers as art tools are considered a means to deliver artistic designs or concepts conceived by human artists, the entire process of which is conducted strictly subject to the conscious mind of the artists. Now people are increasingly interested in using the computer to push for more exposure of the unconscious part of human intelligence. Though often unrealized, this part is still a part of human intelligence, which is hard to trigger, and is not possible to measure qualitatively. If the computer can indeed stimulate the unconscious thinking of a highly trained brain, it can facilitate and encourage the displaying of the brain's hidden design and creative talents. Such stimulated intelligence or skills are only invocable when both computers and human artists are working together. It is similar to the real-world phenomenon that when one intelligent mind talks with another, they would see a third one appearing in the midst of them.

There is nothing fundamentally new about computers as tools assisting in art creation or for other similar purposes. It has been a common practice for centuries for architects to use a pencil to stimulate their creative thinking during their design work, especially at the early stages of the design. Indeed we are not talking about the chances for some novice to create a world masterpiece, but rather a seasoned professional to get imbued with ideas which he normally would not think of. Thanks to the voices from the computer, the artist now has a much wider scope in which to search for new ideas and design motivations. Therefore computers as tools are no longer only for delivering and presenting those ideas that are fed to them; they become collaborator of the artist, and the situation becomes the conscious part of the artist's mental faculty talking with the unconscious part. The intelligence and artistry achieved jointly by an artist and a computer can be greater than the sum of the two, if operating separately.

In summary, there are two different design goals in making the computers an art tool: one is to design a computer with the best artistic intelligence and the other is to design a computer with the best capability to stimulate the invisible skills and talents of the human artist. And the two, can happen at the same time. In the ideal situation, a great piece of *human* artwork which is computer-assisted can also be a great piece of *computer* artwork.

1.2 Digital Arts

1.2.1 What Are Digital Arts?

Literally, the term *digital art* could refer to any form of arts which has a certain deployment of digital means during the art creation process. However, simply digitizing, storing, transmitting, or retrieving digitally a piece of art does not count, which may be referred to, as just technology support for arts. We should point out the boundary between digital art and digital support for art is not always that clear-cut. For digital arts there can be two broad categories: either it is a form of traditional art, but has been migrated onto some digital medium; or it is a previously non-existent form of art now made possible with the support of digital technologies. At present, digital arts predominantly belong to the first category while truly novel art forms which only exist in the digital domain but do not have a real-world counterpart are relatively still very rare.

1.2.2 Manual or Automatic Art Creation

There exist many dimensions by which different forms of digital arts can be classified, e.g., the dimension of the input method, the kind of sensations the art piece induces, the way to present or perform the piece, etc. Here we concentrate on a particular dimension which can be seen as a key parameter for organizing our research work presented in the book: the dimension of how much work is done by the user (manually) versus that done by the computer (automatically). Along this dimension, the art creation process can range from completely manual to completely automatic, and hence correspondingly, the contribution by the computer through machine intelligence to the artistry of the result ranges from 0 to 100%, so to speak. We can say that if the computer's contribution is larger than a certain threshold, the result is *computer art* or *intelligent computer art*. The 100% manual option requires a tool, electronic or not, which satisfies the "skill" criterion as mentioned in Sect. 1.1.2. 100% automatic or something in that neighborhood requires a tool that is intelligent (hence possibly violating the skill criterion). Results from the lower part of the range may be called *human art* or more explicitly, *human art assisted by the computer.* Fig. 1.1 summarizes the different possibilities.

Referring again to the scale just presented and Fig. 1.1, towards the upper end of the spectrum, the computer can make up for what the user lacks in skill. A trivial example is that an unskilled user who cannot draw a straight line or a smooth curve can rely on the computer to (intelligently) complete the straight line or curve for him. Generalizing, the computer will be more than able to draw a beautiful looking stroke with rich texture for the user; this is exactly the problem we study in Chapter 11 of this book.

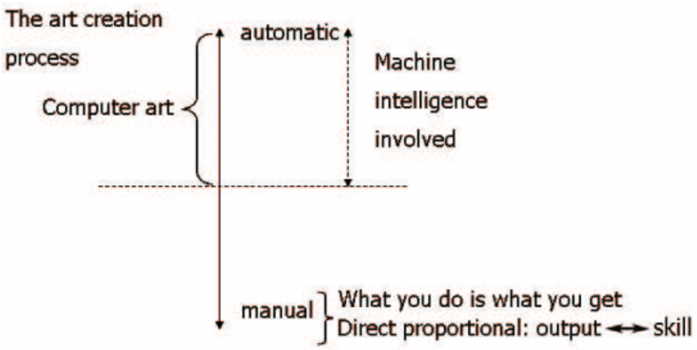

Fig. 1.1. The range of art creation processes

1.2.3 Three Elements of Digital Arts

We propose three key elements or concepts involved in the process of art creation: (1) the tool, (2) the materials, and (3) the created art and its presentation. As an example, Table 1.1 shows the instances of these key elements in digital painting and computer music, respectively. Fig. 1.2 fits the elements into a conceptual pipeline. If one so wishes, and if one or more of (1) to (3) are in digital form, the result may be called digital or electronic art.

Table 1.1. Three key elements in digital painting and computer music

Elements	In digital painting	In computer music
Tool	Paintbrush	Music keyboard
Materials	Paints or ink	Different kinds of sounds or notes
Art creation and its presentation	Whole painting	A music performance

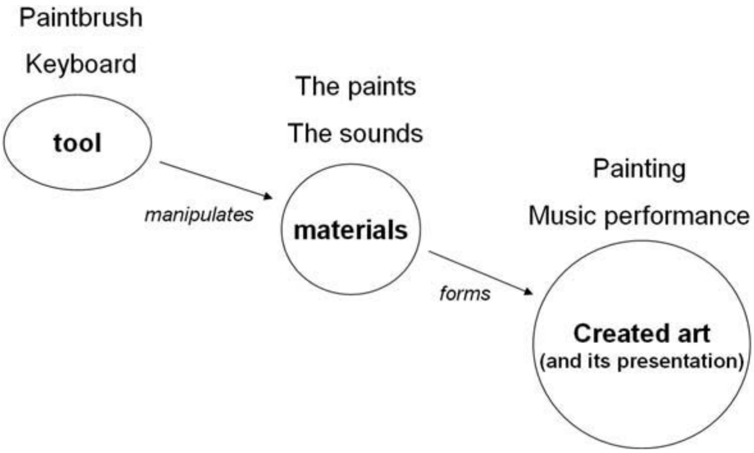

Fig. 1.2. The art creation "pipeline."

1.2.4 Classification of the Book Chapters

By adopting the simple taxonomy proposed in Sect. 1.2.3 and considering the spectrum discussed in Sect. 1.2.2, the contents of the technical core of this book can be labelled as shown in Table 1.2.

Table 1.2. A view of the contents of the book. For Chapter 11, the stroke-based Chinese painting animation system we developed is the tool; the key-frames and the animated strokes are the materials, and the generated painting animation is the art creation

Chapters	Elements	Mode
4	Tool, Material	Manual
5	Tool	Manual
6	Material	Manual
7	Tool	Manual
8–10	Art creation	Automatic
11	Tool, material and art creation	Semi-automatic, semi-manual

1.3 Examples of Digital Arts

Different kinds of digital arts span a wide spectrum, including digital music, digital painting, digital sculpturing, digital dance, and digital movies, just to name a few. We give a brief overview of some of the most popular ones in this section.

1.3.1 Digital Film

Digital film or cinema has become one of the most common experiences in our everyday life in the 21st century, sometimes without us knowing it. Their coming about and sophisticated demands have helped shift computer graphics and virtual reality research into high gears. Today a significant portion of US films have been produced with intensive employment of digital technologies to achieve stunning visual impression but at much reduced cost. Filmmakers like digital effects in fact, because they are absolutely safe on the set. Examples of successful digital films include: *Forrest Gump, Titanic, Toy Story, Harry Potter, The Lord of the Rings* and *Spider-Man.* Digital films and their special effects are a popular topic for any popular magazine or TV/film guide today. We suggest interested readers try a search for the keywords “digital film” or “digital cinema” in Amazon (www.amazon.com). As of August 2007, a search for the first keyword in Amazon returns over nine hundred book records and a search for the latter keyword returns over three hundred book records.

1.3.2 Digital Painting

Talking about painting using the computer, Photoshop would probably be the first one to spring to mind. Sue Chastain listed the top ten other art-oriented software programs in November 2006 (http://graphicssoft.about.com), which are: Corel Painter, ArtRage, Microsoft Expression Graphics Designer, SketchBook Pro, Project Dogwaffle, Deleter CGillust, Pixarra TwistedBrush, PhotoArtMaster, Studio Artist.

Because this is exactly the topic of this book and there exist abundant work in the area of digital painting, we dedicate an entire chapter (Chapter 2) to survey the work of computer science research on painterly rendering.

1.3.3 Computer Music

Digital music, also known as computer music, is probably the field that has attracted the most attention from computer scientists and engineers, and is the most established form of digital arts. There is a dedicated organization known as *International Computer Music Association* (http://www.computermusic.org) promoting computer music research. There is also a dedicated quarterly journal on the topic: *Computer Music Journal.* Another periodical which targets the non-academic readers is the UK-based monthly magazine *Computer Music.* Academic conferences relating to computer music include the *International Computer Music Conference* (ICMC), *Computer Music Modeling and Retrieval* (CMMR) and the *International Conference on New Interfaces for Musical Expression* (NIME). There are some computer science conferences in other fields which have special tracks on computer music, e.g. the *International Joint Conferences on Artificial Intelligence* (IJCAI) and the*National Conference on Artificial Intelligence* (AAAI). The whole scope of computer music is very broad, which can only be sufficiently covered by many books, e.g. [Roa92, Man94, Roa96, DJ97, Cop01, Nel05].

The study of computer music covers but is not limited to the following areas:

Algorithmic composition: It focuses on proposing algorithms to compose new music pieces.

Computer-assisted composition: It aims at providing assistance in a composition process by a human composer, rather than replacing completely the human composer.

Computer music programming languages: This is to design new special purpose languages for computer music applications, including low-level sound synthesis, high-level music production, etc. Some famous ones include ABC, ChucK, CMix, CMusic, Common Lisp Music, CSound, Haskore, HMSL, jMax, jMusic, Max/MSP, Music I, Music-N, Nsound, Nyquist, OpenMusic, Q-Audio, Real-time CMix, SuperCollider SynthEdit, etc.

Digital audio workstation: This is a hardware/software system providing various functions in music promotion: recording, editing, music playback, etc.

Digital signal processing and synthesizer: This approaches music processing and production from a signal processing-point of view.

Human-computer interaction: This aims at new designs of human-computer interaction via hardware or software to make computer music applications work in better ways.

Physical modeling: This is about using physically-based modeling and simulation to synthesize new sound effects, usually through equations or algorithms.

Music information retrieval: An important area as the amount of music data increases at a phenomenal rate; many issues relating to intellectual property, music representation and analysis, special purpose database support, etc. need to be considered.

More information can be found in Wikipedia's computer music webpage (http://en.wikipedia.org/wiki/Computer_music).

1.3.4 Digital Sculpture

Research on digital sculpture can be roughly classified into the category of software solutions and the category of hardware solutions.

For the first category, algorithmic attempts have made dealing with large scale sophisticated geometry models more efficient in terms of the rendering and transmission, more user-friendly in terms of the digital sculpture metaphors and model acquisition, and more flexible and accurate in terms of the model representation. These studies are known to the general graphics community as *3D graphics*, and are covered in major graphics conferences like ACM Siggraph (www.siggraph.org) and Eurographics (www.eg.org). Two biennial specialized conferences are entirely dedicated to these studies—the *International Conference on 3D Digital Imaging and*

Modeling (www.3dimconference.org) and the *International Symposium on 3D Data Processing, Visualization and Transmission.*

As to the latter category people are fascinated by new hardware and what they can do. Collins [Col97] mentioned a comprehensive set of equipment essential for digital sculpture practices, which are organized into three groups: 1) Those for the purpose of data acquisition, including scanning probe microscopes, confocal microscopes, 3D laster scanners, scanning electron microscopes, MRI machines, CT scanners and 3D Ultrasound machines. 2) Those for the purpose of data visualization, including Cave Automatic Virtual Environment (CAVE), LCD stereo shutter glasses, Virtual Reality (VR) headsets. 3) Those for the purpose of form realization, including 3D printers, rapid prototyping systems such as computer-aided cutter/plotter devices, laser sintering/fusing machines, thermoplastic extrusion systems, stereolithographic systems, computer-controlled plasma and laser cutters, Electro-Discharge Machining (EDM) systems, automated hi-pressure waterjet cutters, sand and glass bead blasting equipment, stereolithographic systems and ballistic particle machines. Many of these hardware pieces were originally invented for other applications in such areas as Computer-Aided Design (CAD), visualization, virtual reality, Computer-Aided Manufacturing (CAM) and Computer-Aided Geometry Design (CAGD). They now serve for digital sculpture research and practice, by making the human-computer interaction component of digital sculpture more friendly, natural, familiar and efficient.

1.3.5 Computer Dance

The team led by Paradiso in MIT Media Lab invented an expressive footwear [PH97, PHB00]. They embedded in a pair of shoes a sensory system capable of acquiring 16 degrees of freedoms concerning the tactile, inertial and positional conditions of the shoes. The sensors there communicate with a controlling microprocessor wirelessly. The entire system achieves a greater 50 Hz response rate. Because of the large amount of sensory information being sampled in real time, they can measure the very detailed, versatile and multimodal gestures of human feet. This system represents a significant step forward from traditional foot motion sensory systems which could only capture tapping of toes and heels, or translational positions. The sampled minute foot gestural information is then mapped to certain music patterns so that the dancer can control the progression of the music through dancing. This is the so called *computer-augmented dance performance*, which is the major target application of their system. A wide range of users including gymnasts, jugglers and dancers have tried their system, and improvising choreographers seem to have found the system most useful.

Biehl et al. devised an arm wearable device called the *mobile dynamic music device* based on a biaxial accelerometer to measure the absolute acceleration force of an exerciser's right biceps movement in real time for estimating the pace of the exercising person when he is running or walking. Their system then relies on a derived model based on the exerciser's pace to dynamically adjust the music to be played to the exerciser [BAB06].

Ip et al. [IHT02] proposed a novel digital performing art form based on traditional dancing. In the interactive environment they constructed human body motions are captured in real-time using motion capture devices. The acquired motion data are then transformed into interesting 3D visual forms and displayed on a large screen. From an angle, the human motions can be viewed as a special kind of brush, a "body brush" manoeuvered by dancing to paint visual patterns on a large canvas.

1.3.6 Computer Puppetry

The study of computer puppetry is interesting because it is concerned with the motion transferring problem from a human performer to a virtual character. One of the earliest pioneers in this field is Lee Harrison III, who won the 1972 National Academy of Television and Sciences Award for his early work on acquiring a human performer's body motion for controlling the movement of a cartoon character, and for the resultant commercial system called Scanimate which was very popular for TV logo production in the 1960's. The review paper by Sturman on computer puppetry [Stu98] covers this early, seminal system together with several commercially successful computer puppetry companies and systems such as DreamWorks Animation SKG, Inc. (www.dreamworksanimation.com), Simgraphics (www.simg.com), Protozoa (www.protozoa.com), Windlight (www.windwardmark.net), DreamTeam, Digits 'n Art (http://www.dnasoft.com/). Sturman then draws upon experiences in MIT Media Lab's computer puppetry research and discusses three key technical and performance challenges for making successful computer puppetry systems, including body performance, facial animation and lip synchronization.

Concentrating on natural and expressive body performance of computer puppetry, Shin et al. [SLSG01] studied the problem of how to map the motion of a human artist to an animated character whose size and proportion may be very different from the actual performing artist's. The key technical problem their work had to deal with is how to dynamically and efficiently choose the important aspects of the motion features to preserve, during motion mapping in an on-line scenario. This decision on what to respect and what to tailor is necessary because it is not possible to reproduce all aspects of the original motion for a target object having different sizes and proportions. This problem is generally and technically known as *motion retargetting* in computer graphics [RGBC96, Gle97, Gle98, LS99, BLCD02, PSS02, TK05, CBK+06, PL06]. Shin et al. argued that only through a dynamic online decision process could what is important be suitably determined according to the context of the motion. Achieving this goal constitutes the most part of their work. In addition, robustness is another goal in their pursuit since typical captured motion data are very noisy due to the functioning mechanism of the motion capturing devices. And coping with this noisy input in real time for computer puppetry is a challenging algorithm design task. Their system was successfully used to produce daily children's TV programs and for news broadcasting on the election of the Korea National Assembly on Korean national television.

1.3.7 Computer Calligraphy

Artistic characters and font sets have been widely used in postcards, the publishing industry, advertisements on posters as well as video production, etc. If we consider them a type of digital arts, it is probably the most widely deployed digital art form. Calligraphy is like computer fonts "on the loose" because the same character of a calligraphic style may put on a different look in different places, which makes calligraphy a much greater challenge for the computer. In our work we confine the scope of computer calligraphy to be the generation of aesthetic characters automatically. Since the character sets for most of the Western languages, e.g. English, Latin, Cyrillic, and Greek, all have a very small size, typically below 100, manual production of a character set in any customized style is not so big a deal. This is probably one of the reasons why current research efforts on computer calligraphy are almost exclusively on Oriental languages, such as Chinese, Japanese and Korean. The character sets of these languages have thousands or tens of thousands of characters.

Computer calligraphy research on the above three languages tend to be very similar in terms of techniques and algorithms since these character sets share many common features. Dongjun's book [Don07] gives a good introduction to computer calligraphy studies, with a focus on Chinese calligraphy research in particular. In the book they also presented their work on generating new styles of Chinese strokes based on some statistical models. Yamasaki and Hattori [YH96] studied the problem of having a computer to form brush-written Kanji characters based on some calligraphic knowledge. Wang and Lee [WL01] appealed to anisotropic diffusion techniques to turn calligraphic documents into binary forms. Despite the heavy noises usually present in ancient calligraphy writing tablets, they have achieved very satisfactory experimental results. Wong et al. [WLI05] analyzed Chinese calligraphy images to inversely determine the parameters of the paintbrushes used to create a calligraphy writing. Okabe et al. [OSN05] proposed a new rendering method for generating line renditions in paintbrush styles using the Hidden Markov Models (HMMs). Yu and Peng have synthesized very realistically looking Cao Shu styled Chinese calligraphy through texture mapping a parameterized stroke contour [YP05]. Lo et al. [LKWY06] proposed and constructed a robot for creating Chinese calligraphy and paintings. All in all this is still a relatively new area having received far less attention than most other digital art forms. Most of the existent work is still concentrating on the represention issue of aesthetic Oriental characters and the provision of efficient and compact font system support. Part IV of this book looks at some of our work on the automatic generation of artistic Chinese calligraphy.

We have mentioned the font a few times. In fact, there is an intimate relationship between computer calligraphy research and the development of font systems. For the latter the most classical and influential work is Tex and Metafont by Knuth in the seventies [Knu79]. Knuth's work directly or indirectly set off in the following decades a long series of efforts dedicated to research and development of font systems, e.g. [Gli84, FK85, How87, HB91, YH96, BNFR98, ZWS00, TK01, Pac01, BLM01, BOB05, TSW06, LS06, Lar06]. Also related is the study on automatic recognition of characters, more popularly known as Optical Character Recognition (OCR). There is a large body of papers published in such journals as *Pattern Recognition Letters* and *IEEE Transactions on Pattern Analysis and Machine Intelligence* on OCR studies.

1.4 Why Digital Arts Are Computationally Challenging?

In this section we examine a few major hurdles to digital art research. These hurdles collectively make digital art a very challenging area for research.

1.4.1 Lack of Semantic Understanding

Traditionally it is the artist himself who has the deepest understanding of the art pieces he created. What about when the artist is the computer? It is well known that automatic semantics understanding is computationally very difficult to achieve, and is recognized as one of the big road blocks in artificial intelligence research. Little progress has been made over the past several decades. So we have the awkward situation where the machine that has generated a piece of digital artwork does not actually understand its artistic value. That means even when the machine has succeeded in generating an acceptable piece artwork, it does not necessarily know that it has succeeded. This is so because the machine has only blindly followed some preprogrammed routine, or it has generated the result by some random choice. The situation is analogous to that of a student, who never attends a class and knows literally nothing about a course, successfully passing an exam through blind guesses or reciting what is in an answer sheet. It is therefore unlikely that the computer will be able to repeat its success in its future creations systematically.

1.4.2 The Versatile Nature of Art

Having some uniqueness and being able to maintain it is a key to success in artwork creation. Unlike in many industry applications where massive copying happens a lot, copying is fatal in original artwork creation. Therefore to achieve uniqueness or distinctiveness must be included as one of the goals in art creation. To be able to meet such a goal by the computer, a large search space of possible solutions is highly desirable, which could mean some changes to the problem solving structure. But most computer programs are built with fixed routines to address a fixed class of problems sharing a common representation and formulation. Thus the ability to automatically vary the problem solving structure to stretch to the utmost in search of a solution is not always supported. In fact, during design time, the human architect may not even be fully aware of the full spectrum of needs when the program is put to use to create novel artworks.

1.4.3 Aesthetic Evaluation and Feedback

In designing our systems we are constantly aware of the incompatibility, sometimes conflict, between exact and soft reasoning. Computers are designed to operate on binary values and be precise in representation, reasoning and evaluation. In contrast, these functions in our brains do not seem to follow any clear and strict mathematic principle. We commented in the previous section on the hindrance to success caused by the computer's blindfolding in evaluating a piece of artwork. To get around the problem, the presence of a feedback loop might offer some help. This same idea is also commonly entertained in many branches of computer sciences, e.g. the backward propagation mechanism in training a neural network. Because the computer cannot quite tell what is aesthetically pleasing, without the availability of such any feedback signal, performance optimization through any automatic means is hard to realize. The feedback loop helps make iterative improvement possible, which in fact is a strategy used in many other kinds of algorithms. But overcoming this hindrance requires not only ideas from computer science. After all, the whole cognitive mechanism behind aesthetics evaluation in the human brain is still a mystery and likely to remain so a long while. Before the working principles governing the biological process of aesthetics evaluation can be clearly revealed, expecting a functionally comparable or equivalent computational simulation device is fantasy.

1.4.4 Inhomogeneity between the Two Types of Intelligence

As discussed in Sect. 1.1, human intelligence and machine intelligence come from very different roots and are fundamentally very different. This is both good and bad news. Good news because human beings and machines can compensate for each other's shortcomings; bad news because this implies that knowledge is represented and processed differently in each model, making it a barrier to the exchange of knowledge between the two. People and machine perceive things differently, think differently, and consequently also tend to create things differently. To fruitfully combine human intelligence and machine intelligence by grafting one onto the other, we need to find a "cut" by which the two forms of intelligence could be seamlessly integrated. This cut is difficult to find, if one exists, and how the two forms of intelligence may be brought together to meet and communicate is non-trivial.

Recently, a flurry of research efforts has taken place which tries to create a kind of intelligent graphical user interface to put human intelligence into collaboration with machine intelligence. The challenge behind this is how to design the most natural way to carry out human computer interaction. Ill-conceived interaction patterns could easily destroy the creative mood and enthusiasm of the user.

References

[BAB06] Jacob T. Biehl, Piotr D. Adamczyk, and Brian P. Bailey. Djogger: a mobile dynamic music device. In *CHI '06: Extended Abstracts on Human Factors in Computing Systems*, Quebec, Canada: ACM Press, pages 556–561, 2006.

[BLCD02] Christoph Bregler, Lorie Loeb, Erika Chuang, and Hrishi Deshpande. Turning to the masters: motion capturing cartoons. In *SIGGRAPH '02: Proceedings of the 29th Annual Conference on Computer Graphics and Interactive Techniques*, San Antonio, TX, USA: ACM Press, pages 399–407, 2002.

[BLM01] Michael Bernard, Chia Hui Liao, and Melissa Mills. The effects of font type and size on the legibility and reading time of online text by older adults. In *CHI '01: CHI '01 Extended Abstracts on Human Factors in Computing Systems*, Seattle, WA, USA: ACM Press, pages 175–176, 2001.

[BNFR98] Dan Boyarski, Christine Neuwirth, Jodi Forlizzi, and Susan H. Regli. A study of fonts designed for screen display. In *CHI '98: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Los Angeles, CA, USA: ACM Press/Addison-Wesley Publishing Co., pages 87–94, 1998.

[BOB05] Jared Benson, Ken Olewiler, and Nancy Broden. Typography for mobile phone devices: the design of the qualcomm sans font family. In *DUX '05: Proceedings of the 2005 Conference on Designing for User Experience*, San Francisco, CA, USA: American Institute of Graphic Arts, page 58, 2005.

[CBK+06] Cristobal Curio, Martin Breidt, Mario Kleiner, Quoc C. Vuong, Martin A. Giese, and Heinrich H. Bülthoff. Semantic 3D motion retargeting for facial animation. In *APGV '06: Proceedings of the 3rd Symposium on Applied Perception in Graphics and Visualization*, Boston, MA, USA: ACM Press, pages 77–84, 2006.

[Col97] Dan Collins. The challenge of digital sculpture: or how to become better tool users. In*Proceedings of the 6th Biennial Symposium on Art and Technology,* Connecticut College. Available as http://www.asu.edu/cfa/art/people/faculty/collins/digital_sculpt.html, 1997.

[Cop01] David H. Cope. *Virtual Music: Computer Synthesis of Musical Style*. The MIT Press, 2001.

[DJ97] Charles Dodge and Thomas A. Jerse. *Computer Music: Synthesis, Composition, and Performance*. Schirmer, 2nd, 1997.

[Don07] Jun Dong. *Introduction to Computer Calligraphy (In Chinese).* Beijing, China: Science Press, 2007.

[Dur02] Fredo Durand. An invitation to discuss computer depiction. In *NPAR '02: Proceedings of the 2nd International Symposium on Non-photorealistic Animation and Rendering*, Annecy, France: ACM Press, pages 111–124, 2002.

[FK85] David R. Fuchs and Donald E. Knuth. Optimal prepaging and font caching. *ACM Transactions on Programming Languages and Systems*, 7(1):62–79, 1985.

[Gle97] Michael Gleicher. Motion editing with spacetime constraints. In *SI3D '97: Proceedings of the 1997 Symposium on Interactive 3D Graphics*, Providence, RI, USA: ACM Press, pages 139–148, 1997.

[Gle98] Michael Gleicher. Retargetting motion to new characters. In *SIGGRAPH '98: Proceedings of the 25th Annual Conference on Computer Graphics and Interactive Techniques*, Orlando, FL, USA: ACM Press, pages 33–42, 1998.

[Gli84] Ephraim P. Glinert. A large font virtual terminal interface: a software prosthesis for the visually impaired. *Commun. ACM*, 27(6):567–572, 1984.

[HB91] Roger D. Hersch and Claude Betrisey. Model-based matching and hinting of fonts. In *SIGGRAPH '91: Proceedings of the 18th Annual Conference on Computer Graphics and Interactive Techniques*, Los Angeles, CA, USA: ACM Press, pages 71–80, 1991.

[How87] John E. Howland. A system for compiling fonts. In *APL '87: Proceedings of the International Conference on APL*, Dallas, TX, USA: ACM Press, pages 349–355, 1987.

[IHT02] Horace H. S. Ip, Young Hay, and Alex C. C. Tang. Body-brush: a body-driven interface for visual aesthetics. In *MULTIMEDIA '02: Proceedings of the 10th ACM International Conference on Multimedia*, Juan-les-pins, France: ACM Press, pages 664–665, 2002.

[Knu79] Donald E. Knuth. *Tex and Metafont: New Directions in Typesetting*. American Mathematical Society; Bedford, MA, USA: Digital Press; Providence, RI, USA: ACM Press, 1979.

[Lar06] Joshua Larrabee. Dear notebook: font memoirs. *Interactions*, 13(4):10–13, 2006.

[LKWY06] Ka-Wah Lo, Ka-Wai Kwok, Sheung-Man Wong, and Yeung Yam. Brush footprint acquisition and preliminary analysis for Chinese calligraphy using a robot drawing platform. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Beijing, China: IEEE Computer Society, pages 5183–5188, 2006.

[LS99] Jehee Lee and Sung Yong Shin. A hierarchical approach to interactive motion editing for human-like figures. In *SIGGRAPH '99: Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Techniques*, Los Angeles, CA, USA: ACM Press/Addison-Wesley Publishing Co., pages 39–48, 1999.

[LS06] Jonathan Ling and Paul Van Schaik. The influence of font type and line length on visual search and information retrieval in web pages. *International Journal of Human Computer Studies*, 64(5):395–404, 2006.

[Man94] Peter Manning. *Electronic and Computer Music*. Oxford, UK: Clarendon Press, 1994.

[Nel05] Mark Nelson. *Getting Started in Computer Music*. Thomson Course Technology, 2005.

[OSN05] Yuta Okabe, Suguru Saito, and Masayuki Nakajima. Paintbrush rendering of lines using hms. In *GRAPHITE '05: Proceedings of the 3rd International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia*, Dunedin, New Zealand: ACM Press, pages 91–98, 2005.

[Pac01] Keith Packard. The xft font library: architecture and users guide. In *ALS '01: Proceedings of the 5th Annual Conference on Linux Showcase and Conference*, Berkeley, CA, USA: USENIX Association, pages 22–22, 2001.

[PH97] Joseph A. Paradiso and Eric Hu. Expressive footwear for computer-augmented dance performance. In *ISWC '97: Proceedings of the 1st IEEE International Symposium on Wearable Computers*, Cambridge, MA, USA: IEEE Computer Society, page 165, 1997.

[PHB00] Joseph A. Paradiso, Kai Yuh Hsiao, and Ari Benbasat. Interfacing to the foot: apparatus and applications. In *CHI '00: Extended Abstracts on Human Factors in Computing Systems*, The Hague, Netherlands: ACM Press, pages 175–176, 2000.

[PL06] Frederic Pighin and J. P. Lewis. Facial motion retargeting. In *SIGGRAPH '06: ACM SIGGRAPH 2006 Courses*, Boston, MA, USA: ACM Press, page 2, 2006.

[PSS02] Sang Il Park, Hyun Joon Shin, and Sung Yong Shin. On-line locomotion generation based on motion blending. In *SCA '02: Proceedings of the 2002 ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, San Antonio, TX, USA: ACM Press, pages 105–111, 2002.

[RGBC96] Charles Rose, Brian Guenter, Bobby Bodenheimer, and Michael F. Cohen. Efficient generation of motion transitions using spacetime constraints. In *SIGGRAPH '96: Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques*, New Orleans, LA, USA: ACM Press, pages 147–154, 1996.

[Roa92] Curtis Roads. *The Music Machine: Selected Readings from Computer Music Journal*. Cambridge, MA, USA: The MIT Press, 1992.

[Roa96] Curtis Roads. *The Computer Music Tutorial*. Cambridge, MA, USA: The MIT Press, 1996.

[SLSG01] Hyun-Joon Shin, Jehee Lee, Sung-Yong Shin, and Michael Gleicher. Computer puppetry: an importance-based approach. *ACM Transactions on Graphics*, 20(2):67–94, 2001.

[Stu98] David J. Sturman. Computer puppetry. *IEEE Computer Graphics and Applications*, 18(1):38–45, 1998.

[Sum74] R. J. Summers. A computer-aided system (CAS) for the design, manufacture, test, and documentation of digital printed circuit boards. In *DAC '74: Proceedings of the 11th Workshop on De-*

sign Automation, Piscataway, NJ, USA: IEEE Computer Society, pages 273–278, 1974.

[TK01] Sivan Toledo and Lars Knoll. Font subsetting and downloading in the postscript printer driver of qt/x11. In *ALS '01: Proceedings of the 5th Annual Conference on Linux Showcase and Conference*, Berkeley, CA, USA: USENIX Association, pages 23–23, 2001.

[TK05] Seyoon Tak and Hyeong-Seok Ko. A physically-based motion retargeting filter. *ACM Transactions on Graphics*, 24(1):98–117, 2005.

[TLM83] Mikko Tervonen, Hannu Lehikoinen, and Timo Mukari. Integrated computer-aided design, documentation and manufacturing system for PCD electronics. In *DAC '83: Proceedings of the 20th Conference on Design Automation*, Piscataway, NJ, USA: IEEE Computer Society, pages 436–443, 1983.

[TSW06] Stefan Thiemert, Martin Steinebach, and Patrick Wolf. A digital watermark for vector-based fonts. In MM&Sec '06: *Proceeding of the 8th Workshop on Multimedia and Security*, Geneva, Switzerland: ACM Press, pages 120–123, 2006.

[WL01] Shenzheng Wang, Hsijian Lee. Dual-binarization and anisotropic diffusion of Chinese characters in calligraphy documents. In *ICDAR '01: Proceedings of the Sixth International Conference on Document Analysis and Recognition*, Washington, D.C., USA: IEEE Computer Society, pages 271–275, 2001.

[WLI05] Sam T.S. Wong, Howard Leung, and Horace H.S. Ip. Model-based analysis of Chinese calligraphy images. In *Proceedings of the Ninth International Conference on Information Visualisation*, London, UK: IEEE Computer Society, pages 221–226, 2005.

[YH96] Toshinori Yamasaki and Tetsuo Hattori. Computer calligraphy–brush written kanji formation based on the brush-touch movement. In *IEEE International Conference on Systems, Man, and Cybernetics*, Vancouver, Canada: IEEE Computer Society, pages 1736–1741, 1996.

[YP05] Jinhui Yu and Qunsheng Peng. Realistic synthesis of Cao Shu of Chinese calligraphy. *Computers and Graphics*, 29(1):145–153, 2005.

[ZWS00] Douglas E. Zongker, Geraldine Wade, and David H. Salesin. Example-based hinting of true type fonts. In *SIGGRAPH '00: Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, New Orleans, LA, USA: ACM Press/Addison-Wesley Publishing Co., pages 411–416, 2000.