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History of Art About and by Means of Computers

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In the realm of contemporary art and museology, computers linked via Internet have many potential uses. Memory institutions (libraries, museums and archives) have traditionally been concerned with enduring knowledge. The past century saw the rise of broadcast media (notably, radio, television and video). The past decades have seen the rise of unstable media, notably, new forms of contemporary art (kinetic, performance art), interactive video, interactive television and Internet. A first challenge lies in integrating these unstable and broadcast media with the enduring knowledge of memory institutions. From the viewpoint of the Internet there has been a rise in collaborative and personal knowledge, which also need to be integrated with enduring knowledge. According to a recent Japanese report the Broadcast network (TV), communications network (telephone) and the Internet will have an equal status by 2005 and will be completely subsumed by the Internet by 2010.[1]

Fortunately, a number of groups have begun to address these problems, notably through a project of the International Network for the Conservation of Contemporary Art (INCCA)[2]; the International Association of Curators of Contemporary Art[3]; the V2 Organization's Institute for the Unstable Media (Rotterdam)[4]; C3 (Budapest)[5]; ProContra (Moscow)[6], the Zentrum für Kunst and Medienforschung (ZKM, Karlsruhe)[7]; the Ars Electronica Centre (AEC, Linz)[8] and at another level, by the Museum of Ephemeral Cultural Artifacts (MECA).[9]

In addition to these bodies formally concerned with the challenges of cataloguing, describing, and conserving contemporary art, there are both a number of technological developments and new applications in the realm of science which are potentially of great interest with respect to new forms of art. On the technological front, for instance, there are new forms of display, including flat screens, portable screens in the form of telephones, personal digital assistants and personal intelligent assistants. There are also new auto-stereoscopic displays, which allow us to see objects in 3-D without needing special glasses. These will permit us to consult information and images via wireless connections in museums and elsewhere. New virtual work-desks mean that individuals in different locations can manipulate collaboratively objects such as skeletons at a distance.

New techniques by companies such as Hitachi permit retrospective colour conversion of images. If, for instance, I have a faded woodcut of Hokusai, a computer can reproduce the image in its unfaded state. Infrared reflectology allows us to look underneath the layers of a painting.[10] More importantly computers help to contextualize images, books and cultural objects.

The Internet is growing with enormous speed, with an estimated seven million new pages daily. Conservative estimates claim that there are now 2.1 billion pages in all. Enthusiasts claim that there are now over 550 billion items. The nature of the Internet

is changing rapidly also. There are now more than 70 major languages online. The percentage of English sites has dropped to 47% at the beginning of 2001 and is predicted to fall to less than 30 % within three years. The Internet is becoming truly international.

Another technological development of the greatest relevance for modern art is the trend towards nanocomputer technologies, which is progressing on four fronts: electronic, biochemical/organic, mechanical and quantum.[11] One recent report claimed that "1 gramme of dried DNA can hold as much information as 1 trillion CDs."[12] While this is all still slightly futuristic the possibility of computers at a scale of billionths of a meter means that computers will become truly invisible, can be imbedded in every object, and used universally for sharing of information and knowledge. This means that the contents of all the major libraries, museums and archives of the world could theoretically fit into something weighing one gramme.

The Internet began as a scientific enterprise in physics, and soon after, astronomy, chemistry etc. Many of the new techniques being developed in the sciences are relevant for contemporary art. For instance, there is a Molecular Interactive Collaborative Environment (MICE) project, which combines description databases and structure databases in chemistry to produce molecular scenes on the fly. Or to take another example: A company called Asymptote has created a real time visualization of the New York Stock Exchange whereby one can see "literally" how a given stock rises and falls over time. How one captures and stores information about moving, changing, evolving, dynamic objects is equally relevant to chemistry, the stock market, performance art and other dimensions of contemporary art and culture.

Meanwhile, researchers at the Chihara Lab in Japan are working on a virtual piano player.[13] At the Max Planck Institut für biologische Kybernetik (Tübingen), Volker Blanz and Professor Vetter have produced a morphable model for 3-D synthesis of faces (Siggraph 99). Using this technique they can take a two-dimensional image of a face such as Leonardo's *Mona Lisa* and reproduce this in three-dimensional form such that it can then be viewed from different angles.[14] The Miralab (Geneva) did pioneering work on a Virtual Marilyn Monroe.[15] This has led to a the idea of creating virtual celebrities using figures such as Sammy Davis Jr., James Cagney, Marlene Dietrich, Vincent Price, George Burns, W.C. Fields, and Groucho Marx, analyzing video clips of their movements "to create realistic animated 3D likenesses of them for commercials, television, film, and Web sites."[16] Such techniques could be applied to performance art such that we are not only able to record performances and show videos of a given performer, but actually reproduce a three-dimensional avatar which could capture all the effects of the original.

Virtual reality is being applied not only to individual objects but also to buildings and even whole towns: Virtual Paris (one by Canal+ another by France Telecom) and Virtual Helsinki are two striking examples. Historical applications of this principle include the Nuovo Museo Elettronico (NUME) project whereby the inner city of Bologna can be followed dynamically from the year 1000 to the present.[17] Such developments introduce a new level of contextuality for objects which has enormous consequences for the future treatment of art history. It means, for example, that we can trace how objects move from an original context in a church to a private collection and then to a museum.

This contextualization can take many forms. In Venice, there is a well known painting by Carpaccio showing two ladies and dogs. In the Getty Museum (Los Angeles) there is a landscape painting by Carpaccio showing persons fishing using bows and arrows. The two panels were originally a single painting, which was sawed in half. Using computers we can reconstitute the original and show what it was like. This cannot replace the original, but by placing these beside the panels now in Venice and Los Angeles the original whole is revealed in new ways.

Contextualization can show us different sides of a museum object not normally visible, such as the underside of a vase, or different layers of the surface. Contextualization can show us copies, versions, and variants of a given painting. Using new kinds of portable personal digital assistants we can potentially consult such materials by Internet via wireless connections. Contextualization can also show us reconstructions of objects and sites. If I am standing in front of Abu Simbel, computer reconstructions can show me various scholars' interpretations of how it once looked. Contextualization can show me the space of Raphael's *Stanze* in virtual reality. It can also take me into the spaces Raphael depicted on the walls of those spaces. A future history of art will not just be records of spatial images. It will take us through the spaces of those images. Instead of just seeing a picture of an ideal Renaissance city we will virtually walk through its streets, thus giving a new twist to the historian Ranke's quest to know how it actually was (*wie es eigentlich gewesen*).

Paintings and cultural objects are collected in museums and galleries. The information concerning them is in libraries and archives. To connect these is another dimension of this contextualization provided by the Internet. Here virtual reference rooms, which are the search methods of the collective memory of mankind, will play an increasingly important role. In the longer term, we need new ways of linking
a) the pointers to knowledge (finding aids via reference rooms) with b) full contents (using new analysis tools made possible through the introduction of Standard Generalized Markup Language and eXtensible Markup Language) and c) the interpretations of these contents.

Such new contextualization is part of a more profound change introduced by the new media. As the late Marshall McLuhan pointed out, the medium is the message, and each medium changes the nature of what is communicated. Printing presented everything in linear, static, form. The new Information and Communication Technologies (ICT) allow knowledge to be presented dynamically. For example, in print media, the goal of art history was the *catalogue raisonnée*, a static list of all the paintings of a given artist. That list was different in 1700, 1800, 1900, before the Rembrandt Commission, after and so on. A computerized list can potentially include all these different static lists and present the appropriate one on the fly. It can do the same for lists of manuscripts by Leonardo or lists of instruments of Faraday, for different transcriptions, translations, interpretations and criticisms. As such, the new media imply a new approach to dynamic knowledge.

An important dimension of this dynamic knowledge, is that we can potentially connect a given fact, event or story with a number of viewpoints reflecting those of a given city, region, country or from international viewpoints. In the past, print culture produced one book for a city's viewpoint (periphery), another for a region's viewpoint

(provinces), another for a national viewpoint (centre) and yet another for an international viewpoint (world centre). These viewpoints were typically seen as if they were mutually exclusive with the assumption that they were hegemonically determined and that ultimately only the one with the greatest might was right. The new media invite an approach where these viewpoints are complementary. Evolution is embracing not replacing and hence former competition leads to new forms of co-opetition and co-operation.

Technology was traditionally concerned with producing generic, universal rules. Culture is concerned with unique expressions. The new technologies introduce possibilities of linking universal rules, such as the standards for building intelligent doors using Industry Foundation Classes, with particular examples of doors found in the context of art history.

In the past, our history books typically reported on a monument such as the Colisseum as if were the only one, telling us nothing of the copy in El Djem, Tunisia, or the 25 other near copies and over 150 imitations spread throughout the Roman empire. Computers can make such connections visible. They can also make us aware of synchronicity at a new level. For instance, in the West we are all familiar of the period 1400-1440 as a first flowering of the Italian Renaissance, the time of Lorenzo Ghiberti, Fillipo Brunelleschi and Leon Battista Alberti. Most of us forget that this was also the time of a new town hall in Brussels (1402), the Palace Museum in Beijing (1406-1420); the Torre de las Infancias in the Alhamra (finished 1408); the Ulugh Beg Madrasa in Samarkand (1417-1420), the Altar of Heaven in Beijing (1420) and the rebuilding of the Doge's Palace in Venice (1424).

Implicit in this new awareness of synchronicity is a much larger view of art history. In the nineteenth century, the idea of progress led many art historians to assume that the history of art could be reduced to a single goal such as imitation (*mimesis*). In retrospect, it is clear that there are at least six fundamental goals of art. In pre-literate cultures there is: 1) connecting, whereby an object serves as a totem which connects us with a magical world beyond the physical world and 2) ordering, whereby the creation of patterns and ornament become a means of linking with the divine or an end in themselves.

In literate cultures there is: 3) imitating (*mimesis*), whereby one imitates beauty in the physical world but usually combines a number of exemplars to arrive at an ideal which goes beyond the originals; 4) matching, where the quest for copying an existing object becomes an end in itself; 5) mixing, where this quest for copying the physical world realistically is consciously mixed with distortions which leaves the original recognizable and yet transforms it and 6) exploring, whereby one introduces into the process elements such as chance and abandons realism as a criterion (e.g. Jackson Pollock).[18]

In pre-literate culture, their expressions of belief are that which we now, in retrospect, call their art. In literate culture, beliefs become written and that which we now call their art are the expressions in various media (painting, sculpture, dance, music) of these written beliefs. In the West, it is typically the *Bible*, which serves as a point of departure. From an international viewpoint, it is clear that in Persia the *Shanahmah*, in India the *Mahabahrata, Ramayana* and *Buddhist Texts* function in a similar way.

One measure of an advanced culture thus becomes measuring the richness and diversity of the expressions inspired by these fundamental texts. From a global point of view this points also to two interesting differences between East and West:

1) Whereas the West typically emphasizes the (static) fine arts (mosaics, illustrations, paintings, sculptures), the East, gives greater emphasis on the (dynamic) performing arts (theatre, marionettes, dance, music) as expressions of these fundamental beliefs.

2) Whereas the East typically uses art as a means of bridging the subject and object (and as such producing an advanced version of the goal of connecting), the West, increasingly uses art as a means of separating subject and object and hence creating aesthetic distance. The Byzantine tradition of icons offers an interesting middle way between these two traditions.

A future art history needs to respect these fundamental differences and help us to understand their origins, their fundamental reasons and their consequences. The contextualization of art and knowledge implied by the new media will reveal that many of the themes which we think of as modern are commentaries on, extensions of or conscious variations on this earlier traditions. The seemingly abstract paintings of bridges by Monet at Giverny grew out of decades of painting realistic versions of the same theme. Classical Greek subjects such as *Three Graces* or *Venus* recur in unexpected forms in modern art. Similarly, traditional themes such as an artist painting or a person reading recur in new ways in contemporary art.

The great religious texts of the major cultures inspired not only art but also literature.[19] Thus the *Bible* inspired Dante's *Commedia*, and Milton's *Paradise Lost*, which in turn inspired many new expressions of art. From this emerged an idea that if one could identify the corpus of these seminal books one would arrive at a canon whereby culture could be defined: that culture lay somehow in the sum total of a) these precious texts shared by every cultured person, b) the images and c) other expressions, which these texts inspired. Culture lay somehow in a shared heritage.

Perhaps the most dramatic step introduced by modern art in the twentieth century was to challenge this fundamental assumption about culture necessarily being a shared heritage. They saw making commentaries on the *Bible* or other classic texts as a limiting factor and assumed that by challenging or abandoning this constriction they would greatly expand the realms of their expressions.

In one sense they were right. By using personal stories from a) their own lives, b) their immediate surroundings or c) exotic topics from unfamiliar cultures (e.g. Gauguin's use of Oceania) as points of departure for their expressions, the potential range of topics greatly increased. But this enormous gain in external images came at a considerable price of imposing on viewers new challenges of comprehension. As long as there was a canon of texts and images, one could assume that everyone in the community, everyone who was cultured, would understand expressions deriving from these basic texts and images.

Modern art increased greatly the freedom of the artist at the cost of imposing an almost impossible burden on the viewer. For the so-called beholder's share, increased enormously. Instead of needing to know a single canon of classic texts and images, viewers now needed to know this canon plus have knowledge of the lives of thousands of modern artists, hundreds of environments and potentially hundreds of unfamiliar cultures.

As long as there was a single canon one could give each aspiring member of the cultured world the equivalent of a Baedecker, or a Guide Michelin and be finished. In a world, where there were dozens or even hundreds of canons the amount to be learned was overwhelming. This changed the relations of text and image. During the Middle Ages where texts were not readily or universally, accessible, images were often added to the text by way of illustration.

During the Renaissance, after the advent of print culture in the West made access to a basic corpus of texts increasingly widespread throughout the community, it became ever easier to separate expressions in the form of images from the texts on which they were based. If every literate/cultured person read the *Bible*, one could represent a nude woman and man with an apple tree without needing to explain that this was *Adam and Eve*, or show a young man killing a giant with a slingshot without explaining that this was *David and Goliath*. Hence, joining a corpus/canon with culture meant one could separate this textual canon from its visual expressions.

Paradoxically separating the canon from (one's definition of) culture meant that one increasingly needed to join one's multiple textual canons with one's visual expressions. Hence, one of the great, and as yet too little studied areas of modern art lies in the rise of a new kind of precious illustrated book (*Malerbücher, Künstler-bücher, Livres d'art de luxe*). The greatest artists of the twentieth century (including Max Ernst, Pablo Picasso, Pierre Bonnard, Salvador Dalì, David Hockney, and Francis Bacon), found themselves both abandoning a single canon and then illustrating numerous alternative canons in order to convey the complexity of their expressions.

The challenges faced by contemporary art at the beginning of the 21st century heighten the problems faced by the pioneers of modern art. In the late 19th and early 20th centuries there was a problem of challenging the canons of the Greco-Roman and Judaeo-Christian traditions and exploring some exotic cultures as if they could be absorbed within these traditions. In the 21st century, globalization means that all the great canons of the world (Aztec, Chinese, European, Indian, Persian, Russian etc.) potentially need attention. And in a truly global village exotic places are no longer frontier posts on our mental maps, but potentially every place which is not in our regular experience.

In the 1960s, when McLuhan spoke of the global village, he emphasized that we are, or can be, in contact with persons all over the globe as if we were members of the same village. In the meantime, we have come to recognize that this privilege brings the same kinds of challenges which modern artists, half unwittingly, began unleashing just over a century ago. If we are not to fall into the traditional traps of cultural imperialism and artistic colonialism, then the more freedom we have in expanding the horizons of communication, the more we need to admit our own ignorance. Either we

keep imposing our own narrow canons, or we need to learn about an amazing number of canons unfamiliar to us.

In this context also the new technologies offer new possibilities. The 1960s introduced the idea of virtual reality: that one could create electronic equivalents of physical reality. The 1990s introduced an idea of augmented reality: that one can superimpose on either the physical world or on electronic versions of the physical world, relevant information and knowledge. For instance, on the image of a bookshelf, we can superimpose information about which new books were added today, which were loaned out etc. Or on the night sky or an image thereof we can superimpose a map of the Greek constellations.

A notion of augmented knowledge and culture takes this idea further. While looking at the night sky we can superimpose not only the Greek constellations but also the Persian, Indian, Chinese, Aztec and indeed any other constellation which has been developed. As such we can learn to see the night sky not only as the Greco-Roman tradition taught us to see it, but in as many ways as there are different cultures in the globe's many villages.

In the past, there was tourism, which was theoretically uniform but unwittingly different. Florence and Rome were goals for all cultured travellers. But German travellers studied through the eyes of German guidebooks (Baedecker), the French through their guidebooks (Michelin) and so on. They saw one place from the viewpoint of their own culture.

Augmented culture departs from the assumption that these viewpoints can be made accessible wittingly. Hence, in preparing for or on arriving in Florence, we can choose whether we wish a tour of the city in the manner of a Victorian English person, a mid-twentieth century German, or a contemporary Japanese person.

In a truly global village, this new kind of Florentine experience can be applied to all the great historical cities be it Cuzco in Peru, Kiev in the Ukraine, or Nara in Japan. To achieve this means, of course, that we need a far greater amount of contextual-ization. A Victorian Lady from London visiting Florence in 1890 could be assumed to know Biblical stories, and to be familiar with Dante, Boccaccio and Petrarch. A person from London in 2001 visiting non-European countries will usually not know let alone be familiar with equivalents in the country they are visiting. So augmented culture needs to provide not just a translation of the object but also provide online access to the canons on which it is based.

For instance, in looking at a Japanese Buddhist statue in Kyoto, it may be necessary to understand how this is a variant of a Korean statue, which itself stemmed from China and ultimately from India. Augmented culture thus leads to new kinds of comparative mythology and religion, as well as comparative literature and art history. Today many persons still assume that the biggest problems of digital culture lie simply in scanning in objects. In light of the above, we can see that the real challenges lie elsewhere. Ultimately the new technologies entail a complete reorganization of knowledge as we now know it.

In this context, it is useful to return for a moment to a number of the questions which are seen as basic in discussions of contemporary art today. For instance, there is great concern about the instability of new media, about changing operating systems, machines etc. These problems face all dimensions of society and since they affect the future of our economy these are problems, which will undoubtedly be solved. A decision in the past year by numerous national governments (including China, France, and the United States) to make Linux their official operating system may indicate an important new direction. Some believe that culture should also have open source for its basic infrastructure.

If artists are the early warning systems of society as McLuhan said, or the researchers of future knowledge as the neo-Kantian, Cohen, said in the 1890s, then it is not surprising that they are continually pushing the potentials of new technologies to its limits, constantly causing problems for those who would like to collect and maintain their works. Here some would have artists limit themselves to enduring works, but to do so would be to impose limits on the boundaries of freedom, which they are attempting to expand.

In the case of those at the frontiers of performance art and happening art, who emphasize the evanescent moment as an integral dimension of their work, perhaps we need new approaches, which draw more on the examples of music and dance rather than the examples of traditional museums and galleries. In the case of music, we store *a*) the notes of Wagner's music and *b*) we record a given performance by von Karajan, but we do not attempt to store Von Karajan and the Berlin Philarmonic in a display showing the way they were on given day in 1979. By playing *b* we can give a good impression of that performance and by studying *a* and *b* we can theoretically come close to copying what is ultimately a unique experience. Similarly in the case of performance art, happening art and other unstable media, we can copy the ingredients in such detail as to make them repeatable without trying to keep fixed displays which were intended to record aspects of change, decay or even dissolution.

There is considerable debate about the future of authorship. It is useful to recall that such questions inevitably arise with the introduction of new media. The advent of print, for example, brought into play typesetters, printers, editors, and distributers (all of whom were subsequently subsumed under publishers) and quite separate from the authors. The seventeenth century brought the advent of new etymological dictionaries (e.g. Della Crusca) and the eighteenth century brought the rise of encylopaedias (e.g. that co-ordinated by Diderot and D'Alembert) which went far beyond the work of a single individual. The new media have introduced new virtual laboratories and collaboratories where hundreds and sometimes thousands of individuals are entailed. All this does not lessen the reality of the contributions of distinct individuals. In a world of new networks of interdependency we need new ways of acknowledging honestly all the contributors within those networks. New media artists who require the collaboration of computer programmers and others for their work are therefore not alone. They are part of a larger trend where we are all more interdependent.

There are great debates about the market consequences of digitization, as if it were merely a question of whether there will be more equivalents of postcards and posters sold online versus in museum shops. One of the deeper insights connected with McLuhan's dictum "the medium is the message" was that every new innovation brings

with it a context of unexpected effects which are usually more important than the initial technology. Printing was officially about books, but as McLuhan showed in the *Gutenberg Galaxy* its effects went far beyond printed letters on a page. Airports may seem to be about airplanes, but their effects entail large places where many persons are hired to clean, refuel and maintain the aircraft and even greater numbers are needed for the restaurants, hotels, shops, and casinos needed to deal with the passengers. So too is it likely to be the case that the business of computers lies not so much in regular hardware and software but in the context surrounding these, in unexpected areas such as:

1) creating new kinds of nano-scopic devices which can eventually be introduced into every art piece around the world. In the 20th century Walter Benjamin confronted us with the problems of art in a period of unlimited reproduction. In the 21st century we may discover that these reproductions can complement the original and that there are many new jobs in expanding our definitions of intelligent objects to include historical and cultural dimensions.

2) producing new kinds of knowledge packages which are combinations of traditional tourist guides and encyclopaedias. If tourism becomes a quest for understanding as opposed to just seeing, serious tourists may find themselves preparing for larger journies by seeing a number of educational programmes via video on demand or even enrolling in special courses to learn about the art and culture of a given country.

There are always those who attempt to deny the words of Solomon that there is nothing new under the sun, and there are always those who believe that what they do is completely new, and would have us ignore everything before their own arrival. The only true test of originality is to see where an object stands in the context of what went before. It is relatively easy to seem a genius in an isolated village of 100 persons. It is considerably more difficult to seem a genius when one is faced with the examples, of Plato, Aristotle, Leonardo da Vinci and their equivalents in all the great cultures of the world. In this sense, the future of memory and its continuous extension is our only hope for true humility, our only hope for a future, which does not unwittingly replicate the past. Only if contemporary art continues wrestling with the eternal questions can it hope to find answers, which will be eternally interesting.

Notes

[1] The themes of this paper are discussed in more detail in an upcoming book by the author entitled: *Understanding New Media: Augmented Knowledge and Culture.*

[2] See: http://www.icn.nl/english.6.2.html

[3] See: http://www.iktsite.org/

[4] See: http://www.v2.nl

[5] See: http://www.c3.hu/

[6] See: http://www.procontra.danet.ru:8101/eng/program/program.htm

[7] See: http://www.zkm.de

[8] See: http://www.aec.at

[9] See: http://www.edgechaos.com/MECA/MECA.html

[10] Cf. the author's "Frontiers in Electronic Media", *Interactions Journal of the ACM*, New York, July-August 1997, pp. 32-64.

[11] See: http://www.mitre.org/research/nanotech/futurenano.html

[12] *BBC News*, 12 January 2000.

[13] See: http://www.kyb.tuebingen.mpg.de/bu/people/volker/. For analogous work in the US see: http://www.latimes.com/business/20010205/t000010695.html

[14] See: http://chihara.aist-nara.ac.jp/public/research/research.html

[15] See: http://www.miralab.unige.ch/MARILYN/marilyn3.html

[16] Alex Gove, "Virtual Celebrity Productions puts the dead to work," *The Red Herring Magazine*, January 1999.

See: http://www.rhventure.com/mag/issue62/animation.html

[17] See: http://www.comune.bologna.it/bologna/nume/numeindex.htm

[18] "Goals of Culture and Art," Lecture to the IIC, Kuala Lumpur, September 1999.

See: http://www.mmi.unimaas.nl also on the site of the International Institute of Communications, http://www.iicom.org). Published electronically in TRANS. Internet-Zeitschrift für Kulturwissenschaften, vol. 1, Vienna.

See: http://www.adis.at/arlt/institut/trans/0Nr/veltman1.htm.

[19] Cf. Northrop Frye, *The Great Code. The Bible and Literature*, New York: Harcourt Brace, 1983.

This chapter is a brief summary of the history of Computers. It is supplemented by the two PBS documentaries video tapes "Inventing the Future" And "The Paperback Computer". The chapter highlights some of the advances to look for in the documentaries. In particular, when viewing the movies you should look for two things: The progression in hardware representation of a bit of data: Vacuum Tubes (1950s) - one bit on the size of a thumb; Transistors (1950s and 1960s) - one bit on the size of a fingernail; Integrated Circuits (1960s and 70s) - thousands of bits on the size of a The history of computing is usually told in terms of the hardware and as a result we tend to think of progress as how much smaller, faster and cheaper computers are. Computing isn't just applied electronics and there is another side to the coin.Â Although computer hardware has changed dramatically in a very short time its basic principles have remained the same.Â meaning subtract contents of memory location x from the contents of memory location y. A program would then be written as a long list of numbers as in 01 10 15 02 18 17 and so on..Â At this early stage programming was the art of putting the machine instructions together to get the result you desired. Machine Code Problems.