Computer Applications in the History of Art

A Perspective from Birkbeck College, University of London

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Whereas historians have been readily using computers for their research for several decades, the application of information technology within the world of the history of art has, until recently, lagged somewhat behind. Much of this tardy progress was due to a fundamental difference between the two disciplines, that being art historians' use and analysis of images. Coupled to this have been the limitations of the ability of computers to handle high resolution graphics and thus display acceptable quality images.[1] It is only within the past decade that new enabling technologies (particularly graphics cards and the ability of commercially available software programmes to handle 24 bit images) have created new possibilities for "high-resolution" electronic digital imaging on affordable computers. This paper aims to be an overview of some of the innovatory applications of computers within the field of the history of art and is centred on the research and teaching activities of the Department of History of Art, Birkbeck College, University of London.

Until the advent of the personal computer at the beginning of the 1980s, few art historians working within universities took the opportunity of using computers. Those that did brave making contact with colleagues from the

[1] By acceptable quality I mean true-colour (24 bit images) of sufficient spatial resolution to prevent readily observable on-screen from an average viewing distance. 500 × 500 pixels has proven to be about the base level.

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other side of the science/art divide were usually directed towards the central computer centre where a terminal could be used to log onto a mainframe. Given the lack of high quality graphics, these pioneers were channeled towards using mainframe computers to carry out text-based database projects. Thus these early applications mirrored the work of other arts-based users, most notably historians. One art historian who effectively used a mainframe computer for his research was Dr. Tim Benton of the Open University (UK) who used the GOS database to create a catalogue of the architectural drawings of Le Corbusier on the University of Cambridge mainframe.

The significance of the introduction of the *IBM PC* in 1981 is already widely acknowledged as one of the major landmarks in the progress of information technology. This machine was designed for the office and the home and gave art historians the ability to come to terms with the implications of the application of the information technology revolution within their own environment. This is an important consideration since undoubtedly many art historians have educated themselves in terms of the application of computing to their discipline and their particular areas/subjects of teaching and research. PC-based word processing and alpha-numeric databasing began to have a significant impact in the art history world by the middle of the 1980s and this produced enough interest, dialogue and debate for a gathering of like-minded people to form a users group.

Coupled to the arrival of the *IBM PC* was the impact of the *Apple Macintosh* and its Graphical User Interface (GUI). While the Macintosh primarily introduced "easy" computing to a mass market the machines strong graphics capabilities, the simplicity of using the *Hypercard* programme and the software utilities which enabled the machine to interface with peripheral devices (particularly videodisk players) had profound implications for art historians. This machine remains very popular, particularly in North America, though in Europe its comparatively high price allowed the PC to gain the larger market share in the academic world.

Following a workshop held at University College London in the Spring of 1985 CHArt (Computers and the History of Art) was formed. Professor Will Vaughan, then of University College London (UCL) and now of Birkbeck College, University of London, proved to be the main mover in both setting up the workshop and creating CHArt. His enthusiasm was based on text-based work he had undertaken on the UCL mainframe computer and his adoption of the *BBC* Micro Computer. He has been chair of the group since its inception.

CHArt

It was clear from the first meeting of CHArt that the group should aim to provide a forum for the discussion of all applications of information technology within the discipline. The international membership includes academic art historians, librarians, museums curators, conservators, scientists and visual resources specialists. However, while text based computer applications were clearly perceived as being of great significance to art historians, the application of the rapidly evolving computer technologies to the creation, management and use of digital images was less distinct. Nevertheless, from its inception members of CHArt have been actively involved in theoretical and applied research into electronic digital imaging.

Since 1986 the organization has held an annual international conference in London. Venues have included The National Gallery, The Victoria & Albert Museum, The Courtauld Institute as well as at Birkbeck College. In 1989 a book based on papers presented at CHArt Conferences was published.[2]

Initially CHArt produced a newsletter for its membership. The growth in membership and general level of interest resulted in the production of this publication becoming more than a small cottage industry and it was decided to approach a commercial publisher who might be willing to take over the publication and distribution of the CHArt Newsletter. In 1990, following negotiations with Harwood Academic Publishers, an imprint of Gordon and Breach, an international journal *Computers and the History of Art* began publication. To date the articles have been a mixture of papers from previous CHArt conferences together with general papers ranging from computer-aided learning to data logging in galleries, from user requirements analysis to digital image processing. Future volumes will cover certain themes such as computer applications in museums and conservation.

The Department of History of Art of Birkbeck College has a strong representation on the CHArt executive committee and editorial board which in turn serves as useful input for both teaching and research with the department.

MORELLI

The limitations of computer graphics, which still remains a significant issue, has not prevented some highly innovative approaches to the application of

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[2] Anthony HAMBER, Jean MILES and William VAUGHAN (eds.), *Computers and the History of Art*, Mansell, 1989.

computers to analyse images. During the mid 1980s Professor Will Vaughan began a project which he named MORELLI named after the 19th-century art historian Giovanni Morelli.

MORELLI is primarily intended as a referencing tool for art historians. It is based on image processing routines which use a monochrome digital image of a painting stored as a very low resolution image of 64 KByte.[3] It can individualize different paintings, recognize (within "reasonable limits") that different reproductions of the same picture refer to a single image, differentiate manual copies of pictures from the original and associate pictures that are formally similar with each other, without actually confusing them.

The MORELLI programme has demonstrated the enormous potential of digital imaging techniques which use very low resolution images. Work is being continued on the programme, which was originally written in *BBC* Basic on a *BBC* Micro but has been ported to run on PC and *UNIX* platforms.

Future research hopes to examine the use of MORELLI on large image databases and from the findings indicate new applications for both teaching and research. One area of interest is the use of MORELLI algorithms as an utility in an image DBMS. Thus each image would have a small reference file (i.e. 64 K) which could be used for full database searches. Tests have indicated that a *UNIX* workstation (*SUN Sparc 2*) could search several thousand of these reference images per second thus making searches of very large image databases a real-time function.

Collaboration with the Dutch Open University

The Dutch Open University has, since its foundation, actively exploited the potential of computer-aided learning and interactive video.[4] In 1987, the History of Art Department at Birkbeck College began collaboration with the Dutch Open University (DOU) on an interactive computer-aided learning (CAL) videodisc project for use by first year students studying the DOU Visual Arts foundation course.[5] This collaboration was highly beneficial since it gave

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[3] Will VAUGHAN "Paintings by Number: Art History and the Digital Image" in Anthony HAMBER, Jean MILES and William VAUGHAN (eds.), *Computers and the History of Art*, Mansell, 1989, pp. 74–97.

[4] F.H.D. GASTKEMPER, "Computer-aided learning and interactive video in distance education" in *Computers and the History of Art*, Volume 1, Part 1, 1990, pp. 39–48.

[5] Wim JANSEN, "The Dutch Open University Visual Arts Videodisc Project", in Anthony HAMBER, Jean MILES and William VAUGHAN (eds.), *Computers and the History of Art*, Mansell, 1989, pp. 65–73.

important insights into the practical, technical and financial issues involved in the creation of large electronic image banks, set a framework within which to develop a user-requirements analysis for digital imaging systems for art historians and introduced them to the expertise of educational technologists.

Although the videodisc is an analogue storage device, and is not the preferred image storage technology for most art historical requirements, it has shown that it has great potential as a teaching tool. Linked to an *Apple Macintosh* it is very easy to produce simple CAL programmes using *Hypercard*. The possibilities of this combination are being studied and it is hoped that a limited number of CAL programmes using both analogue videodisc and digital images may be introduced as additional teaching tools on some specialist courses.

VASARI

By the mid 1980s the possibility of the applications of computers to the visual arts began to influence a wide range of individuals involved in all aspects of the study and conservation of art. These included photographers, image collections managers, gallery and museum scientists and conservators.

Those involved in photographic image collections creation and management are only too well aware of the limitations of both the photographic medium as a system for accurately recording the visual arts (and painting in particular).[6] These limitations centre around the colour and contrast accuracy of the recorded image together with its stability and permanence.

In galleries and museums the accurate recording of the changes in colour and surface texture (craquelure) of an object have, to date, been limited by existing commercially available technology. Spectrophotometric spot readings of subjectively selected areas of paintings have been made in some galleries and museums for some time but recording the whole surface of a painting has not been possible. Similarly, recording the changes in the craquelure on a painting has been traditionally carried out by conventional photography. Visual comparison of two photographs taken at different points in time has also been conventional practice for those studying craquelure. As with colour difference measurement, the photography used for craquelure studies has been restricted to areas of specific interest on a painting rather than the whole surface.

The VASARI project, a project in the Commission of the European Communities ESPRIT II programme, which was completed in the spring of 1992,

[6] Anthony HAMBER, "Colour Photography vs Electronic Digital Imaging As A System for Recording Works of Art" in *Journal of Photographic Science*, Vol. 35, 1987, pp. 200–208.

was the result of a synthesis of the requirements of several different user groups. The project aimed, and indeed suceeded, in producing a prototype scanner to acquire very high resolution digital (around 20 pixel/mm from an original) to produce colorimetric digital images directly from paintings. Three applications of these very high resolution images were studied: colour difference measurement, surface texture analysis and computer-aided learning.

The chosen platform was *UNIX* running *X11* under *Motif* on a *SUN Sparcstation 2GS* with 32 MByte of RAM and 2 GByte of optical disk storage. Two galleries, The National Gallery in London and the Doerner Institute of the Bavarian State Galleries in Munich, had custom designed XYZ repositioning devices built to accurately move a high resolution CCD camera over the picture area. The camera, a *Kontron Progress 3000* which can resolve 3200 × 2400 pixels, can be moved accurately in front of the painting to take several overlapping subframes which then can be "mosaiced" together using specially written software to form a full view.

In order to obtain colour accuracy images from seven points in the visible part of the spectrum are taken for each frame. A special lighting system using a filter wheel with seven interference filters illuminates the painting through six fibre optic arms as the scanning takes place.

The VASARI project is described in more detail elsewhere.[7] Birkbeck College was involved most areas of the research with particular responsibility for systems design and mosaicing software lead by Dr. Kirk Martinez and Dr. Nicos Dessipris and the PC-based computer-aided learning workpackage, the responsibility of the author, who was also project manager of the Birkbeck team.

The CAL workpackage was able to use some of the findings from the European Commission's DELTA programme. The findings of the exploratory action of the DELTA programme have been fully evaluated.[8] It is clear from these findings that in all aspects CAL is still very much in its infancy. There is a fragmented market and, due to the limitations of the Treaty of Rome, the CEC cannot give the academic world the emphasis it diserves. A methodology to evaluate the didactic utility or efficiency of CAL has yet to be formulated. A Common Training Architecture has yet to be established. Copyright problems

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[7] See Anthony HAMBER, "The VASARI Project", in *Computers and the History of Art*, Volume 1, Part 2, Harwood Academic Publishers, 1991, pp. 3–20 and K. MARTINEZ, D. SAUNDERS and J. CUPITT, "Paintings as numbers" in *Image Processing*, Volume 4, Issue 4, September/October 1992, pp. 10–13.

[8] *Final report on the DELTA exploratory action*, DE2205, May, 1991

have yet to be resolved and, fortunately, these are now rightly appreciated as being fundamental issues which will determine the success of electronic publishing and multimedia/hypermedia applications.

The DELTA exploratory action underlined important elements and characteristics which are key to the development of flexible CAL systems:
- portability
- interoperability
- adaptability
- usability
- reusability of materials
- cost effectiveness.

The leading edge of educational technology research is examining all aspects of hypermedia environments though in many respects these systems are currently more theoretical than practical. Neither hardware platforms nor suitable software (particularly multimedia authoring tools) exist as standard commercially available products. Furthermore, to date, the practical realities of the time/cost considerations in the origination of learning materials (i.e. images/texts) for CAL software applications have been either overlooked or seriously underestimated. Hardware/software tools to handle origination of learning materials need to be developed.

One interesting result of the CAL work carried out with the DOU and on the VASARI project is the manner in which educational technologists and contents specialists (in this case art historians) react to each other. Systems design for CAL systems can be caught in trap whereby user requirements are continually modified as the users/contents specialists learn more about the functionalities possible with the technology. While educational technologists take an approach that they will take the aims and objectives of a CAL programme (say the architecture of Renaissance Florence) outlined by art historians and design and build a system (integrating both hardware and software), art historians may continually ask "tell me what the technology can do and I will design the system and programme myself." How art historians and educational technologists evolve a happy and productive working relationship will be one key element to watch during the 1990s. Undoubtedly art historians will have to address the issue of the new information technologies and the fundamentals of educational technology but, similarly, educational technologists will have to evolve a more refined methodology to take into account their lack of knowledge of specialist subjects and the manner in which they are currently taught.

Even the most fundamental of considerations of digital imaging provide very significant hurdles. The number of different image file formats currently

in use in popular programmes and the number of different variants of these formats places is bewildering, even to the specialist. The situation for still and moving image compression algorithms is also a complex one with a variety of technologies and formats causing many to ponder over key decisions for future projects. Kodak's recently launched Photo CD may be an important step to proving a *de facto* standard though it is not clear how compatible the still image compression technique used is with the JPEG standard algorithm or fractal compression techniques. Similarly moving image compression techniques vary. The size and complexity of multimedia data formats will have to be seriously addressed in order to ensure that data produced today will be future-proof, that is be useable on future computer systems.

The VASARI CAL workpackage examined the potential of CD-ROM as an image/text storage and delivery device. The final CAL demonstrator was a programme based on an exhibition about the techniques of Rembrandt held at The National Gallery in London. It was created using Superbase 4 (using 24 bit images) running under *Windows* 3.0. Some evaluation of the JPEG image compression routine was carried out and it was concluded that the combination of CD storage with JPEG, or other image compression techniques, should have a very significant impact on the potential application of CAL within the field of art history at all levels of education.

Perhaps of more significance will be the rapid development of object-orientated programming which holds vast potential for teachers to create their own interactive CAL programmes without calling upon the services of a production team. *Hypercard* for the *Apple Macintosh* has already been mentioned. *Toolbook* for the PC is a similar programme which allows the user to very easily handle 24 bit images. Furthermore, *Hypercard* and *Toolbook* both have multimedia "extentions" and in future versions they may be powerful, standardized, compatible and affordable multimedia authoring and replay programmes.

MA

The involvement of the department in the various projects mentioned above, coupled to the interest in computer applications in the history of art shown by the CHArt group, led to the introduction of a postgraduate MA course in Computer Applications in the History of Art. The course started in October 1990 and accomodates full-time students on a one year course and part-time students on a two year course. It exploits the full potential of the History of Art computer laboratory which contains 386 and 486 PCs, *Apple* (*Macintosh* and *Quadra*) machines and a *SUN* workstation. There are also videodisc, CD-ROM

drives together with flatbed and 35mm slide scanners. Software available includes *dBase IV*, *WordPerfect*, *CorelDRAW!*, *Toolbook*, *Superbase 4* and *Photostyler* on the PCs. The Macintosh machines have software including *Hypercard*, *Word*, *WordPerfect*, *Superpaint*, *Photoshop* and *Cricket Graph*, and *Mac3D*.

The MA course is designed to initiate students with a B.A. Degree in the History of Art (or with appropriate equivalent qualification) into computer applications relevant to the subject. The course is not aimed at students who have a background in informatics. However, the first two years of the course has included students from a very wide range of backgrounds and degrees of computer literacy. The international nature of the student intake (USA, Spain, Japan, Germany, Italy, Eire) has also provided a stimulating environment for teacher and student alike.

Since computer applications in the history of art is a new and rapidly evolving academic discipline the syllabus is regularly updated. It aims to give students a basic understanding of the principles of computing as well as a knowledge of relevant projects and current theoretical and applied research in the area.

The course consists of four elements:

- **Issues in Historical Computing seminars**
  This is shared with the University of London Computer Applications for History M.A. course. It consists of:
  a. *Approaches and Techniques*
     The "coding debate"; alternative database systems; discipline-specific software; the declarative approach – artificial intelligence and expert systems; record linkage; family reconstruction; simulation and data modelling; pictorial analysis; cartographic methods; the publishing of sources and research; computers and the teaching and presentation of the past.
  b. *Applications*
     Archaeology; art history; bibliography; demography; psephology; measurement and theory in economic history; historical geography; textual studies; onomastics; prosopography.
  c. *Computers and Art History seminars*
     This starts with an introduction to computing and moves on to specific areas which are useful in research, teaching, museums and galleries. Special attention is given to recording and processing images.
     - *Computer Hardware*: chips, processors, instructions, memory, bytes, disks, graphics, communications, optical media.
     - *Software*: programmes, languages, operating systems, multi-tasking, MS-DOS, device drivers, networks.

- *Software packages*: Graphical User Interfaces, wordprocessors, desktop-publishing, databases, spreadsheets, authoring programmes, utilities packages.
- *Hypercard & Toolbook*: principles and programming for hypermedia.
- *Databases*: concepts and principles, examples using *dBase*.
- *Databases*: relational and multi-user.
- *Quantitative methods*: classifying data, cases and variables, introduction to the Minitab programme, tables and charts, cross-tabulation. Summarising data, averages and variation, testing relations between variables.

- **Visual Computing**
  - *Image Capture and Storage*: image capture methods and theory, video, scanners, CCDs, analogue and digital storage, colour, 3D objects, distortion, calibration.
  - *Image Processing*: sampling, aliasing, contrast enhancement, filtering, edge and crack detection, correlation, frequencies (FFT), classification, pattern recognition, mosaicing, comparing visible with X-rays. Compression techniques, DPCM, JPEG, MPEG, Photo CD.
  - *Computer Graphics*: paint, draw, CAD, 3D, devices, displaying 3D, shading and rendering, ray-tracing, animation, physical models.
  - *Imaging Projects*: The Louvre and Musée d'Orsay in Paris; The National Gallery, London; The National Gallery of Art, Washington; The Getty Art History Information Program, applications including systems examining infra-red and X-rays images.
  - *Colour*: perception, colour spaces, measurement and calibration, applications in conservation.

  Projects visits are arranged to:
  - The VASARI project: high resolution imaging of paintings, with visit to the National Gallery laboratory.
  - The Witt Computer Index of the photographic archive of The Witt Library, The Courtauld Institute, University of London.
  - The Buildings of England database: database using *dBase* to database the series of architectural guide books written by Nikolaus Pevsner, a former Professor of the Department of History of Art at Birkbeck College.

- **Application option**

  An option is chosen to concentrate on a specific area. These include:
  - To work with the Witt library of the Courtauld Institute of the University of London on archiving, classification, etc.

- Imaging and Hypermedia which is based entirely on hands-on experience with scanners, videodisks and PC/Macintosh hypermedia primarily using the *Toolbook* and *Hypercard* software programmes.
- An introduction to Programming. Students will study the elements of programming in two languages, Pascal, a high level procedural language offering a good theoretical and practical model for problem-solving with a computer, and Prolog, a modern declarative language which illustrates the potential of logic programming in addressing historical problems.

- **Dissertation**
  This is the major piece of written work in the form of a report on an approved topic of a maximum of 10,000 words. The dissertation is based on independent study on a topic relevant to the course and several students have taken up to option of include the production of a computer based package/programme to complement their written work. Examination of dissertations must be based on the written work rather than the computer package/programme. This can cause difficulties when the quality of the computer programme is a very significant piece of quality work that cannot be adequately reflected in a written report.

EVA

Another significant development of the involvement of the department with digital imaging projects has been the annual *Electronic Imaging and the Visual Arts* (*EVA*) conference, the first being held in 1990 at Imperial College, University of London.

The EVA conference and exhibition is jointly organised by the department and Brameur of Aldershot (U.K.), the prime contractor/manager of the VASARI project.

EVA acts as an international forum for all those interested in the application of digital imaging technology within the field of the visual arts. The participants are international in nature and are drawn from a very wide cross section of the visual arts and the field of information technology. During the first three years of EVA European developments and projects have received particular prominence. Several EEC projects such as VASARI, the Museums Network and NARCISSE (which is involved in digitizing records in scientific departments of several European galleries and museums) have played a central role in forming the parameters though in the most recent conference speakers from the USA and Japan played a prominent role in widening both the geographical scope and

the subjects being discussed. The 1994 EVA Conference will take place in The National Gallery, London at the end of July.[9]

One feature highlighted by the conference is that the interchange of ideas and information between "art historians" and technologists is a crucial element in improving the application of information technology within the visual arts. In certain cases technologists have invented or developed solutions for certain scientific problems. These solutions may be adapted to provide additional solutions in the visual arts world. Similarly the user requirements of art historians have spurred some technologists into new areas of research, or added different perspectives to existing research projects. It is hoped that these features will remain a central part of future EVA conferences.

Conclusion

The application of computer technologies within the visual arts in general, and the history of art in particular, will accelerate dramatically during the 1990s. This has very significant implications for all aspects of the history of art whether it be for teaching, research or collections management. However, multimedia and hypermedia applications for art history will only become realities if the practical considerations of data acquisition and data management are fully understood and suitably addressed. This includes adequate staffing as well as adequate equipment. The corollary of this is that all art historians must be made aware of these issues so that the necessary lobbying for funding may be started sooner rather than later. To explain to funding committees that art historians have more demanding computational requirements than their computer science colleagues may seem daunting but it is a matter which will have to be asserted if computer applications within the history of art are to reach their full potential.

However, as many questions have yet to be asked as those which have received answers. Will, for instance, the art history classroom of the future display high resolution images on large, wall-sized, full-colour LCD devices? Will students research using online digital text together with still and moving image databases to create new data sets which they can then use to make multimedia essays? If so, what are the copyright and reproduction right considerations which must be addressed?

Many hardware and software manufacturers are now of the opinion that users will play a major role in the direction computer applications will take during

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[9] See *Electronic Imaging and the Visual Arts 1992 – Conference Proceedings*, edited by Anthony HAMBER, Brameur Ltd, Aldershot, 1992 (ISBN 0-95199-800-5).

the 1990s. The experience of the Department of History of Art at Birkbeck College has shown that direct involvement in information technology projects has very considerable rewards to offer. The results of the VASARI project and the MA in Computer Applications are perhaps the two most significant examples.

However, while this user-driven approach may not be feasible for many working within the art history world it is important that all those involved in art history take an interest in computer applications. The voices of those involved primary education are just as important as those working on leading edge research projects. The earlier children learn to apply information technology to the study of art the better since in secondary and tertiary levels their ability to exploit the technology will pay greater dividends. There are enormous challenges to be faced but the rewards will be equally immense.