Graphically Speaking

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Digital Art: When Artistic and Cultural Muse Merges with Computer Technology

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If we analyze artistic objects up close, we can describe them at their essence as information content of a specific perceptive nature (visual, auditory, and tactile, for example), displayed by means of physical material (such as stone, paper, and wood). Digital artifacts, or "artistic applications" as they are usually called, aim at displaying information content by materializing concepts in a digital format. Digital art pieces differ from classical ones by the digital nature of their information content and supporting display material (canvas). Artistic creation begins with a concept or an abstract idea, which is gradually modeled into a form of tangible or intangible digital content that can be both the means and the end product.

The digital medium witnessed extraordinarily accelerated technological developments in the 1990s, a period usually referred to as the "digital revolution." Though the foundations of many digital technologies and digital art experiments had been formed up to 60 years earlier, digital technologies have become ostensibly ubiquitous and highly expressive over the last 15 years. Today, more people are exploring innovations in information and communications technology in global communication networks, as well as in media tools, to create new aesthetical representational forms of information. In this article, I will discuss and analyze the concepts and definitions behind digital art and the technological issues related to artistic and cultural heritage applications. I will also provide an overview of the Artech digital art initiative.

Defining Digital Art

The United Nations Educational Scientific and Cultural Organization has recognized digital art through its DigiArts initiative (http://portal.unesco.org/), which incorporates both visual and new technology arts that can be dynamically defined as "the conscious use of skill and creative imagination to produce artistic artefacts and cultural contents using new technologies."

We propose the following definition for digital art: art that explores the digital medium (tools, technologies, and contents) as a process or tool for creation, as an end-product (informative content and support), or as an artistic topic.

History of digital art

Digital art has been formed as much by the development of science and technology as by artistic-historical influences. In the 19th century's first half, several experiments explored technology and mechanical devices to render artistic creations. Two artists, Marcel Duchamp and László Moholy-Nagy, deserve special recognition for their seminal work on the integration of interaction and virtuality (in the sense of the immaterial) in art, as they explored pivotal notions that laid the foundations of today's digital art. In 1920, Duchamp and Man Ray presented "rotary glass plates," an interactive machine that invited users to interact with concentric rotating glass plates to generate visual effects. In 1933, Moholy-Nagy created "kinetic sculpture moving," a device for creating light sculptures by projecting silhouettes in movement. The innovation here that influenced later development of digital art was the shift from object to concept in the form of the "virtual object" that was seen as a structure in the process—sometimes dynamic and volatile—to create expressive effects on the part of the observer as an active player when interacting with the artwork itself. As in Dadaist poetry (the combination of strict rule-based processes), computer art also adopts the instruction as a conceptual element in the creative process. To a certain extent we can argue that creative inspiration should be subject to calculation, as it is becoming an intellectual game based on the combination of information and the exploitation of a precise sequence of instructions.

Another notion that emerged during the pioneering era of digital artwork is randomness—that is, forms of controlled randomness that generate and activate instructions for information access and processing. You'll find the notion of randomness and instruction-based information process in the work of American composer John Cage, who in the 1950s and 1960s extensively explored these concepts. Cage described music as a structure divisible into successive parts that could be filled by means of automatically controlled randomness and instruction-based algorithms.

Controlled randomness, presentational virtuality, and interaction have been the central notions behind emergent artwork from the 1960s to today's digital art. Randomness access opens the possibilities of instant access to media elements that can be reshuffled in seemingly infinite combinations.[1,2]

Digital art, as it is now known, entered the art world in the late 1990s when museums and art galleries (finally) started to incorporate digital art installations and artifacts in their exhibitions and support initiatives in this field. Groups that have supported and initiated digital art consistently over the last 20 years include the NTT InterCommunication Center in Tokyo; the Center

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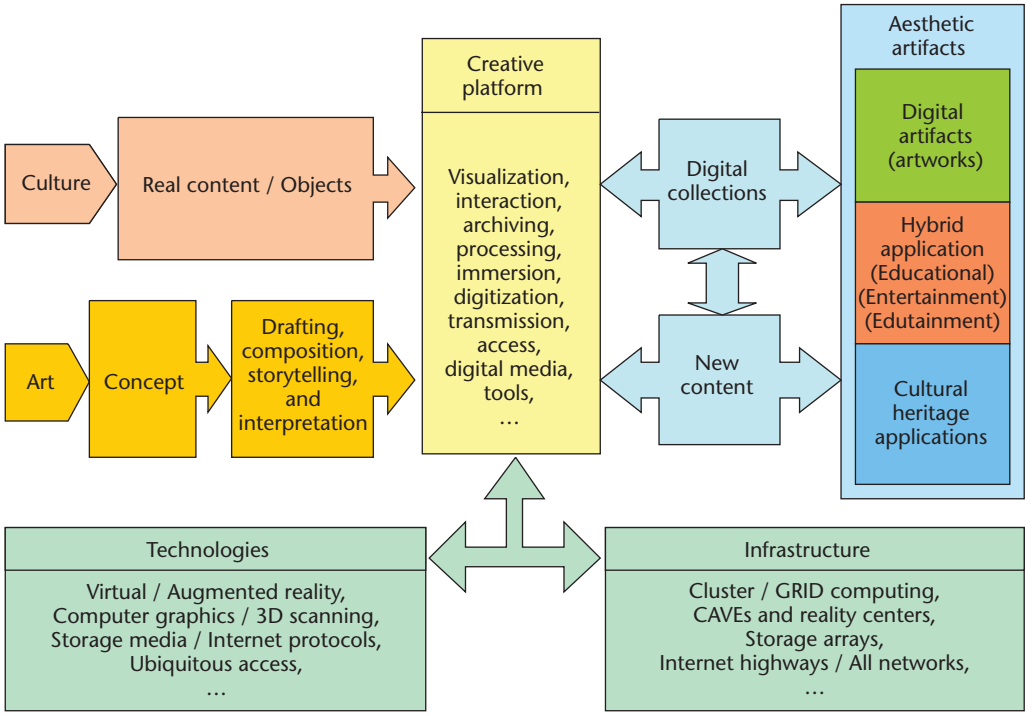

1 Overview of the creative design space.

for Culture and Media in Karlsruhe, Germany; the Ars Electronica Festival in Linz, Austria; and the Dutch Electronic Arts Festival.

Digital and interactive art applies techniques from multimedia, virtual reality, computer vision, and/or digital sound to create interactive installations and produce digital artifacts. You'll find computers being used at all levels of digital media from video, image, and sound production, to allowing an artist to modify, correct, integrate sound, paint over, cut, and paste aspects of digital media. Digital artists consider computer technology as a way to enhance creativity and as a final artifact (artistic object).

Digital art (based on the digital medium) faces a number of unprecedented challenges, if we compare it to traditional art because of the characteristics of the medium itself in presentation, collection, and preservation. Digital art often requires user engagement, which can be highly volatile when its message (content) is not understandable at a glance. It also poses specific challenges in its preservation and collection because of the pervasive characteristics of the digital medium and the continual software and hardware development. This makes digital art, in general, unstable and difficult to deal with.

We need to devise a common design space where digital artists can smoothly progress from the concept/idea to the final product (artwork) while exploring the digital medium to its maximum potential.

The creative design space

I propose an outline for the creative design space, which has been evolving for some years in local digital art and cultural heritage initiatives, such as the Artnouveau (European Project IST-2001-37863) and Artech (European inter-regional project Minho-Galiza—InterReg-III A) projects (see Figure 1). The design space describes the abstract components for the transition from a conceptual level to a final artifact or product. It also defines its own workflow for this transition and helps to identify the key procedures that are and must be performed to reach the desired outcome.

The conception and design of artistic content is at the heart of any artistic work. Content and data from digital repositories can be used as raw materials to implement artistic applications (digital artworks). The key features of any digital art are that digital content should be replicable, extensible, and reusable. Digital content may not be strongly coupled with the intended application, as it is in the case of an audio file, for example, but in certain types of productions, application and content are inseparable.[3,4]

Artistic and cultural heritage applications

The dual manifestation of artistic and cultural heritage applications results in workflow that differs for each application class. Cultural content when applied in an artistic application, such as film, is frequently the historical background or simply the supplier of stylistic ideas to support the narrative and help it evolve convincingly. Building an interactive scenario based on an important era, famous site, or historical fact is often a good starting point for a successful application that is ideal for educating, entertaining, and gaining community interest.

Artistic applications are usually shaped by a high level of free inspiration, where aspects such as historical or cultural accuracy are not essential. Conversely, in cultural heritage applications, artistic freedom may introduce informative elements that can contradict historical facts, resulting in a severe risk of distorting or mocking them.

Each artistic manifestation represents itself as a result of a free aesthetical experience that explores all the design tools and materials available, including the digital ones. For instance, as soon as the World Wide Web appeared, it emerged as a new platform for artistic creation; it allowed the public to become an active participant, turning artistic activities into a real, everyday, and even routine practice for ordinary citizens. The Web supports this extraordinary art movement called Net.Art. From its inception Net.Art has sought to break down autonomous disciplines and outmoded classifications imposed on artistic practices. This has been accomplished by maintaining independence from institutional bureaucracies by working without being marginalized to achieve a substantial audience and by realizing ways out of entrenched values arising from a structured system of theories and the ever-widening gap between art and everyday life. Net.Art has in fact democratized the practice of art.[5]

Is digital artistic creation confined to content production? Surely, it is not—especially when interactive applications and multimedia presentations come into play, where the supporting artifact (canvas) can be itself a piece of artwork.

The creative platform

The creative platform is the collection of infrastructures, tools, and technologies that enables the generation of artistic and cultural heritage content and the storage, transmission, and exchange of digital data. It also provides the presentation space for access to information and content by both specialists and the public.

In most cases, the tools for developing artistic and cultural heritage applications or content are the same. This is due mostly to the fact that the needs for cultural heritage content and the platforms that drive the related applications are affected by, and usually borrowed from, artistic creativity tools and current technological trends.

Digital artists have to learn how to extract the maximum potential from the digital medium (tools, technologies, and content), if they expect nothing but the best results. For instance, artwork based on controlled randomness access usually requires programming skills.

As a whole, the creative design space, as depicted in Figure 1, is not entirely affected either by technological advances or the needs of users and creators. The workflow from one step of content and application creation to another remains the same.[6]

Application constraints

Application constraints identification is one of the most important but often undervalued issues in digital art creation. Inevitably, the correct choice of input and output devices depends basically on the conditions and constraints under which the application will be used. Applications can be classified with the following constraints:

- *Site usage.* The choice of the input, output, and computational hardware depends mainly on the prevailing environmental conditions. In mobile applications for an outdoor scenario, for instance, only lightweight hardware such as light, pocket PCs and binoculars should be used.
- *Environmental conditions.* New input devices like optical tracking systems impose illumination constraints, which restricts their usage to indoor scenarios with controllable lighting.
- *Mobility.* Mobile applications need lightweight hardware, while stationary installations often use large-scale screens for displays.
- *Single/multiuser applications.* Clearly, the number of individuals using an application at the same time possibly requires different input and output devices. Small displays with a restricted viewing angle cannot be used for multi-user applications.
- *User experience.* The range of different individuals using an application plays an important role in the choice of input and output devices, so it is important to know if the system will be used by experts or beginners and whether the application is mainly addressing children or adult users.
- *Addressees.* A typical constraint for the design of a new application is the target group. Such constraints are less technical but have to be dealt with equally.

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Case study: The Artech Initiative

A case study that brings into practice the concepts and ideas behind the creative design space workflow model is the Artech (Art and Technology Industries) Initiative. Established in 2002, Artech concentrated on local activities around digital art to promote a community of digital artists in the Minho-Galiza regions of Portugal and Spain, while establishing an experimental common creative design space for artists. The creative design space was constructed in three locations: Guimarães (http://www.uminho.pt) at the Computer Graphics Center (http://www.ccg.pt) at the School of Engineering at the University of Minho, the Vila Nova de Cerveira International Biennial of Art (http://www.bienaldecerveira.org), and Pontevedra at the Faculty of Arts at the University of Vigo (http://www.uvigo.es/).

The creative design space infrastructure has been gradually implemented over the last five years and includes the following main components:

- An experimental lab is located at each location, functioning on the front end of a creative platform. Each lab integrates hardware and software tools, specific experimental infrastructures (at a virtual reality lab in Guimarães, an audio lab in Cerveira, and a multimedia lab in Pontevedra), and printing facilities to support creative work.

- A common information and communication infrastructure is based on the Torga.net (a trans-Portugal-Galicia communication network connecting the locations of Minho and Galicia [http://torga.net.ccg.pt/]); one access grid room set up at each location; and shared multimedia content repositories made accessible through the access grid. The access grid is an ensemble of resources including multimedia large-format displays, presentation, and interactive environments; it interfaces with grid middleware and visualization environments. These resources are used to support group-to-group interactions across the creative design space.
- Exhibition spaces where artists can present their final artifacts are set up at each location—namely at the Vila Nova de Cerveira International Biennial of Art, Faculty of Arts in Pontevedra, and a future exhibition space at Computer Graphics Center in Guimarães.

The local artistic community is living around art fairs, conferences, workshops, and training actions where they can exchange ideas, present their works, and establish collaboration within the Artech community. Two events deserve special mention here: the Vila Nova de Cerveira International Biennial of Art, which is in its 14th edition, and Artech, the International Conference on Digital and Interactive Art, which has been held alternatively in Portugal and Galicia since 2004 (http://www.artech2006.ccg.pt/).

Use of the common creative design space is growing since the Torga.net network began three years ago. What started out as about two dozen direct and indirect users of the infrastructure has grown to 50-100 today. The artifacts produced within the Artech community are also increasing each year.

The Artech Initiative also promotes postgraduate courses in the field of digital arts and cultural heritage. In this respect, the University of Minho is offering a new master course on technology and digital art (http://www.mtad.dsi.uminho.pt), which aims at forming a professional profile in the fields of digital art, cultural expression, education, and entertainment.

Though the Artech Initiative is still in an implementation phase, the feedback received so far is positive, from the number of artworks presented to the increasing number of users and the rising number of digital art related initiatives in the region. So, we can conclude that the adoption of common creative design space enhances the artistic production and promotes collaboration among the local community of artists. It is an essential component for the development of the local digital art community.

Since its operations began, the Artech Initiative has hosted more than three dozen digital art installations, ranging from pure infotainment applications to more formal artworks exploring different interactive and media technologies such as computer vision, virtual reality, digital sound, and music.

Artech Initiative examples

Artech Initiative events feature three examples of artwork and the relevant application constraints encountered during their setup in the creative design space.

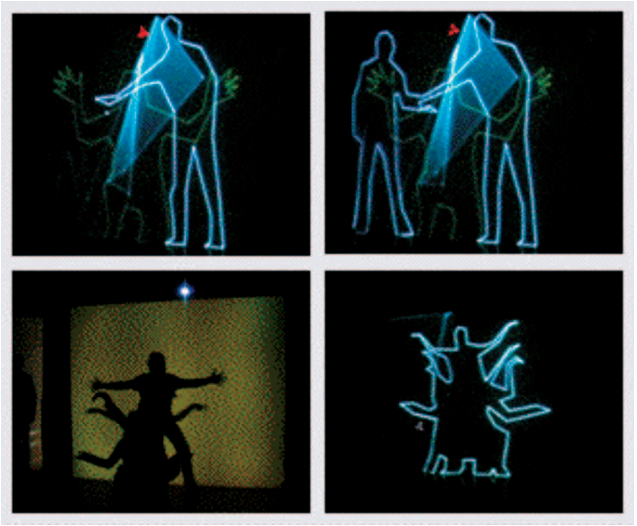
2 User performing in a WAVE installation, as presented at Artech 2004.

WAVE: A virtual audio environment

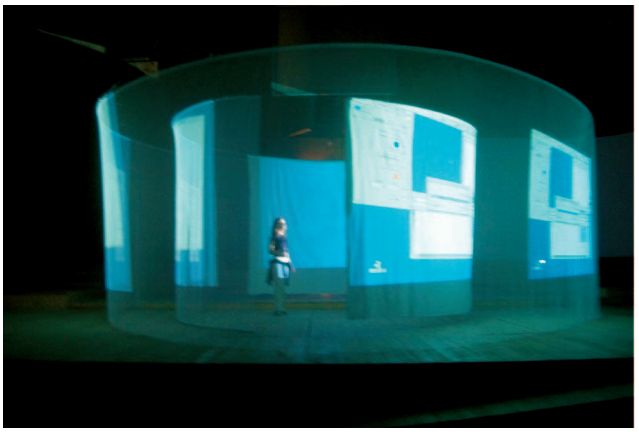
WAVE (Wave Audio Virtual Environment) is an immersive musical instrument based on exploiting the concept of users' micro and macro gestures, sound and musical objects with embedded sound sources and synthesizer sounds, and facilities behind visual and sound immersion. It integrates the real-time displacement of several musical categories of sound objects together with the performance control of external Musical Instrument Digital Interface synthesizers, as shown in Figure 2.

The main application constraints of WAVE are the following:

- *Site usage.* WAVE is for indoor use. The minimum room dimension (4 m. × 3 m. × 4 m.) had to be considered to accommodate the configuration of the loudspeaker set's physical positions necessary for the aural immersion implementation.
- *Single/multi-user applications.* WAVE has been primarily designed for single users. However, a relatively large visual display (preferably stereoscopic) was necessary for the audience to follow the performing actions.
- *User experience.* WAVE addresses different kinds of users, from experts to beginners and adults to children. The system's interaction was mainly based on gestures, that is, hand and arm displacements, as well as finger movements. The I/O devices have been constructed over a 6 DoF (six degrees of freedom) tracking system with enough amplitude to cover all the displacements of a typical user's open arms.
- *Addressees.* WAVE addressees ranged from experienced musicians to people without music background. No evidence of specific constraints was apparent. Based on empirical evidence from usability studies and user surveys, it has been concluded that immersive musical instruments have a significant



3 Displacement installation for body performance presented at Artech 2005.



4 Dynamic topography: a photograph of the installation as presented at Artech 2004.

acceptance, since users have demonstrated a positive intention to use them.[3]

Displacement

Displacement is an interactive installation applying augmented reality technology. It explores computer vision to capture the image of the performing user to generate its geometrized contour while projecting it over a large display. The image projected changes along with the user displacement within the installation area. The user can interact with his or her dynamic contour as well as with other projected objects where collisions produce sound effects. This allows for an audiovisual dialogue between the user and the installation. Visual and auditory elements are tightly linked and cannot be dissociated within each other.

The main application constraints of displacement are as follows:

- *Site usage.* Displacement is for indoor usage. The minimum room dimension (3 m. × 3 m. × 4 m.) had to be considered to accommodate the configuration of an adequate immersion of the users within the audiovisual space.
- *Environmental conditions.* Displacement requires specific illumination constraints to allow the visual tracking of the users' contours. Users' images must be captured against a contrasting background.
- *Single/multi-user applications.* Displacement has been designed for both single and multiple users. The space constraint applies here also (see Figure 3).[7]

Dynamic topography

Dynamic topography consists of a cylindrical interactive multimedia installation. Three projectors spread the information onto three retroprojection screens—a transparent, a plain, and a rough/creased one—to support the historical axis of the work. These screens are surrounded by another one—cylindrical and transparent—whose purpose is to represent the globalization of information in both space and time. The creased screen represents the birth of writing: stone. The plain screen represents the invention of printing: paper. And the transparent screen represents just that: the screen.

The visitor is given a wireless mouse that enables free interaction with the projections throughout the installation that display blocks of combining texts.

A set of fluorescent letters placed on the floor guide the visitor into the center of the installation and across the space and to motivate him or her to explore the installation. The installation also employs sound to emphasize the projections' different aspects.

The main application constraints of typography are as follows:

- *Site usage.* Dynamic topography is for indoor use. Minimum room dimension (15 m. × 25 m. × 5 m.) had to be considered to accommodate the configuration of an adequate immersion of the users within the interactive space. The installation's structure consists of two concentric cylinders with diameters of approximately 15 and 25 meters. The three projection screens (3 m. × 2.8 m.) are placed within the inner cylinder.
- *Environmental conditions.* Dynamic topography requires specific illumination constraints to allow the adequate environment of light and shadow, opaqueness and transparency, and sharp or out-of-focus images in an attempt to create a magical and ritualistic atmosphere.
- *Single/multi-user applications.* Dynamic topography has been designed primarily for both single and multiple users. The space constraint applies here also.
- *User experience.* Dynamic topography addresses different kinds of users: experts and beginners and adults and children. The system's interaction was mainly based on manipulating a wireless interactive device called the "gyromouse." It not only translates the physical movements of the visitor or user within the space, but it also controls cursor movements during the projection. The gyromouse uses the technologies of radio frequency and gyroscope. The gyroscope lets users operate the mouse without a firm support (in the air), and the radio technology makes

it possible to keep control over the cursor even at a great distance from the CPU.[8]

Conclusion

The Artech Initiative will continue its implementation among the different running activities. Future work includes the development of a sketch-based instructional laboratory for Digital Arts and Computer Graphics at the University of Minho based on the intensive use of Tablet PCs, linked by wireless networking and shared information spaces. The artists are expected to develop their projects by exploring visual and auditory plastic materials, where wireless information sharing, annotations, communication, and sketch-based free design are important activities for establishing collaboration among artists, students, tutors, and professors. It is expected that this laboratory will increase the production of artworks with special emphasis on visual and auditory arts for general-purpose presentations.

It is worth mentioning here the setup of a four-face CAVE at the University of Minho. It will enable the development of immersive 3D-animation artworks promoting the establishment of a new line of research in the field of personality-rich virtual persons, vulgo "virtual actors," that explores the Avatar technology and character design. Artistic creation of virtual personalities that is not bound by known scientific laws is a valid and important emerging field for art-related creation, and digital personalities can be employed for a variety of different classes of applications. ■

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References

1. C. Paul, *Digital Art,* Thames & Hudson Ltd., 2003.
2. O. Grau, *Virtual Art: From Illusion to Immersion,* MIT Press, 2003.
3. L. Valbom and A. Marcos, "WAVE: Sound and Music in an Immersive Environment," *Computer & Graphics*, vol. 29, no. 6, Dec. 2005, pp. 871-881.
4. A. Marcos and T. Lavender, "Some Issues on Artistic and Cultural Heritage Applications," *Proc. Int'l Conf. Digital and Interactive Art* (Artech), Nov. 2006, pp. 68-73.
5. Linaza et al., "Recommendations and Generic Framework," Artnouveau Project Deliverables, European Commission, Project ID: artnouveau IST-2001-37863; Deliverable ID: D.5, 2003.
6. S. Göbel, T. Smithers, and M. Schnaider, "art-E-fact: A Generic Platform for the Creation of Interactive Art Experience in Mixed Reality," *Computer Graphik Topics,* vol. 14, Apr. 2002, pp. 18-20.
7. R. Quintas and T. Dionísio, "Displacement: Instalação Musica-Visual Imersiva que Analisa e Retracta a Expressividade Corporal," [Displacement: Installation of Immersive Visual-Music that Analyzes and Portraits Corporal Expressivity] *Proc. Int'l Conf. Digital and Interactive Art* (Artech), Aug 2005; CCG, (in Portuguese), pp. 39-45.
8. T. Pimentel and V. Branco, "Dynamic and Interactive Typography in Digital Art," *Computer & Graphics,* vol. 29, no. 6, Dec. 2005, pp. 882-889.

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