INTERNATIONAL JOURNAL OF
ARTIFICIAL INTELLIGENCE AND EMERGING TECHNOLOGY

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

A Modern Vision for the Applications of Artificial Intelligence and Emerging Technology in Museums and Cultural Heritage

Badawy M. Ismail

Consultant at the National Museum of Egyptian Civilization

Abstract

Artificial intelligence (AI) technologies provide remarkable opportunities for museums to learn more about their visitors, play with their collection data, and together influence how people experience a museum. Artificial intelligence and the potential impact of these technologies in enhancing the user experience have gained an increasingly important presence at the past few Computer Museum Networks conferences. This article will reflect the emergence of artificial intelligence in museums and its role in museum operations as these tools become widely used. As a result of these implications, this article will look at the practical implications of artificial intelligence and how museums can become informed consumers of these emerging technologies.

Smart museums aim to attract more people (children and adults) through augmented reality technology that helps the visitor to understand a work of art or to get easier information about the creator. Today's e-learning applications that use augmented reality.

Nowadays, the development of technology where Augmented Reality (AR) ranks first in the list of most used technologies as far as in the gaming industry as well as for applications based on the concept of educational software applied in cultural heritage. The Smart Museums project aims to attract people of all ages to visit.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

The proposed application uses the capabilities of augmented reality technologies to transform a visit into a museum in an engaging experience full of unforgettable memories. Basically, we can access text or audio information about a work of art or its creator, or we can access photo galleries with works by the author himself.

Keywords: Artificial intelligence (AI) , Augmented reality, Museum, Usability testing.

Introduction:

Artificial intelligence is being lauded as the "future". There is untapped value to be unlocked across sectors looking for their commercial, scientific and educational potential. With machine learning tools and insight more accessible than ever before, museums have the opportunity to innovate and improve in areas that were previously too expensive or too resource-intensive to pursue. Regarding the broader applications of AI, we must admit that creative robots are already creating paintings, writing screenplays and composing music. In the future, will AI write object labels, script guides, and help with interpretation? Should we allow machines to do this?

Stephen Hawking predicts that “computers will outpace humans with artificial intelligence within the next century **(*Ciecko,* 2017)** “This may sound ominous, but we can (almost) be sure that museums and cultural institutions will take into account the best interests of mankind. Artificial intelligence and its place in museums If scathing media coverage and scathing talk about politics are any indication, AI will shape people's lives for years to come. From breakthroughs in medicine to improving spam filters, applications of artificial intelligence and machine learning are growing every year.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

In the museum sector, AI presents a range of opportunities, from new patterns of engagement with collections to institutional advancement initiatives and beyond. From new patterns of engagement with groups to institutional progress initiatives and beyond. However, entry barriers can be high before a sustainable operational impact is demonstrated using many AI applications; Upfront investments to "build from scratch" are out of reach for many museums. Despite this reality (and in contrast to the hype), there is at least one accessible use case nowadays for AI in museum operations: Well-developed digital content is the basis for engaging new audiences through voice-assisted technologies. Looking to the future, museums are uniquely positioned to foster conversations around issues of AI, ethics, impact, and opportunity.

If the popularity of AI-related conference topics continues its upward trend and public use of these technologies similarly grows, we may soon be able to consider the issue of museum readiness beyond the "pilot project" approach to AI. Asking and evaluating questions and continuing to drive dialogue around these technologies is a recent but highly relevant topic for museum conferences and similar forums, particularly those focused on humans. Without a global authority to regulate the development of AI, it is up to the educated public to discern its ethical (and practical) applications. While AI is constantly evolving human interaction patterns - through touch, sound, sight and sound.

The concept of the virtual museum appeared for the first time in 1947 by the scientist Andre Malraux, and the virtual museum is defined as a group of digitally recorded images of historical, scientific or cultural importance that are accessed through electronic documents. The virtual museum offers an unconventional method for communicating with visitors with flexibility towards their needs and interests. The virtual museum takes different forms depending on the museum display scenario, where the museum is presented in a three-dimensional image.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

The virtual museum presents the museum collections through the web, the Internet or the personal computer, and there are three categories of virtual museums on the Internet that have been developed as an extension of the physical museums: the brochure museum, the content museum and the learning museum. The brochure museum is intended to inform future visitors of the museum and is mainly used as a marketing tool, with basic information such as location, opening hours, sometimes calendar events, etc.

(*Teather*,1998) , in order to create the motivation to visit the walled museum. Content Museum is a website created for the purpose of providing information about the Museum's collections. It can be defined by a database containing detailed information about the museum's collections, with content presented in an object-oriented manner. An educational museum is a website, which provides different access points to its virtual visitors, depending on their age, background and knowledge. The information is presented in a context-oriented way, rather than an object-oriented method. Moreover, is improved The site is educational and linked to additional information aimed at motivating the virtual visitor to learn more about a topic of particular interest and to visit the site again. The goal of the Museum of Learning is to bring back the virtual visitor and make them establish a character. Emerging technologies used by virtual museums:

Technological developments that have emerged as areas of critical importance make it possible to use sophisticated tools to provide customized interfaces for creating virtual museums, to design a virtual museum exhibition in many ways **(*Milgram, and Kishino, 1994*)** and to use information vectors to build, acquire and integrate knowledge. New types of interfaces, interaction technologies, and tracking devices are developing at a rapid pace and can be integrated into multimedia VR and interactive AR interfaces [9].

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

Exhibits are intended to be more dynamic and interactive rather than static in nature and authoritative to create a more realistic approach and enhance the experience of virtual visitors. The main features of the online interactive exhibition are:

(a) Multiple contexts so that the user can connect to the gallery in a seamless manner;

(b) Good instructional design.

(c) Proactive learning contexts;

(d) Good balance between learning and entertainment;

(E) The absence of pages full of texts to interfere with the learning experience.

Ways to create a virtual museum:

Include the following *(Styliani* , etal., 2009)

Photography technology-

Virtual museums need high-resolution images in order to provide as much information as possible about the virtual exhibits. It relies on the resolution of digital and traditional high-resolution images. Images produce very large files that are difficult to manage and transfer over networks due to their reliance on bandwidth availability. (slow internet connections). The strategy adopted to counter this problem is image servers that use a “Russian doll” imaging architecture and give the user opportunities for expansion and interaction, because the multiple resolutions of the image are stored in a single file and make it possible to gradually transfer the image. FlashPix and then JPEG2000 are two image formats that introduced a new concept of imaging architecture. It also allows storing metadata.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

This image format is used by various museums such as (***Talagala,1998*** **)**. Some Flash Pix features are certified by the JPEG2000 image format which also has progressive image portability and scalability and some new features that fill in the gaps of metadata insertion and content protection Content of previous standards for digital media encryption. The advantages of the image format have been extensively investigated in research or work and the JPEG2000 format has been adopted by cultural institutions **(Sylaiou,etal.,2004)**.

-Web3D Galleries

Internet technologies have tremendous potential to provide virtual visitors with ubiquitous access via WWW to the museum's virtual environment. The increasing efficiency of Internet connections (ie ADSL) makes it possible to send important media files relating to artifacts to virtual museum exhibits. The most popular WWW visualization technology includes Web3D that offers tools such as VRML and X3D, which can be used to create an interactive image Virtual Museum TheWeb3D Consortium contains standards for real-time 3D communication and the most important standards include: VRML97 and X3D. Since 1997 it has been VRML97 which stands for Virtual Reality Modeling Language. Technically, as a 3D interchange format that defines most of the commonly used semantics found in today's 3D applications such as hierarchical transformations, light sources, viewpoints, geometry, animation, material properties, and mapping. VRML is also defined as a simple, cross-platform language for publishing three-dimensional web pages as well as to provide the technology needed to integrate three dimensions, and transform texts into multimedia into a coherent form. When these types of media are combined with scripting languages and the capabilities of the Internet, a whole new type of interactive application becomes possible." Which makes the presentation of virtual exhibitions possible, the visualization usually consists of dynamic web pages combined with 3D VRML models **(Liarokapis,F etal.,2004)**.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

This can be enhanced with other multimedia information (such as movie and audio clips) and used remotely via web protocols (such as HTTP). A more 3D graphics format, COLLAborative Design Activity (COLLADA) [46] defines an open standard XML schema for exchanging digital assets between various graphics software applications that may store their assets in incompatible formats. One of the main advantages of COLLADA is that it includes more advanced physical functions such as collision and friction detection (which is not supported by Web3D).

The most powerful technologies that have been used in museum environments include OpenSceneGraph (OSG) and a variety of 3D game engines. OSG is a high-performance, cross-platform, open source 3D graphics toolkit, used by museums **(Calori,etal.,2005)** to create more powerful VR applications, especially in terms of immersion and interaction since it supports text, video, audio, and 3D scenes in a single 3D environment.

On the other hand, 3D game engines are very powerful and provide superior visualization and physics support. Serious games are a new concept and allow the collaborative use of 3D spaces that are used for learning and teaching purposes in a number of educational fields. The main strengths of serious gaming applications can be generalized as in the areas of communication, visual expression of information, mechanisms of cooperation, interaction and entertainment. Both technologies (OSG and 3D game engines) compared to VRML and X3D can provide highly realistic and immersive museum environments, but they have two main drawbacks. First, they need advanced programming skills in order to design and implement custom applications. Secondly, they do not have support for mobile devices such as PDAs and 3G phones.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

Virtual reality exhibitions

Virtual reality is a simulation of a real or fictional environment created in 3D through digital technologies that are visually tested and provide the illusion of reality. Over the past few years, modeling software has become affordable and the cost of building virtual environments has decreased dramatically, fueling new application areas such as virtual heritage. For example, low-cost, highly interactive VR experiences for museum visitors can be created on the basis of standard hardware components (a relatively low-cost computer with a cheap graphics accelerator, touch screen, and sensor, for example an inertial cube), and some application software and browser plug-ins. Virtual reality applications can be used by distributed groups of a large number of players, and are immersive and interactive. In a virtual reality environment, participants are immersed in a completely artificial world but there are different types of virtual reality systems, which provide different levels of immersion and interaction. Heim believes that weak virtual reality can also be characterized by the appearance of a three-dimensional environment on a two-dimensional screen **(Heim,1993)**. In contrast, powerful virtual reality is the complete immersion of the senses, which includes immersion screens and tracking and sensing technologies. Common visual displays include head-mounted displays and polarized holographic glasses while inertial and magnetic trackers are the most common positioning and guidance devices. As far as sensing is thought, a 3D mouse and glove can be used to create a sense of control in a physical space. Kivotos is an example of a highly immersive VR environment, a virtual reality environment that uses the CAVE® system, in a room measuring 3m by 3m, where the walls and floor act as projection screens and in which visitors embark on a journey thanks to stereoscopic 3D glasses. As mentioned earlier, virtual galleries in a web browser can be visualized in the form of 3D galleries, but they can also be used as a standalone interface (ie not within a web browser).

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

In addition, there are a number of commercial virtual reality software tools and libraries, such as Cortona, which can be used to create fast and efficient virtual museum environments. However, the cost of creating and storing content (i.e. 3D exhibitions) is too high for medium and small-sized museums that represent the majority of cultural heritage institutions. An overview of the tools and methods is available.

- Augmented reality exhibits

It provides museum visitors with an enhanced experience by visualizing, interacting with, and navigating museum collections among artifacts, or even by creating museum exhibits in an augmented reality environment. Virtual visitors Virtual artifacts can be placed anywhere in the real environment using either sophisticated software methods (eg ….computer vision technologies) or specialized tracking devices (eg Inerti-aCube). Although AR exhibition is difficult to achieve, it offers more advantages to museum visitors than Web3D and VR exhibitions. specially , In the Augmented Reality Museum Gallery, virtual information (usually 3D but can also be any type of multimedia information, such as text or image information) is displayed on video frames captured by the camera, giving users the impression that virtual culture artifacts It already exists in the real environment **(Macariu, and Iftene.,2018)**. Through human-computer interaction techniques, it can Users carefully examine virtual artifacts by tactile manipulation of data (i.e. tags) or sensors (eg pressure gloves). This "augmentation" of the real world environment can lead to easier access to museum information and enhance the impact of the museum exhibition on virtual visitors. The automated tour guide system uses augmented reality technologies for an interactive virtual exhibition and can superimpose meaningful audio on the real world based on the user's location, providing the advantage of enriching visitor experiences.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

The Meta-Museum Guide System **(Mase,K.,etal.,1996)** is based on augmented reality and artificial intelligence technologies and provides a communication environment between the real world and cyberspace to make the most of the museum's archives and knowledge base. Moreover, AR has been experimentally applied to allow visualization of real objects that are incomplete or broken as they were in their original state by overlaying missing parts.

The ARCO system **(White,etal.,2004)** provides customized tools for virtual museum environments, ranging from the digitization of museum collections to the tangible visualization of both museum and antique exhibits. ARCO has developed tangible interfaces that allow museum visitors to visualize virtual museums in Web3D, VR, and AR environments sequentially.

-Mixed reality exhibitions

Mixed Reality (MR) is based on a combination of virtual reality, augmented reality, and the real environment. According to Milgram and Kishino's Virtual Reality and Real and Virtual World series, objects are presented together on a single screen with a visual representation of real and virtual space. 3.6 Touch

The method of touch and feel involves the shape and texture that the observer feels when exploring a virtual object. “Haptic touches make it possible to achieve the extension of visual presentations to make them more realistic, useful and attractive to visitors. The PHANToM device is used inside the museum allowing visitors to touch and feel the virtual reality.”

PHANToM is a desktop ground robot that allows simulating the contact of one finger with virtual objects through a pointing device (such as a pen), as it detects collisions with virtual objects, simulating the sense of touch.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

- Use of mobile devices in museums

Mobile devices represent a wide range, including cell phones, personal digital assistants (PDAs), and tabloids. Improvements over the past few years in optics, processing power and ergonomics have begun in a number of museum applications.

- Conclusions

Various types of virtual museums are discussed in light of a range of classifications. Using imaging technology, Web3D, VR, AR, MR, touch and mobile devices as personal aids, museums can exploit all the possibilities of new media, analyzing and answering in different ways to visitors. It needs intuitive interaction with the displayed content and provides an entertaining and educational experience. It should be noted the benefits of virtual museums in terms of museum curators and in terms of documentation, preservation, research and exhibition. Virtual museums have the ability to preserve and disseminate cultural information in an efficient and cost-effective manner through innovative methods and tools. They are an attractive medium with great attraction to a diverse group of visitors and can promote "real sites" by providing information about museum exhibitions and offering an improved display of museum artefacts through emerging technologies. Various groups of end-users such as tourists, students and professionals can benefit from and meet their educational and recreational needs. Visiting virtual museums can be an enjoyable and fruitful experience that engages the user and helps promote real museums **(Jackson,etal.,1998)**. Virtual museums enrich the museum experience by allowing intuitive interaction with the artifacts of the virtual museum. The comparison between real and virtual museums indicates that there are still important issues for virtual museums to solve.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

Good cooperation between cultural heritage professionals (museum curators, historians, archaeologists, etc.) and information science professionals must be ensured to achieve optimum results and to avoid dependence on market-produced software and to promote open source software that may be produced with the help of cultural heritage professionals. Virtual museums cannot and do not intend to replace walled museums. They can be described as “digital reflections” of physical museums that do not exist in themselves, but function in an integrated manner to become an extension of the exhibition halls of physical museums and the comprehensive vehicle for the ideas, concepts and “messages” of a true museum. Their primary goal is (or should be) to investigate and propose models to explore the true purpose and conceptual orientation of the museum. Artificial intelligence (AI) technologies provide remarkable opportunities for museums to learn more about their visitors, play with their collection data, and together influence how people experience a museum. Artificial intelligence and the potential impact of these technologies in enhancing the user experience have gained an increasingly important presence at the past few Computer Museum Networks conferences. This article will reflect the emergence of artificial intelligence in museums and its role in museum operations as these tools become widely used. As a result of these implications, this article will look at the practical implications of artificial intelligence and how museums can become informed consumers of these emerging technologies.

There are multiple classifications of AI technologies2 and among the most common methods we find are computer vision, machine learning, robotics, and natural language processing. All of these approaches provide a way to speed up processes that may involve human labor and costs, such as language translation or image identification.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

Although we may We're in another hype for the term "AI," but the tools' popularity is normalizing their use in research and practice. Moreover, while some of the AI-generated output is still very preliminary and experimental, some applications have become functionality expected by users, such as recommendations, browsing by tags, image recognition from taking a picture or getting a response from a voice assistant. One of the most promising technologies is the application of computer vision to museum collections.

Machines can extract individual items from digital recordings of objects quickly that can take a long time to compose. Running an algorithm on collection data can lead to data visualizations of all 4 dimensional object or identify faces or 5 features—providing new ways for the team of curators to analyze, research, and describe Museum collections. Ideas for new ways to explore collections can be highlighted by color, for example at the Cooper Hewitt Smithsonian Museum of Design 6 and Dallas.

Museum locations, filters by shape and direction of lines, or space and light as seen on the Barnes Foundation website8. In another fun example of using artificial intelligence to generate new ways of group interaction, the Harvard Art Museum Public API includes machine-generated data in the “magic message” its own, in which users receive portions of images based on a sentence, or "face matching" that invites the user to add faces to corresponding bodies.

Negative effects of the use of artificial intelligence in the field of museums and heritage:

1.Bias

Since AI algorithms are created by humans, they can have internal bias by those who intentionally or unintentionally inserted them into the algorithm. If the AI algorithms are built with bias or the data in the training sets they were given to learn from is biased, it will produce biased results.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

This reality could lead to unintended consequences like the ones we saw with discriminatory recruitment algorithms and Microsoft's Twitter chat bot becoming racist. As companies build AI algorithms, they need to develop and train responsibly.

2. Loss of certain functions

While many jobs will be created by AI and many people expect a net job increase or at least expect the same amount to be created to replace jobs lost thanks to AI technology, there will be jobs that people do today that machines will take over. This will require changes to training and education programs to prepare the workforce of the future as well as helping current workers transition to new jobs that will take advantage of their unique human capabilities.

3. Transformation of the human experience

If AI takes on menial tasks and allows humans to drastically reduce the amount of time they need to work, the extra freedom may at first glance seem like a utopia. However, in order to feel that their lives have a purpose, humans will need to direct their newfound freedom to new activities that give them the same social and mental benefits that their job used to provide. This may be easier for some people and communities than others. There are likely to be economic considerations, too, when machines take over the responsibilities that humans used to pay to do. The economic benefits of increasing efficiencies are quite evident in corporate profit and loss statements, but the overall benefits to society and the human condition are a bit more ambiguous.

4. Global regulations

While our world is becoming a much smaller place than ever before due to technology, this also means that AI technology that requires new laws and regulations will need to be defined between different governments to allow for safe and efficient global interactions. Since we are no longer isolated from each other, the actions and decisions regarding AI in one country can negatively affect others very easily.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

We are already seeing this happen, with Europe adopting a strong regulatory approach to ensuring approval and transparency, while the US and China in particular are allowing their companies to apply AI more freely.

5. Accelerated Hacking

AI is accelerating the speed of what can be achieved and in many cases, beyond our ability as human beings to follow through. With automation, it can be difficult for humans to detect nefarious actions such as phishing, handing viruses into software and taking advantage of AI systems because of the way they see the world, until there is a real quagmire to deal with.

6. AI Terror

Likewise, there may be a new form of AI-enabled terrorism to deal with: from the expansion of autonomous drones and the introduction of robotic swarms to remote attacks or disease transmission through nanobots. Our law enforcement and defense organizations will need to adapt to the current potential threat.

It will take extensive human time and thought to determine the best way to prepare for the future with more applications of AI to ensure that although there is potential for negative impacts with further adoption, they are minimized as much as possible.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

References

Calori,L., Camporesi,C., Forte,M., Guidazzoli,A., Pescarin,S.," Openheritage:integrated approach to web 3D

publication of virtual landscape.", in: Proceedings of the ISPRS Working Group V/4 Workshop, 3D-ARCH 2005: Virtual Reconstruction and Visualization of Complex Architectures, Mestre-Venice, Italy, 22-24 August, 2005.

Ciecko, B. " Exploring Artificial Intelligence in Museums *" . Last updated February 25, 2016. Consulted February 2017.*

Heim,M." The Metaphysics of Virtual Reality.", Oxford University Press, Oxford, 1993.

Jackson,R., Bazley,M., Patten,D., King, M. " Using the web to change the relation between a museum and its users.", in: D. Bearman, J. Trant (Eds.), Proceedings of the Conference Museums and the Web 1998, Toronto, Canada, April 1998, Archives and Museum Informatics, Pittsburgh, 1998.

Liarokapis,F, Sylaiou,S Basu,A , Mourkoussis,N , White,M , Lister,P " An interactive visualisation interface for virtual museums, in: K. Cain, Y. Chrysanthou, F. Niccolucci, N. Silberman (Eds.), Proceedings of the VAST 2004 Conference, Belgium, EPOCH Publication, Belgium, 2004,pp. 47-56.

Macariu,C. and Iftene.A" ARChemistry Learn - Augmented reality. " In BringITon! 2018 Catalogue, 13-14 December, Iasi ,2018,pp. 36-37.

Mase,K., Kadobayashi,R ., Nakatsu,R. "Meta-Museum: A Supportive Augmented-Reality Environment for Knowledge Sharing.", in: Proceedings of the Conference VSMM '96, Japan, September 1996, IEEE Computer Society Press, 1996, pp. 107-110.

Online ISSN2735-4806 volume 4, issue 2, 2021, 56 –72. **Print ISSN2735-4792**

Milgram,P. Kishino,F. " A Taxonomy of Mixed Reality Visual Displays ,IEICE Transactions on Information and Systems.", Special issue on NetworkedReality, E77-D (12), 1994,pp. 1321-1329.

Styliani ,S., Fotis,L., Kostas,K.and Patias Petros,P., " Virtual museums, a survey and some issues for consideration." In Journal of Cultural Heritage 10, no. 4, 2009,pp.520-528.

Sylaiou,S. ,Patias,P., Georgoula,O., Sechidis,L." Digital image formats suitable for museum publications." Proceedings of the 2nd International Museology Conference in Technology for the Cultural Heritage, Lesvos, Greece, 2004.

Talagala,N, Asami,S, Patterson,D FuternickB, Hart,D." The Berkeley-San Francisco Fine Arts image database.", in: B. Kobler, P.C. Hariharan (Eds.), Proceedings of the 15th IEEE Symposium on Mass Storage Systems, Maryland, USA, March 1998.

Teather,L. " A museum is a museum. Or is it?: Exploring museology and the web.", in: D. Bearman, J. Trant (Eds.), Proceedings of the Conference Museums and the Web, Pittsburgh, 1998.

White,M., Mourkoussis,N., Darcy,J., Petridis, P., Liarokapis,F., Lister,P., Walczak,K., Wolciechowski,R., Cellary,W., Chmielewski,J., Stawniak,M., Wiza,W., Patel,M., Stevenson,J., Manley, J., Giorgini,F., Sayd, P., Gaspard,F. "ARCO-An Architecture for digitization, management and presentation of virtual exhibitions.", Proceedings of the CGI’2004 Conference, Hersonissos, Crete, June 2004, Los Alamitos, California: IEEE Computer Society, 2004, pp. 622-625.