White Paper: Feasibility of using Holographic or Holographic-like technology in Museum Exhibits

Executive Summary

NEH funds were awarded to MPM for the purpose of determining the feasibility of using holographic or holograph-like technology to exhibit CT-scan data of Egyptian mummies and to enhance the display of fragile museum objects. To determine this, we proposed to review the capacity of universities, research labs, or commercial companies to take CT-scan data (DICOM), segment it for analysis, and then create a hologram that could be projected in 3D without the use of glasses (Figure 1).

Additionally, we proposed to assess whether holography is a viable alternative to "loaning" real objects from the collection.

Figure 1 Concept Image of MPM Holographic Mummy for Exhibit

Findings

About holography

The genesis of holography dates back to the 1940s. Early methods used electron microscopy; with the development of the laser in the 1960s, optical holography was born. It became popular after Dennis Gabor, a Hungarian-British physicist, won the 1971 Nobel Prize in Physics for his invention and development of the holographic method.

Technologies often confused with holograms ("holographic-like"): The term "holographic" is greatly misused in the industry. Many companies claim to be using holography to create 3-D presentations, when actually they are not using true holograms. Three-dimensional stereoscopic projections are commonly used to project onto a translucent material, creating impressive, 3-D still or moving images floating in air. Projects using lenticular construction or Pepper's Ghost techniques are commonly called holographic. See Appendix B – Glossary.

True holograms record light refracted from a physical object onto a light-sensitive film (similar to photography except the data recorded is not an image but rather values referring to how the light is refracted from the physical object.) A light can be shone onto the recorded film in a precise location as determined in the recording phase. When the eye sees the light shining on the hologram, the same pattern is created on the retina as would have been seen if viewing the actual object. The image appears to be a 3-D replica of the original physical object.

The discovery made during this grant-funded project focused on true holography. Other techniques that companies suggested to create projected 3-D images for a museum exhibit are valid in the museum context and should not be discounted simply because they are not truly holographic; however, for this grant, they are not being considered. Volumetric holographic projections are leading edge at the time of this research. For a list of companies contacted, see APPENDIX A – Companies Contacted within the Scope of the Grant (in alphabetical order)

We found a solution that uses a true hologram and a rear-projection technique that met the criteria defined in the grant proposal. Holorad LLC has developed and patented a technique for projecting holograms. The solution consists of a holographic film attached to the front of a lightbox; focused light shines through the film and projects a 3-D free-floating image to a visitor without the use of glasses. The viewing angle measured from center to each side edge of the lightbox is 100 degrees. Holorad LLC shipped a demonstration unit called a Voxbox™ that served as our proof of concept. The demonstration Voxbox™ was shipped with sample holographic films of medical patients, but we did not see holographic films of our mummy DICOM data in the demonstration.

Voxbox™ device

The Voxbox™ is the only device found in our investigation that is a true holographic projection. The device similar to a lightbox used to show x-rays. It is capable of rear-projecting a 3-D image from a hologram attached to the front panel of the device. A focused beam shines through the hologram and projects the viewable 3-D image without the use of glasses or any other viewing aid.

Software

Computed tomography data (DICOM) is the source for the mummy imagery we plan to present in the exhibit. This data format is well-known in medical imaging and commercial animation companies we interviewed. The data can be imported into one of several specialized computer programs for manipulation to expose details of interest.

This process is called “segmentation.” Segmentation exposes the various layers desired for the imagery for the final product. This work would usually be done by a contractor as they have specific knowledge of this specialized software. A subject-matter expert would also be needed during segmentation to provide specialized knowledge about the mummy data and areas of interest. These techniques would be performed as a first step independent of the type of display technology used for the final product.

After the segmentation process, the file can be converted to a typical graphic file format and then subsequently animated or colorized. From this point, the graphic file can be imported into other software to create moving images, animations, and enhanced with other graphical content.

For the holographic presentation using the Voxbox™, various still images would be captured onto 12 or more holographic films. No software is required to display or project the holograms if using the Voxbox™ hardware and true holograms.

One limitation to using the Voxbox™ is that only still images are used. They can be layered and then transitioned one into the next, but this is only a simulation of animation, not a true animation.

Representatives of Holorad LLC say it is technically possible to further develop life-sized, full color, 3-D holograms projected in air without the use of glasses. By using the Voxbox™ and several holographic films (12 or more) orchestrated to transition to different films in sequence, we could achieve the results we defined that are similar to an animation. This works by ramping up and down the brightness of the electronically-switched light source and adjusting where it is focused from behind the film. The demonstration unit had a flat surface. With a curved surface design, it may be possible to get 170 degrees of viewing angle.

Using a flat surface design like the demo unit, the films are estimated to be 2 films wide x 5 films high. A red, green, blue color palette is attainable which would display objects in full color using 8-10 bits/color. Full color work has been done by Holorad LLC in other projects, mainly for trade shows. The hardware can be embedded into a wall so that the holographic image would seem to be projecting out from the wall.
Another hardware configuration discussed is a full color 6x6 film array in 360 degrees by using a cylindrical sheet of plastic and projecting from the rear. Either acrylic or glass can be used on the device – whichever is determined to be more practical.

The technology is durable for museum use. The self-contained lightbox requires no special environment, lighting, or wiring. When embedded in the wall, no parts of the device are viewable or able to be tampered with by the public. It uses a standard 120 Volt outlet and draws under 150 Watts of electrical power. The images, in stills or in motion, can be updated or replaced as easily as switching out a film, so the hardware could be re-purposed if needed.

Museum ambient light is usually low, which is optimal for the viewing of this display. The technology used as the light source is well-known and easy to maintain and/or replace. At the time of the conversation, Holorad LLC was using a highly-reliable, modified Mitsubishi laser television.

Although we had not received a detailed quotation, it seemed the cost would be feasible for museum budgets and maintenance of the system would not be prohibitive and could be absorbed into museum operating budgets. The longevity of the hologram films is at least 10 years and probably longer. Films do not require any special care. Dusting of the films is recommended to keep the display sharp; if needed, cleaning with an acrylic cleaner is easy. We would plan to have a duplicate set of holograms created as an archive should films become damaged.

It is possible to have a system developed in 2 to 6 months, depending upon how many trials of the films need to be created during production.

Grant Activities Performed

As planned in the grant proposal, an initial meeting was convened at the Milwaukee Public Museum on October 6, 2011. In addition to Carter Lupton, Linda Gruber and Dr. Ellen Censky, the developers of this grant project, the invited consultants were: Bob Senzig (CT Chief Engineer) and Fausto Espinal (Visualization Principal Engineer), both from GE Healthcare in Waukesha, WI; Dr. James D. Myers, Director of the Computational Center for Nanotechnology Innovation at the Rensselaer Polytechnic Institute in Troy, NY; and Dr. Jonathan Elias, Director of the Akhmim Mummy Studies Consortium in Harrisburg, PA. We had budgeted for a fourth potential consultant but did not ultimately add anyone.

Initial discussions centered on understanding the nature of the CT-scan data and speculation on how this data could best show key points desired. One of the Milwaukee Public Museum's mummies, Padi Heru, has been scanned at GE Healthcare (originally GE Medical Systems) several times, going back to May, 1986. This mummy was scanned most recently in April, 2011, using the latest in medical imaging technology. The state-of-the-art dual energy scanner produces the highest possible resolution, which was most desirable for a newly planned exhibition area. The DICOM data generated by these scans was used during the grant period to discuss possible visualization and presentation techniques with a variety of commercial companies specializing in 3-D visualizations.

We discussed how the segmenting of data would be done and who may be capable of doing the segmentation. It was apparent, however, that this aspect of the work was not the real challenge of this grant; that such work could be done easily enough through a variety of means, and that in fact Elias had already performed some initial segmentation of the 2011 scans in Pennsylvania. Topics tangential to basic segmentation included the potential nature of superimposing images of real or animated human organs over areas where they would occur in the mummy, a process called Atlasing.

Discussion then turned to the primary issue, the feasibility of projecting the segmented mummy images in a holographic-like manner that could go beyond video screens and 3-D glasses. The thinking at the time was that we would need to have a self-contained booth where visitors could peer through portals. Ideas that were discussed included doing a 3-D stereoscopic projection that would appear as if it were coming out toward the visitor. We discussed the possibility of using 3-D printing with a projection on to the 3-D print. None of us had seen anything like what we discussed; however, during the course of this grant, we added to our knowledge of state-of-the-art holographic projection.

Travel to Research Institutions

On November 2, 2011, Lupton and Elias were at the University of Illinois in Urbana for a series of meetings based on contacts made prior to the grant submission and also resulting from suggestions at the October meeting.

Beckman Institute for Advanced Science and Technology

Host: Janet Sinn-Hanlon
Travis Ross - lab manager, Alex Jerez (3D artist; games specialist; MAYA Instructor)
Software which they showed/demonstrated:
AMIRA (used for segmentation) displays in color-enhanced X-ray mode (similar in its appearance mode to Fovia, a program used on a mummy in San Francisco)
MAYA (used for more artistic editing of digital information)
GEOMAGIC (uses polygonal meshes to move from 2D X-ray data to optically solid forms)
FREEFORM (used for sensible haptic sculpting)
Discussion focused on using technology to educate and display information to the public.
Creation of Interactivity: example—a medieval helmet in the collection of the Spurlock Museum (U. of Illinois Urbana-Champaign) was used as a model to optically put the visitor inside the helmet to allow them to see what a knight would have seen when looking out of the visor during a battle.
Interest in 3D Animation Software: example: Freeform
Interest in Gaming technology—Xbox style—could be used to produce a 3D version of the mummy developed as a "speaking model" of an ancient Egyptian—based on the forensic reconstruction. This game character could interact with visitors to the exhibit—seen as a strong argument in favor of greater interactivity in museum exhibits.

ANALYSIS: Most of this concerned segmentation and, though familiarizing us with some new software, did not offer anything related directly to holographic projection. We did come away with the suggestion of possibly animating the (forensically restored) mummy to interact with visitors. We had budgeted more funds for additional trips to Urbana and for Beckman's cost of staff time to develop prototype elements, but our visit revealed that their involvement was not going to lead us further toward achieving our ultimate goal of holographic projection.

NCSA (National Center for Supercomputing Applications)

A team composed of Robert Patterson, Alex Betts and Stuart Levy demonstrated their 3D HD animations projected from behind on a 10.5 foot screen using dual JVC projectors. This was a theater environment with the visitor seated and wearing low-tech 3D glasses (no switch on).The overall effect was equivalent to 4xHD and very large. This group produces on-screen animated imagery for IMAX films. Size of Image: 4096 x 2160. The group indicated that they had written their own software for the productions they created.

A variety of projects were demonstrated, including:

a) IMAX film segment showing the creation of solar systems within a nebula—optically one was able to float around and travel through the vast expanses of space to see the birth of stars and examine protostars. (narrated by Leonardo DiCaprio).
b) Movement through a hurricane, seeing the trajectory of different air and water currents as 3D structures indicated by arrows of movement and force. Several projects of this kind were shown.

ANALYSIS: Despite the impressive scope and quality of projection, it was space prohibitive, used 3D glasses and a screen, all features we were attempting to bypass.

Also at NCSA, we met with Alan Craig (suggested by Jim Myers in October) to discuss his work with Augmented Reality. Craig is a published guru on virtual reality:
Understanding virtual reality: interface, application, and design, Volume 2
William R. Sherman, Alan B. Craig Morgan Kaufmann, 2003 - Computers - 582 pages.

Developing virtual reality applications: foundations of effective design
Alan B. Craig, William R. Sherman, Jeffrey D. Will
Morgan Kaufmann, 2009 - Computers - 382 pages

Craig is now interested in Augmented Reality. He has experimented widely with the use of QR marks (fiducial markers) to activate imagery that is viewable on cell phones/smart phones. He has worked on museum projects before, including at the St. Louis Science Museum on a project involving the Mississippi River (a camera above was used with a projector to create what he called a dynamic fluid environment).

Augmented reality is defined as technology which allows digital interaction with real objects. Fiducial markers can be simple pieces of paper placed on a surface which can be read by phones and tablets (available technology) and uses their optics to present a new reality into an existing space. This happens when the tablet is pointed at and reads a fiducial marker placed somewhere in the space. This was demonstrated for us in several ways. We were shown an image of a skeleton that appears only when the sensor on the cell phone was pointed at the fiducial mark; the skeleton was otherwise invisible.

U. of I has a facility called The Cave—for experiments in perception and technology—Virtual reality—the Cave environment has no inherent up or down. Can be like floating in limitless space—in this connection Craig mentioned Visbox— as a way of creating immersive 3D experiences. We did not visit the Cave, housed in yet another building. When asked what is most important to him in technologically-driven museum exhibits Craig answered:
1) Novelty
2) Story—aka Content
3)Appearance—verisimilitude may not always be the key to success—sometimes the more "cartoony" approach is more effective, and better liked by visitors.
Does the world behave expectably? In augmented reality it needs to for the response of visitors to be positive. In all augmented reality (and in virtual reality) physical engagement (between the viewer and the objects in their environment) is important.

ANALYSIS: This discussion opened us up to potentialities of using such a technology in various types of exhibits, but did not directly address holographic projection.

Museum Visits

In March, 2012 we arranged several visits to new exhibits of Egyptian mummies to examine the current state of museum presentation of CT data. Lupton and Elias were in Richmond, VA on Mar 5-6 to visit first the University of Richmond and then the Virginia Museum of Fine Arts.

At U of Richmond, we met with the professor and student curator of a new exhibit on their recently scanned mummy, but the only projection was a small video screen showing a forensic reconstruction of the head. We later met with Dr. Ann Fulcher at Virginia Commonwealth University, who had analyzed the CT-scans.

At the VMFA, we saw the travelling exhibition from the British Museum, *Mummy: Secrets of the Tomb.* The exhibit held four mummies but was really focused on just one, Nesperennub. A large screen film, requiring 3D glasses, that dealt with CT reconstructions acted as prologue to the exhibit. The animations were well done, by Benjamin Moreno of IMA, one of the companies we had previously contacted (see Appendix A) but again did not offer the holographic, relatively small scale approach we are seeking.

On March 7, we visited the Smithsonian – Natural History Museum to view their newly re-installed exhibit on Egyptian mummies. Unfortunately the curator, David Hunt, was unavailable to meet with us. The exhibit, though highlighting some relatively recent CT work, used standard labels and photographs rather than any video programs.

A few weeks later, on Mar 29, Lupton, Elias and Gruber, along with two of our museum's exhibit designers, drove to Chicago's Field Museum to see their new, but short-lived, exhibition of mummies scanned in the summer of 2011. We met with conservator JP Brown, who had curated the show, and with Jean-Manuel Nothias of Vizua, who produced the projected CT programs. One screen allowed visitors to use a familiar X-Box gamepad to perform a limited virtual unwrapping of one mummy, while another larger screen showed looping videos of some of the other mummies' scans. These programs were limited by the Field's budget and purposes, but we are still investigating other display capabilities with Vizua, including 3-D LED flat panels and iPads.

Second (final) meeting with Consultants

The second meeting with consultants was held at the Museum on March 30, 2012. The visits to Urbana and the various museums detailed above were summarized for everyone.

We discussed the various companies we had contacted (first by e-mail, with follow-up phone consultations) that claimed to have holographic projection capabilities. All these companies already had experience with DICOM data, having worked with it for trade shows, product launches, entertainment venues such as casinos, etc. A few had experience working with a museum and a few had either temporary or permanent exhibitions using their products. The company with the most promise of delivering our envisioned end product was Holorad LLC. Further information on other firms we called can be found in an appendix to this report.

Accomplishments vs Objectives

We set out to find a method to project CT-scan data in three dimensions and full color without the use of glasses. We have accomplished that goal, though discovering that it has limitations. As a secondary objective, we had also hoped to determine whether holography is a feasible technique to use for traveling exhibitions. We have not yet determined whether this functionality is feasible but we do know that the methods used to create a hologram for that use would not be identical to the process for projected content from DICOM data.

Plans to Continue

We plan to continue working with various companies identified and any new companies that may become known to us to further develop the concept of true holographic projection as an element for a permanent exhibit.

We also plan to keep abreast of other emerging display technologies as the 3-D technology market progresses. Vizua has an interesting model that may be promising for segmentation and creation of the display content. The cloud-based solution could be used by collaborative groups to study mummies and share findings among others in the collaborative. The ability to show 3-D volumetric displays in real time may have a place in the exhibit or it could be supplemental to the holographic projection.

Vizua's capabilities allow real-time rendering to a simple browser-based device such as a computer, an iPad or other devices capable of running a standard Safari or Firefox browser. If Vizua output were to be chosen to display in the exhibit gallery, the use of 3-D LCD/LED screens would be used. The technology used in the 3-D monitors is a lenticular technique. A demonstration of two screens was done to show how the volumetric renderings would look on them. The brands demonstrated were Alioscopy and Tridelity. These are the only true 3-D monitors on the market now, but other manufacturers are entering the market. Of the two screens, the Tridelity appeared to display the content better. We anticipate the quality of the screens to improve as competition enters the market.

We may phase in certain elements such as the segmentation and enhancement of the DICOM data as resources become available. We will define the layers and transition sequences by the educational content to be displayed and other graphical elements that may clarify the learning experience. We determined that in thinking about this project, we could easily split the project into two parts; 1) the segmentation / supplementary graphics and , 2) the display techniques.

New Partnerships Formed

Both Holorad LLC and Vizua have extremely viable technical solutions for content we are intending to create and display for the exhibit. Both companies are continuing to research and develop products for 3-D visualizations and both have identified museums as an area of growth. The technologies examined here continue to progress at a pace that makes keeping up a challenge. As our exhibition plans develop over the next couple of years, we will continue to stay in contact with these companies and follow developments from each.

Efforts to Publicize

This White Paper was written to be shared with individuals or institutions considering an innovative way to display content, especially data obtained by a CT-scan of museum artifacts. It is useful as a starting point and references those companies identified as having potential for high-definition displays.

APPENDIX A – Companies Contacted within the Scope of the Grant (in alphabetical order)

Holorad LLC, 2929 South Main Street. Salt Lake City, UT 84115
Daniel Burman, President and CEO and Stephen Hart, Chief Technology Officer

Holorad LLC has two divisions – one that participates in the medical imaging market and one that develops products commercially. Voxel participates in the medical market and is the only company found during our investigation that had developed holographic imaging technology and products that can generate life-size three-dimensional holograms created in mid-air without the use of special viewing glasses. The differentiating factor from all other companies researched to date was that this technology claims to create a truly volumetric image occupying space that allows the viewer to see depth at any viewing angle. It is possible to look around the object that is projected in full color 3-D. Ironically, part of the genesis of our projection idea was based on a very early 1990s holographic projection by Voxel of a portion of a mummy in Urbana, IL.

The following paragraph from Voxel's website describes the technology:

> "Voxel's products implement our patented process which creates multiple exposure holograms, Voxgram® images, from a series of sequential slices of CT or MR data. A single piece of holographic film is exposed multiple times for the multiple two-dimensional scanned cross-sectional slices. Each exposure accurately stores not only the XY contrast-detail of each slice, but also the Z distance which separates each slice from the film and from every other slice. When this film is processed and re-illuminated, an "anatomical twin" of the patient's anatomy is seen glowing projected in space. A special portable viewer for medical holograms, the Voxbox™® display, eliminates the usual requirement for laser illumination, and allows the clinician to safely see and use this accurate display of their patient's anatomy."[i]

Contact was made with Holorad LLC on February 1, 2012. Carter Lupton and Linda Gruber spoke with Daniel Burman and Stephen Hart on February 9, 2012. We discussed the business organization where it was explained that Holorad LLC is not under any compliance constraints as the Voxel division due to the nature of medical imaging. Therefore, Holorad LLC has the ability to use its technology with greater liberty than is permitted in an FDA-regulated industry such as medical imaging.

The specific techniques that would be used for the projection of the mummy DICOM data would involve the creation of up to 12 holographic films that would transition through the imagery from the mummy coffin to the outer linen wrapping, to the skin, the bone, the internal organs, etc. Each film would fade into the next and the viewer can look around all sides of the image at all times.

The projection technique uses backlighting of the films from light sources (lasers and mirrors) concealed behind a wall.   The hardware is rugged enough to run 24/7. It uses standard 120 volt outlets with 250 watts of energy consumption. This can be a permanent installation in the exhibition. There is no off-gassing or any foreign matter distributed from the unit into the air. A Voxbox™ can be made to accommodate a life-size image of the mummy. With the actual mummy and coffin, plus the Voxbox™ projection and additional label panels, the space required may be approximately 6’6” x 6’6.”

A non-disclosure agreement was made between Milwaukee Public Museum and Holorad LLC on February 24, 2012. DICOM data of the mummy’s CT-scan was sent to Holorad LLC on Monday, February 27, 2012 but the original data was unable to be read from the CD.   This did not matter for our purposes as a hologram from our data could not be made for a demonstration.

Daniel Burman sent a Voxbox™ unit for demonstration at the March 30 meeting. This Voxbox™ is being used in medical imaging and is state-of-the art for surgical planning. FDA regulations have not yet approved color for medical imaging, so the demo unit was in gray scale. The actual functioning of the unit did not seem as impressive as we had hoped. The projection of human anatomy, mostly bone elements, had a limited peripheral field and good dimensionality only if viewed straight on from relatively close. In a follow-up call we were assured that these limitations were a result of the specific, smaller, medically approved Voxbox™, but that a larger color model would drastically expand the holographic potential; however, we have not yet seen such a unit in person.

Figure 1 - Voxbox™ True Holographic Projection

Figure 2 - A Voxgram® image is a special kind of hologram

Traditional holography requires that light be reflected off a physical object. The "object" for a Voxgram image is a screen upon which one slice from a CT/MR scan is displayed. A hologram of this first slice is recorded, then the screen is moved back a distance corresponding to the gap between slices. The next slice is displayed on the screen, and a second hologram is superimposed on the first, and so on for all subsequent slices. The multiple-exposure hologram encodes the depths as well as the intensities for each exposure, all on a single Voxgram film. Then, using a Voxbox™ display, the individual holograms are optically reassembled and projected in space, each at its original anatomical position.

I02Technology, Hermosa, California
Chad Dyner or sales@io2technology.com

IO2 Technology is a company that has a turnkey presentation system using water vapor as the "projection screen."
Information from IO2 Technology's website:

> "IO2 Technology ships worldwide and we can work with you to deploy Heliodisplays in your location starting at $48,000USD, for the L90 hardware, and more for turnkey solutions. There are no consumables or need to buy anything else. It does not affect the environment as it works using the existing air that is already in the room to create the image. The system can be configured for operating continuously for a week, month or years, playing live video feeds, pre-recorded, or content you would display on a computer. See quote/purchase link below or click here.
>
> Images project 5 cm (2") beside the unit. Heliodisplay works in any indoor controlled lighting, such as the lighting in stores, museums, offices, and lobbies. The base unit stands as a column, or can be ordered in other orientations (as a special order). Price includes white glove delivery and setup by trained IO2 staff in every city on any continent in the world."[ii]

The technology is suitable for permanent installation. The Buffalo Bill Museum is using this technology. (The contact is Paul Brock, Head Curator) The longest running system is from a 2005 manufacture used for rentals. The visualization content is straightforward. Anything that can be shown from a PC can be displayed in 3-D using this technology. The projection is best in low light conditions with a dark background preferred. The unit should be set away from air vents or cross ventilation. The projection can be 1024 x 768 or 1900 x 1000 or greater depending upon the projector used. The projector is bundled in the package, but would be specified to the venue's location. Rear projection is used with a distance of 2.5 meters away from the projection surface.

We inquired quite extensively about the technology as it is said to use water vapor. The water vapor emitted is said to be no more than a room of people would emit during normal breathing operation. The model L90 uses regular tap water with a water filter. A permanent water source would be required. The unit takes 300 watts of power and the projector also takes 300 watts of power.
Maintenance is low and consists of dusting and vacuuming the unit with cleaning of the filters behind the units.

Another model is produced for interactivity. The model L90i is more expensive. Both are comparatively off-the shelf.

Figure 3 - Heliodisplay uses fine vapor

Musion Eyeliner, Westcott House, 35 Portland Place, London, W1B 1QF
Andreea Timis, Business Development Executive
Musion produces a unique high-definition video holographic-like projection system allowing freeform 3D effects to be projected within a live stage setting using Peppers Ghost illusion. Eyeliner produces high resolution images that make them appear real. Musion Eyeliner is a specially developed foil that reflects images from a high-definition video projector, making it possible to show virtual images of variable sizes and distinct clarity. Their work is mainly with trade shows and other on-stage productions.

The foil screen is a licensed product that is priced depending upon application and size of the sreen. The foil must be replaced once per year. The technician's time plus travel and accommodations would be at the museum’s cost. A high-quality projector with at least 18,000 lumens is required.

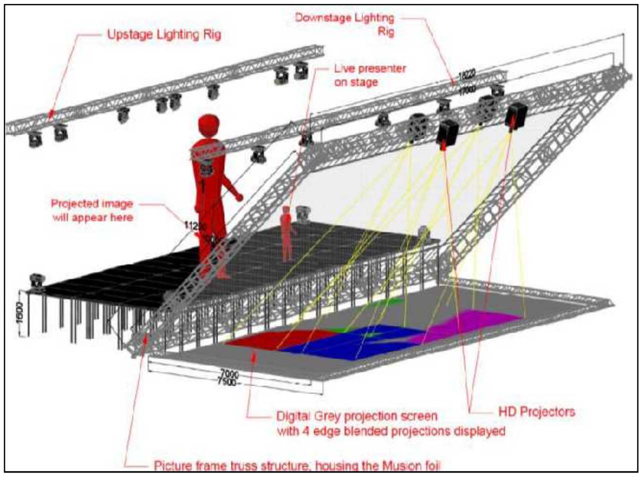

Figure 4 - Drawing of a typical Musion Eyeliner stage production

Musion has also developed another product called EyeCandy. The EyeCandy unit shown below offers a more portable display solution suited to trade shows, corporate reception areas and retail spaces. The units can be easily configured to provide audience interactive services and even e-commerce transactional processing.

Figure 5 - Retail Marketing Display

IMA Solutions, Centre d'Affaires Amphipolis, 19, rue Jean Mermoz, 31100 Toulouse, France, 33 675 761 567
Benjamin Moreno, CEO
IMA Solutions is involved in acquiring CT-scan data and creating visualizations for volumetric analysis. 3-D models generated can then be integrated into real time 3-D animations or precomputed, 3-D multimedia applications, 3-D stereoscopic movies, prototypes or machined at different scales.

IMA does not offer any hardware components and therefore, all work done by IMA would be in collaboration with another company.

A non-disclosure agreement was entered into and a preliminary quotation was generated by Benjamin Moreno.   It was suggested that we obtain a non contact laser scanning of the sarcophagus.

Figure 6 - IMA Museum Production at The British Museum

Vizua, Seattle, Washington, Seattle, Chicago, Illinois, Montreal, Canada and Paris, France
1-888-928-7988
Dean Lester, CEO, Jean-Manuel Nothias, Director of Vizua Biomedical Partner Relations

Vizua is a 1-year-old company. Its technology has been in development for five years. The company's technology is being used by The Field Museum in their exhibition **"***Opening the Vaults: Mummies***."**   The visualization is in three dimensions using full color, but is not a holographic technology. The differentiating technology that Vizua brings is that the data is streamed in real time. It is not pre-rendered. The data can appear in a web browser or be projected onto a screen.   Data can be manipulated either in the web browser using a tablet (iPad or tablet with Safari) or using a standard game controller on a projection screen as large as 47" using rear projection. Particular views can be saved with presets or data can be navigated as desired by the user.

3-D data is generated with the use of 3-D LCD/LED monitors without glasses.

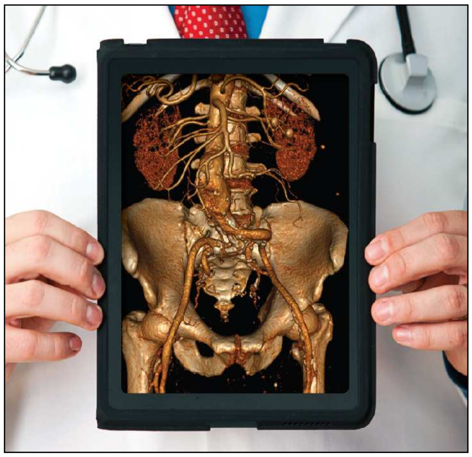

Figure 7 - Volumetric data shown on iPad using Vizua software.

The CT-scan data (DICOM) can be stored either locally or by Vizua using their SAAS (Software as a Service) technology. For medical imaging data to be shared among different sites, the Vizua SAAS cloud service is a very good choice.

The following paragraph describes Vizua's technology:
2D and 3D Viewing

> "Members and Guests can see DICOM views or view a full-fidelity volumetric model for greater comprehension. Vizua delivers these tools inside a simple user interface with full image model controls. The controls are easy to use, and the three-dimensional image model can be manipulated in any axis, down through any depth, for interaction in real time. The original CT-scan, MRI or Ultrasound image is never altered."[iii]

A non-disclosure agreement was made between Vizua and Milwaukee Public Museum on February 7, 2012. DICOM data was sent to Vizua for analysis. Jean-Manuel Nothias offered to visit Milwaukee Public Museum and bring the technology to demonstrate.

viZoo/MadHat, Centre d'Affaires Amphipolis, 19, rue Jean Mermoz, 31100 Toulouse, Benjamin Behrens

viZoo has merged with MadHat to serve all of viZoos business relations. Mad Hat is a full service media agency based in Offenback, Germany. With the air of the merger, they are able to offer an expanded product range and implement whole projects from the planning to the delivery.

From viZoo website, the following is a description of the products that viZoo provides:

> "Founded in 2004, viZoo has become an integral part of product launches, demos, product displays and permanent installations around the world.

viZoo specializes in developing new media products with an edge. Assisting you each step of the complex way from idea through video content production to final show, our passion is to create the unexpected. With a long list of partners and co-developers, viZoo has become a popular partner when it comes to using and implementing innovative display technology, be it for branding, events or product launches.

From creating a live film inside your brand's logo with VideoLogo's, to free floating 3D objects in our Cheoptics360 range to "invisible" screens using our Free Format solution, viZoo can assist in making your creative ideas come alive!"[iv] FreeFormat permits three-dimensional objects to be displayed in controlled lighting environments. It sends realistic 3D images of objects and people to a transparent gauze screen, using patented back projection technology and specially produced film material.

MadHat has worked with DICOM data before for other animation projects. We explored the idea of using viZoo Free Format display. The Free Format uses projection on to an "invisible" transparent film material. The projection is distributed from two pillars on each end of the stretched film.

During discussions with Benjamin Behrens, he recommended that a peppers ghost technology be used for our project rather than the Free Form or Cheoptics products we had originally inquired about.

A non-disclosure agreement was entered into on January 4, 2012. DICOM data was sent to MadHat on January 9th, 2012.

Figure 8 – MadHat/ViZoo's Cheoptics 360 Display

Appendix B - Glossary

Hologram – A technology to record light refracted from a physical object onto a light-sensitive film (similar to photography except the data recorded is not an image but rather values referring to how the light is refracted from the physical object.) A light can be shown onto the film in an precise location as determined in the recording phase. When the eye sees the light shining on the hologram, the same pattern is created on the retina as would have been seen if viewing the original object. The image appears to be 3-D and a replica of the original physical object.

Lenticular printing/display - A technology in which a lenticular lens is used to produce images with an illusion of depth, or the ability to change or move as the image is viewed from different angles. Examples of lenticular printing include prizes given in Cracker Jack snack boxes that showed flip and animation effects such as winking eyes, and modern advertising graphics that change their message depending on the viewing angle. This technology was created in the 1940s but has evolved in recent years to show more motion and increased depth. Originally used mostly in novelty items and commonly called "flicker pictures" or "wiggle pictures," lenticular prints are now being used as a marketing tool to show products in motion. Recent advances in large-format presses have allowed for oversized lenses to be used in lithographic lenticular printing.

Pepper's Ghost - The Pepper's ghost technique, being the easiest to implement of these methods, is most prevalent in 3D displays that claim to be (or are referred to as) "holographic". While the original illusion, used in theater, recurred to actual physical objects and persons, located offstage, modern variants replace the source object with a digital screen, which displays imagery generated with 3D computer graphics to provide the necessary depth cues. The reflection, which seems to float mid-air, is still flat; however, thus less realistic than if an actual 3D object was being reflected. 1
Examples of this digital version of Pepper's ghost illusion include the Gorillaz performances in the 2005 MTV Europe Music Awards and the 48th Grammy Awards; and Tupac Shakur's virtual performance at Coachella Valley Music and Arts Festival in 2012, rapping alongside Snoop Dogg during the latter's set with Dr. Drev
Stereoscopic - refers to a technique for creating or enhancing the illusion of depth in an image by presenting two offset images separately to the left and right eye of the viewer. These two-dimensional images are then combined in the brain to give the perception of 3-D depth. Besides the technique of freeviewing, which must be learned by the viewer, three strategies have been used to mechanically present different images to each eye: have the viewer wear eyeglasses to combine separate images from two offset sources, have the viewer wear eyeglasses to filter offset images from a single source separated to each eye, or have the lightsource split the images directionally into the viewer's eyes (no glasses required; known as Autostereoscopy).

Autostereoscopic - is any method of displaying stereoscopic images (adding binocular perception of 3D depth) without the use of special headgear or glasses on the part of the viewer. Because headgear is not required, it is also called "glasses-free 3D" or "glassesless 3D". There are two broad approaches currently used to accommodate motion parallax and wider viewing angles: eye-tracking, and multiple views so that the display does not need to sense where the viewers' eyes are located.[1] Examples of autostereoscopic displays include parallax barrier, lenticular, volumetric, electro-holographic, and light field displays.

[1] www.voxel.com. In *Voxel Products.* Retrieved March 5, 2012, from http://www.voxel.com/product.htm
[1] www.i02technology.com. In *Heilodisplay Interactive*. Retrieved March 5, 2012 from http://www.io2technology.com/salesinquiry.php
[1] www,vizua3d.com. In *Take the Tour*. Retrieved March 5, 2012, from https://vizua3d.com/tour_browser/
[1] www.vizoo.com. In *viZoo Profile.* Retrieved March 5, 2012, from http://www.vizoo.com/flash
[1] www.wikipedia.com. In *Lenticular Printing.* Retrieved May 25, 2012 from http://en.wikipedia.org/wiki/Lenticular_printing
[1] www.wikipedia.com. In *Holography*. Retrieved May 25, 2012 from http://en.wikipedia.org/wiki/Holography
[1] www.wikipedia.com. In *Stereoscopy*. Retrieved May 25, 2012 from http://en.wikipedia.org/wiki/Stereoscopy
[1] www.wikipedia.com. In *Autostereoscopy*. Retrieved May 25, 2012 from http://en.wikipedia.org/wiki/Autostereoscopy