Determination of the Most Suitable Technology System for Virtual Touring at The National Museum of Denmark

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Abstract

This report documents the process by which a virtual touring system was designed for the National Museum of Denmark. The selection of the most suitable solution was made based on background research of various types of imaging technology as well as the specific desires and characteristics of the museum. The solution consists of panoramic images, still images and relevant text to be presented on the museum's website. A prototype website was created on CD-ROM to demonstrate the system.

Executive Summary

The National Museum is Denmark's leading historical and anthropological organization. Along side tendencies to be a leading research institution, the museum's current focus is also to educate people of all ages about the 'histories' of Denmark and the connection of these histories to European and world history. In the early 1990s, acknowledging the benefits of technology for education, the museum increased the level of interactivity of the educational programs using new technologies. The Education Department is a primary source for exciting innovations that grab the viewer's attention with a continuously tighter grip. Today, the Education Department continues to search for new technologies to continue this trend.

The National Museum wishes to devise a virtual tour system that could be accessed on the Internet. The first tour is to showcase an early eighteenth-century bourgeois apartment in an exhibit called 'Histories of Denmark 1660-2000.' This virtual tour system is to provide the user with a full 360 degree view of each of the rooms in the apartment as well as options to zoom in on areas of interest. The integration of still pictures and texts should provide additional information about the artifacts within the apartment, thus making the system a valuable learning resource. The goal of our project was to present a virtual touring system that is well suited for the museum and can be linked with the current website. In addition to our written report, a prototype tour has also been developed.

The original problem statement from the museum suggested the use of 'Webcams;' specialized cameras adapted for live video transmission over the Internet. Immediately, we realized the challenges the museum would face if this venture were to be pursued, so we began to search for possible alternatives to live video. During this preparatory phase, we decided that a decision matrix would be a useful tool to aid in the determination of the best-suited technology system for the museum. A decision matrix is a method of quantifying the

performance of options with respect to specific criteria. We compiled a list of possible solutions and concerns for the virtual tour, realizing that data critical for the completion of the decision matrix will be collected at the project site.

Upon our arrival at the National Museum, we began to 'fill in the blanks' for our decision matrix by drawing on the results of interviews with various museum staff. Due to recent cutbacks in the museum's budget, cost was easily determined as the primary concern for the virtual tour. Other criteria included image quality and computer network requirements. Each of these concerns had differing levels of importance, thus making it necessary to use weighting techniques in the decision matrix. After a very short time at the museum, with the support of our decision matrix, we identified panoramic images as the best-suited method for providing the primary images for our virtual touring system.

Panoramic images provide viewers with a full, 360 degree view of an environment by stitching together many small images. Recent advances in computer software have made it possible to convert the traditional flat panoramas into *immersive* virtual scenes. These scenes provide the viewer with a sense of existing in the depicted environment. The user may pan the view left or right and tilt upward or downward, viewing the entire panorama. Also, many of the viewing programs enable the web browser to display a zoom function, which allows the user to closely examine individual objects within the panorama. Linking objects within the panorama to still object images and detailed text information was determined to be a crucial component of the virtual touring system. The still object photos provide great image quality and a sense of the intricacy of the artifacts that is lost in the construction of panoramas. Although high-resolution still images are capable of providing such detail, we propose the use of object panoramas in the future. Object panoramas provide views from all sides on an artifact, allowing the user to turn the object in any direction as if they were holding it in their hands. Texts presented in a layering format created by museum present

anecdotes and detailed commentary about individual artifacts. The first layer of information presents interesting stories and anecdotes about individual artifacts. Additional commentary and discussion is available in the second layer, and links to detailed accounts of the subject matter is available on the third layer. We determined that links or hotspots between objects in the panorama and relevant texts and images would greatly increase the level of interactivity. To demonstrate these features, we developed a prototype.

In order to develop a prototype, we needed to take pictures with a digital camera, stitch them together using software, and then place these images with text on web pages. This simplified process also applies to future implementations and was intended to demonstrate the feasibility of the system. After an initial inventory of the museum's resources, we found much of the equipment required for panoramic photography was available. We did not, however, have a key component; a panoramic head. This device is crucial for mounting the camera to a tripod in such a way that all pictures are taken from the correct perspectives. Since we did not have a panoramic head, many of the images were not suitable for panoramic construction. Fortunately, we had secondary camera system as back up. The primary drawback to this system is that only a limited field of view could be captured.

Our recommendations regarding the future implementation of the virtual touring system includes the purchase of professional panoramic hardware and software. The possibility of hiring professional photographers to take the pictures was compared against the purchase of equipment and this might be acceptable on a few occasions. We believe, however, that the presence of resources within the museum would provide the impetus to use panoramic technologies with other exhibits and reinforce the statement of increasing the level of interactivity of teaching endeavors. Therefore, we recommend the purchase of the

following hardware and software titles to be utilized by current museum staff in the creation of virtual tours.

A panoramic head that allows for multiple-row photography is required in order to capture accurate pictures of an entire room. After reviewing several options, the KiWi+ Spherical Panoramic Head appears to be the best-fit solution. The least expensive out of the panoramic heads that met our criteria, the KiWi+ can provide images of the same quality against heads that cost double the amount. The retail price of the KiWi+ Spherical is 500 USD or approximately 4200 DKK. Shareware or evaluation versions of software were used to construct the prototype but we recommend the purchase of a professional package called *3D Vista Studio*. This program has the ability to stitch multiple rows of images, and create hotspots for virtual tour creation. The price is reasonable, when compared to other titles at 200 USD or 1700 DKK. The remaining equipment, including a digital camera, tripod, computer and lights, are owned by the museum.

We hope that our research, decision-making techniques and prototype construction has provided the National Museum of Denmark a clear depiction of the exciting possibilities for virtual touring at the museum. Our intent is to provide confidence and motivation for the museum to implement panoramic virtual touring in the near future.

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1.0 Introduction

In most cases, museums are places for showcasing rare artifacts, which can be very old or quite futuristic. A personal trip to any museum can be an enjoyable experience, and the individual character of each establishment provides a unique opportunity. Yet, there is one central characteristic that almost always remains: the visual nature of museums. The purpose of a museum is to have artifacts on display for people to view and study but many times, small plaques or tour guides are required to provide an explanation or a brief history about the displayed item. There is however, a limit to what a tour guide can say or what a small plaque can display. Some exhibits are so rare or delicate that visitors cannot be allowed near them and can only be observed from the exterior of a glass case or window. One solution to this problem would be to allow the visitor to explore exhibits from a remote location where an abundance of information is available. Such a location could be an Internet web page, which would provide a look into the museum and present relevant information.

The Danish National Museum wishes to devise a system that would allow potential museum visitors to take virtual tours of rooms found in the exhibit, "Histories of Denmark 1660-2000." A description of the National Museum can be found in Appendix A. A "virtual" tour allows people to experience an environment without physically being there. This is typically accomplished by displaying images of the virtual world or remote location on a viewing screen or monitor. If the user can control the views presented by the display, then the tour is interactive and as the degree of interactivity increases, the virtual experience becomes more realistic. These virtual experiences can be provided in a number of ways, each of which has unique characteristics. Some solutions provide only still pictures while others have live video imaging capabilities. There are however, several trade-offs amongst the types of systems, thus making it more difficult to choose the most suitable system. Pan and zoom web cameras could allow users to study exhibits in detail using the Internet, but there

are limitations with these cameras, which can only be controlled by one party at a time. The potential for backlogs and time delays must be considered so that the degree of reality in the virtual tour is satisfactory to the both the museum and public. Extremely high speed Internet connections are required both at the museum and at the user's location in order to provide clear video, therefore other potential solutions should be considered.

The goal of this project is to present a technology system that will inexpensively but effectively send images of museum exhibits over the Internet using the existing website. Further consideration must be taken with the desires and specific characteristics of the National Museum in order to find the most suitable match. In situations where the user is in the same building as the cameras, no Internet connection is needed and all camera viewing can be done with a CCTV (Closed Circuit Television) system. This solution easily provides detailed video images, but is typically not accessible over the Internet. Fortunately, there are some alternatives to web cameras that are much less demanding on Internet connections while still providing a realistic virtual experience. Two of these options are panoramic imaging and virtual object creation.

Panoramic images give users the illusion of being completely surrounded by a scene in which they can turn and look in almost any direction. A collaboration of carefully connected pictures creates the sense of standing in one spot, but more advanced techniques can allow the user to navigate within the virtual room. Virtual objects replicate the ability to pick up an object and turn it around for examination as if it were in the users own hands. These objects are created through a process of three-dimensional rendering, which gives depth to otherwise flat images.

Each of the above techniques possesses characteristics that may make it more or less suitable for a situation based on specific criteria. To find the most suitable virtual presentation package, criteria such as cost, reliability and functionality must be considered as

well as the desires and goals of the museum. The selection of a suitable solution can be supported by the results of a decision matrix, a helpful technique for assisting in making organized and unbiased decisions. In addition to selecting an imaging system, the images must also be made available for viewing from remote locations.

In order to make any virtual display accessible over the Internet, it must be hosted by a web page, which acts as the crucial link between the remote user and the museum. The web page could serve two purposes: to reach out to people who cannot make a real life visit and to enhance the experiences of potential visitors or researchers by acting as a supplementary tool. In addition to images, the web page must also provide factual information to accompany the artifacts being displayed.

This document will present background information regarding virtual touring systems as well as describe the methods used in this project to determine the most suitable technology system for the National Museum. In addition to the recommendations and conclusions described in this report, a simulation or prototype of the most suitable technology system is also provided. This prototype provides a clear depiction of the exciting possibilities for virtual touring at the museum and demonstrates the relative ease with which the process can be carried out. This will provide confidence and motivation for the museum to carry out the implementation of panoramic virtual touring in the near future.

2.0 Background

The information appearing with museum exhibits is typically informative but concise. This allows the museum visitor to focus primarily on visually taking in the sights rather than being slowed down with detailed reading. In the case of the virtual visit over the Internet however, it is possible that some people would be interested in performing more in-depth research about the artifacts. In this case, more detailed historical documentation and descriptions would be appropriate. Since the integration of text information into the web page would be different for each method of virtual touring, it is necessary to consider the content and organization of supporting material when selecting a system. To gain insight into the ways information regarding artifacts is presented, we must consider the advice of experts as well as existing online tours.

2.1-0 Artifact Descriptions

In the past, some museums have tried to put emphasis on their collections, rather than educating the general public about their exhibits and the artifacts presented in them. Sir Henry Miers performed a study on these museums, and his report was quite dismal. People were not enthusiastic about visiting museums because they didn't understand the information that they were given (Belcher 173). The information presented with exhibits is vital to the interest of the visitor, and therefore, the livelihood of the museum. Descriptions need to be both interesting and informative, but remain short enough to hold the reader's attention because people often associate stress with learning. This balance can be difficult considering the wide range of classes, ages, educational levels and nationalities that view an exhibit. The best presentation of information will provide visitors with a feeling of satisfaction that they have gained useful knowledge. Anything that is too long or complex will most likely lose the

reader's interest (188). The information in Figure 1 is an example of the information that is

provided with a painting found in an exhibit, according to David Cassedy (10).

Figure 1: Typical exhibit information

Title   Year Made
Type of Painting
Length x Height
Inscription:
How it was acquired and
Year of acquisition

2.1-1 Online Tours and Exhibits

One way for museums to extend their audience and make information available to

remote viewers is though the use of the Internet. Developments in computer technology

continue to make this option easier to achieve and increasingly effective.

2.1-2 The Worcester Art Museum

The Worcester Art Museum has a portion of its painting collection available for

online viewing as still photographs. Instead of having a "virtual tour," it just gives the

audience an opportunity to see one part of the museum online, and gain a little bit of

knowledge about it. This site gives the audience a taste of what the real museum has in order

to increase the interest level, and tempt people to come and visit the actual museum. The part

of the collection found online is called the Early American section. On the first page there is

a small time line from 1672-1829. Along the line there are paintings in chronological order

on the top, and there are historical facts in chronological order along the bottom. For

example, the first history fact is "1672- Third Anglo-Dutch War". At the top of the page, the

user can click for an introduction to the collection. This introduction contains two pages.

The first page gives a short description of the kinds of paintings found in the collection while

the following section explains how the user can navigate the website. This informational

section is written by the museum experts and describes where historical information is

located on the website. The user can also view a bibliography where all sources are listed as well as a contact page with people who can answer questions about the section. Also, the user can click on "acknowledgements" for a list of people who helped with the setup. Visitors also have the option to view paintings by author, genre, or place of origin. Each painting can be seen in miniature below its classification but clicking on this thumbnail brings the user to a lager display of the painting. Underneath this display is the name of the author and a brief biography as well as the type of painting, size and the means of obtaining it. From this page the user can click on the painting and get an even larger picture of it.

2.1-3 Museum in Florence

At The Institute and Museum of History of Science in Florence, Italy, a special technique called panoramic imaging has been implemented to provide a 360-degree view of a chosen exhibit. The user can look at the room and choose to look to the left or right, and zoom in and out. In order to zoom into one section of the room, the user positions the cursor over the object and presses the SHIFT key to zoom in, and the CONTROL key to zoom out. More details regarding panoramic imaging will be discussed later in the chapter. The user can click on any artifact in the room and a detailed photo and description will appear in the other half of the screen. This detailed photo atones for the lack of image quality when viewing the entire room. The associated information lists the year or century the object was created, the creator, uses, components, and its overall size. For example, Figure 2 shows a Geometrical Sector used by Galileo that is presented with the following format:

Figure 2: A sample of online displays.

Geometrical Sector

Seventeenth century. Galileo Galilei. Brass, Length 256 mm; width (open) 360 mm
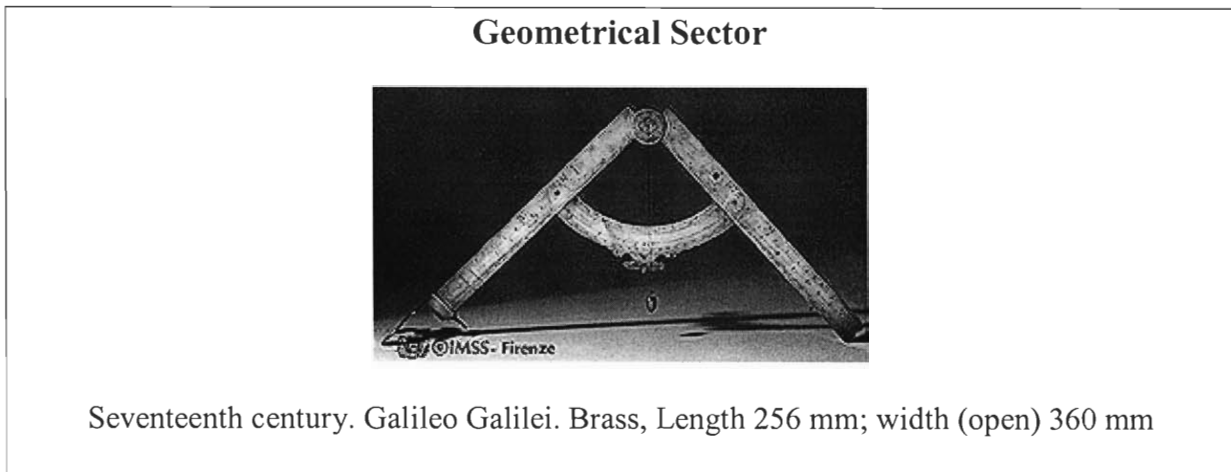
Also accompanying this picture is a short description of the object in view. It describes the period in which object was used, its purpose, and persons who used it. It gives a brief history of the owners and interesting uses. Important parts of the description, such as other names, and special terms are linked to websites that go into more detail about each part. On this site, there are paintings portrayed with links to the painter and related matters, where the description paragraphs are much shorter.

2.1-4 Audience Perspective

An important consideration when creating a virtual tour or online presentation is the viewpoint or perspective of the audience. For most people, the best positioning for viewing is at eye level. Therefore, images in a virtual tour should mimic this sensation rather than placing the viewpoint low on floors or from very high ceilings. The human brain reads information in a very specific manner. The first thing that a visitor will do when approaching an exhibit is to scan the presentation. Many subtleties contribute to the perception of objects in the human mind and it is very important that the viewers are comfortable with their field of

view in order to have confidence in their examinations and personal conclusions (Belcher 187).

2.2-0 Video Technologies

So far, we have seen two examples of existing online virtual tours that are potential options and will be discussed in more detail later. However, these techniques happen to lack the same feature. This would be their lack of realism or interaction with other viewers. As stated by Michael Belcher, "An exhibition does not in fact exist until it is crowded with people, and what really matters is how these people react to what they see" (172). The livelihood of museums depends completely on their visitors, but still images or panoramic views eliminate the presence of other human visitors. Fortunately, there are more sophisticated developments of technology, which can effectively convey the energy of a crowded room.

2.2-1 The First WebCam

A short article titled *Coffee Cam* in the June 2001 issue of Technology Review described the creation of the first WebCam by a group of researchers at the University of Cambridge in 1991 and presents an interesting anecdote. At that time, the Internet was still in its infancy and the relatively few people using the worldwide connection were primarily technology-minded individuals. The research labs were spread out over different areas of the building but there was only one coffee maker in the building. Naturally, those people closest to the coffee maker found it easy to help themselves to the coffee, but this wasn't the case for the researchers in other parts of the building. One day, they decided they were tired of walking up the stairs only to find an empty coffee pot so they set up a camera. The video camera pointed right at the coffee pot and was wired to a nearby networked computer. This

setup, along with some programming code, captured images of the coffee pot three times a minute and made them viewable for any computer on the network. A couple years later the system was still in operation but a newer group of researchers decided to share the coffee pot images over the entire Internet. The first WebCam was in place and so it stood until August of 2001. Surprisingly, the principles of WebCams have changed little over the years and the original setup has remained as a standard configuration for WebCams.

2.2-2 Modern WebCams

WebCams are specialized video cameras that are meant to send video images over the Internet. They come in a variety of shapes and sizes as well as levels of capability and cost, which start as low as $50.00 up go up to several thousands of dollars, depending on the features of the camera. Applications range from security surveillance and traffic monitoring to personal hobby or even virtual tourism cameras. Despite the many variations, the central concept remains the same: to send images from a camera through the Internet for people around the world to view on their computers. Currently there are numerous options available that will produce results, but the challenge is to configure the optimal package for a particular situation. The following sections are dedicated to explaining the steps for putting together an efficient WebCam system.

2.2-3 Camera Capabilities

The qualities and capabilities of WebCams generally improve with increased cost. Some are able to change direction and zoom while others remain completely stationary. A camera mounted on a highway overpass to monitor traffic flow needs only to be aimed in a fixed direction and have a fixed focus. Since the goal of the traffic camera is to provide a broader picture of traffic rather than examining the fine details of each passing car, the

camera does not need to change its direction or zoom in for detail. This type of camera gives the bigger picture quite effectively and does so reliably and inexpensively. Small companies or hobbyists wishing to utilize the Internet for video communications commonly use this fixed camera configuration. These camera systems are relatively easy to put in place and require fewer resources than elaborate setups. Sometimes these components are called ***PnP***, short for plug and play devices because they can be plugged directly into the back of a computer through an existing port such as the ***USB port*** and are nearly ready for operation. (All bold faced terms can be located in the glossary.) Even the electric power required to run the camera is provided through the computer. The computer, to which the WebCam is linked, becomes the host computer for that camera. So long as the hosting computer has software to communicate with the camera and is connected to a ***web server***, video can be sent out over the Internet. A web server is another computer that runs software programs, which allows connected computers to communicate with one another .

In places such as casinos or busy department stores where security is an issue, a more sophisticated camera system is needed. With large numbers of people moving around randomly, it is necessary that the camera be able to ***pan*** left and right, ***tilt*** up and down and ***zoom*** in and out. This is made possible by electric motors and mechanisms incorporated into the mounting fixture of the camera. The operator controls the camera remotely and has the ability to narrow in on a specific area of interest and examine it more closely. In the cases of stores or casinos, the images from the camera are usually sent back to monitors within the same building. However, if these cameras were utilized in a WebCam system, the images could be viewed from other computers on the Internet and the user could still have control over the camera motions. These robotic WebCams provide the most realistic experience for remote viewers, but they are significantly more expensive than fixed cameras. For this reason, it is critical to examine the intended purpose of the WebCam so that the most

practical and economic solution can be implemented. The quality of the image is also a factor to consider when selecting the best WebCam for a given situation.

2.2-4 Higher Quality Images

When setting up a WebCam, it is important to remember that the quality of the image the viewer will see depends greatly on the quality of the camera capturing the images. When clear detailed images are important, more sophisticated WebCam systems should be utilized. These include adapted commercial video cameras and specialized network cameras. Rather than rely on a host computer, these systems actually have their own computer built in and are powered from a separate source such as a standard electrical outlet. Network cameras are the most advanced WebCams available on the market because their built-in computers have *web server* capability included, which allows them to connect directly to the Internet for use (Teschler). This allows them to transmit higher frame rates than WebCams that use a USB cable and host computer. The frame rate is commonly indicated by *fps* or frames per second and is an indication of how many still images are captured by the camera each second. Motion video can be accomplished with just a few frames per second, but higher frame rates provide smoother images. Network cameras are also quite expensive and for this reason, typically only large companies and well-funded organizations purchase this equipment, as opposed to WebCam hobbyists.

Standard video cameras and even some digital photographic cameras can also be used as WebCams if they are linked to a *video capture device*. The video capture device is usually a circuit board that can be added to the hosting computer. Some more recent versions include web server capability and don't require a host computer. These devices change the electrical signal from the camera into a digital code that can be passed as data over the Internet. This method can provide higher quality images from a WebCam system and make use of pre-

owned video equipment. However, close attention must be paid to the electronic characteristics of the camera and capture devices when combining hardware from different places around the world.

2.2-5 Hardware Compatibility

Different parts of the world have adopted independent sets of regulations and standards regarding the electrical signals that are output by video cameras. The camera type must match the computer or capture device in order to work properly. In the United States and Japan, the standards are set by the NTSC (National Television Standards Committee) while most of Europe follows PAL (Phase Alternative Line System). These regulations determine specific frame rates and image resolutions and although this discontinuity can be inconvenient, is typically not a problem to overcome. In addition to hardware compatibility, the software used to communicate with the WebCam must also be in compliance. The software must also be suited to carry out the desired speed of data flow depending on the Internet connection. Often, the software comes with the WebCam, but for when it doesn't there are many companies selling software packages.

2.2-6 Internet Connection

Despite great advances in WebCam hardware, a real limiting factor is actually the Internet over which the data must travel. Connection speeds are increasing all the time, but the Internet is still a long way from providing the smooth, clear images produced by broadcast television. Even the leading Internet connection known as a T-1 is not yet fast enough (EarthCam School). No matter how capable a WebCam system is at producing clean images, the connection of the user on the other end plays just as a significant role in determining the final image quality and transmitted frame rates. An important concept for

transmission of data over the Internet is known as **bandwidth**. Bandwidth translates to the rate at which information can be carried over an Internet connection. It can be thought of like roadways where multilane highways can carry much more traffic than a two-lane street. When attempting to set up a WebCam, the type of Internet connection that will be used must be considered since connections vary in speed, reliability and cost. Standard dial-up modems are like the small streets and T-1 connections are like the high volume expressways. However, just having a high bandwidth connection doesn't mean that all of it is accessible. With some Internet connections, multiple users share the same bandwidth and it is possible to overstep one's fair share. It is important to determine from the **ISP** (Internet Service Provider) what consumption of bandwidth is permissible. Also, the characteristics of the **IP** (Internet address) must be considered. Internet connections such as dial-up modems only provide a **dynamic address**, which means it can be different each time a connection to the Internet is made. Direct network or Internet connections allow for a **fixed IP address**. Having a fixed IP address is crucial to sending higher quality images over the Internet. An analogy could be a person trying to receive mail through the postal service. Living in one place makes it much easier for the mail service to complete deliveries rather than if the person constantly moves around to hotels or apartments. Further discussion of networks and Internet connections can be found in Appendix B.

2.2-7 Specific Setup Options

A major step in setting up a WebCam system is deciding whether to use snapshot techniques or streaming images. Any WebCam is capable of taking snapshots. Individual pictures are captured and then sent out to the server on a fixed time interval. This interval could be as low as once a day or as often as every 15 seconds. Generally, these slow rates are still considered good enough to be "live" but obviously lack continuity. However, this

technique does provide very high quality images and for some situations, that is more important. The standard method for providing sequential snapshots is called *client pull*. With this setup, the most recent image captured by the camera is sent via *ftp* (file transfer protocol) to the server then on to the web page. In order to see the next image, the user or client, must reload the web page. However, clicking a button on the web browser to reload the web page can get redundant, and for this reason people have developed codes and small programs that direct the web page to reload automatically. These codes can be incorporated into the same code that defines the other characteristics of the web page or small programs called *applets* can be downloaded onto the client computer.

When attempting to capture motion activity, more continuity is required. Imagine attempting to watch a television show despite turning the set off and on for seconds at a time. This would result in missing a great many details and cause the associated disorientation and confusion. For example, a robotic camera system would be difficult for the user to control if the images were discontinuous. Therefore the *streaming* technique should be implemented. Streaming requires the WebCam system to capture and transmit images several times per second. Commonly, this is done using a technique called *server push*, where images are continuously sent to the client while others are still being watched. Server push is the only way to *broadcast* images that are live or in real-time. However, it also requires a high *bandwidth* connection and a *fixed IP address*. Due to the large amount of data being passed quickly, some clients will be unable to enjoy the WebCam images. People with dial-up modems simply do not have enough bandwidth to view these streaming images; there is just too much information being passed all at once. For those with better Internet connections, the most up-to-date Internet *browsers* are required along with downloadable *applets*.

Another parameter affecting the amount of data being transmitted from a WebCam system is the *resolution* of the image on the hosting web page. The image size is described

by resolution, which is indicated by a product of horizontal and vertical pixels. A pixel is a tiny dot composed of three yet smaller dots. By flashing red, blue or green, nearly any color can be displayed on the monitor. Resolutions range from as low as 160x120 up to 640x480. The larger the image is on the web page, the longer it will take for each image to download. If the frame rate is faster than the time needed to download a single frame, the image will be a mess.

2.2-8 Closed Circuit TV

In situations where video images are to be viewed from a nearby monitoring station, transmission of data over the Internet is unnecessary. Closed circuit television systems (CCTV) provide video monitoring with higher reliability, clarity, and user control than even the best robotic WebCam systems. This type of system was described earlier as being useful for department stores or casinos and thus CCTV security systems are widely used for surveillance.

2.2-9 Companies and Suppliers

Online WebCam stores provide overviews of the most popular WebCams on the market, in addition to tutorial information (Earth Cam School, Web Cam World). Other articles offering product reviews listed company information and web addresses for several reliable companies (Teshcler). They include, the WebCam Store, EarthCam, Be Here Corp, Darim Vision Crop., Inetcam Inc., Logitech Corp., Opto 22, and PixelCam Inc. These companies have remained active over the past two years and still provide a variety of WebCam solutions. An example of a WebCam system produced by EarthCam is described below.

2.2-10 Robotic Camera System

The EarthCam Robotic Camera System is a package solution for providing live video and remote camera control to web site visitors. The system includes a server, which controls up to two cameras and can be linked directly to the Internet or through a network. Camera motions include full pan, tilt and zoom while the server has a queuing feature that allows users to wait in a virtual line and have a set amount of time to control the cameras. Up to 20 users can however view the current images at once despite not having control of the camera motions. This high-tech solution see in Figure 3 is valued at $4739.95 for two cameras and one server.

Figure 3: Robotic camera system. www.earthcam.com

2.3-0 Alternatives

Although the live broadcast of robotic WebCams provides a sense of control over a medium and guarantees "authentic" reproduction of a scene, problems such as bandwidth requirements, time delays, and backlogs present daunting concerns. To solve the wait time for the camera, a link to a portion of the website that offers pictures with appropriate descriptions may be offered. Creating the portions of this website may be as easy as snapping a few photographs and summarizing existing descriptions. Patrons who visit the website solely for camera access however, may be turned away by the wait and/or the substitute tour mentioned above. Alternatives that can supplement or replace the use of

cameras may utilize panoramic views or three-dimensional rendering of still photos. *Panoramas* provide the user with the notion that one could turn 360° and zoom in and out. Objects created from rendering photos provide the user with the notion that they could touch the object ("What is VR?").

2.3-1 Panoramas

Panoramic views *stitch* together numerous photographs, taken at different angles all the way around the viewer 360° and 180° in the vertical plane. To create a panoramic image, pictures that overlap each other by a pre-set percentage are taken and stored. This overlap is required to match images on differing photographs so a seamless image can be created. The amount of overlap is dependent on the *field-of-view* of the lens that is used. Field-of-view is the horizontal cycle that is swept by the camera image, measured in degrees. For this reason, wide-angle lenses are advantageous because of a reduced number of pictures that are required to create a panoramic image (Panoguide).

2.3-2 Panoramic Hardware

The first step in creating a panoramic image is to select the type of camera to be used. Traditional film and digital cameras can be used, as well as more expensive specialty cameras. Traditional film cameras have high resolution, are less expensive than digital cameras, and have a wide variety of lenses. However, the images must be digitized for the stitching software, and effects such as color correct and dust mark removal are required, which results in longer processing time. Digital cameras are easier to operate and are fast to process, but are more expensive and have lower resolution than film cameras. Additionally, memory requirements are steep; large storage mechanisms must be carried along to handle the vast volume of pictures that are required. A panoramic camera can shoot 360 degrees

horizontally in one shot, which reduces the number of stitches required, but this method is much more expensive than conventional film and digital cameras and is difficult to master. Parabolic mirrors enable the photographer to shoot a perfect panoramic image in one shot, which means no stitching will ever be needed. No special equipment is required. The learning curve is very short. However, this setup cannot shoot spherical panoramas. Additionally, the resolution of the final product is limited to the maximum resolution of a single picture shot, so overall quality may suffer. Panoramic cameras and parabolic mirrors are effective devices, but their high costs justify the use of less expensive film or digital cameras and stitching software (Panoguide).

It is critical that the pictures taken come from the same height and location. Not doing so will result in *parallax*. Thus, a tripod with a *panoramic head* is often used to eliminate this problem. A panoramic head is an additional piece of equipment similar to a turntable. It is placed on top of a tripod and allows one of the *nodal points* of the camera to be directly above the point of rotation. (Figure 4) Nodal points are a set of points, in front of and behind a lens, that refract light rays at the same angle. Kaidan, Manfrotto, and Peace River Studios are a few companies that sell panoramic heads (Panoguide).

Figure 4: Camera mounted on top of a panoramic head

(http://www.kaidan.com/products/qpx2pan.html)

2.3-3 Projections

Once a bank of photographs is digitized onto a computer, a method of stitching these photographs begins.   There are many ways by which a computer program stitches photographs. The term ***projection*** describes how the stitching tool works, how it saves an image, and how the final product is viewed. If the image from a movie projector is displayed on a surface that is not perfectly flat, the image is distorted. Stitching programs morph the photographs taken because they are written on a two dimensional medium. These pictures must be "bent" in order to provide the perception of depth. Examples of projections include flat, planar, cylindrical, spherical (or equirectangular), or cubic (Panoguide).

Flat projections do not correct for distortion. This introduces difficulties in maintaining continuity between stitches, but since very little is done with the photographs, the resulting images are the sharpest and the process is not lengthy. Planar projections only describe the way the image is stored. For example, a spherical image can be rendered flat for about 120 degrees horizontally. This method is advantageous if one desires to print partial panoramas or mosaics. Cylindrical projections can be corrected horizontally, but not vertically. If wide-angle lenses are to be used, distortion in the vertical directions will be obvious. Spherical projections offer the best overall quality when dealing with an unbounded scene. Correction both vertically and horizontally results in more processing time and increased memory requirements. Cubic projections display the image as if it were on one of the six faces of a cube. The view is very similar to the spherical projection, but the hardware requirements for viewing are lower. This method may be advisable for the projection of a room, which has pre-set stitches on the corners (Panoguide).

2.3-4 Software

A computer program gives the author the power to choose the projection that best fits the application. Apple's QuickTime VR Authoring Studio is a widely used program. Retail price is $395 USD and it does not provide a PC version, but the options and features are plentiful. This program has "virtual tour" capability in that objects in the tour can be linked to websites, or descriptions provided, perhaps in another frame. MGI/Live Picture's Reality Studio is a Windows version of stitching software with virtual tour capability. Retail price is $189 USD. VR Toolbox's VR SceneWorx is a cross-platform virtual tour creating program. Retail price is very modest, at $89.99 USD [6].

2.3-5 Multi-camera Panoramic Video

If a robotic WebCam is set up to send live streaming images, only one person can have control over it a time. This makes it necessary to have guests wait in a virtual line for their chance at controlling the camera. An alternate approach is to assemble one large video image that plays continuously but allows individual users to zoom in and around the image. This will give the feeling of a robotic camera system without moving the camera. Actually, this is accomplished by using multiple video cameras and lacing their views together in order to make a seamless panoramic view. This system allows many more people to experience the video imaging at once and minimizing the amount of data that must be transmitted over the Internet (Foote). Since there are no moving parts, this setup should be very durable. Live control of a WebCam would require moving parts, which translates to wear. A popular method for providing 360 degrees of view in a video is the use of a FlyCam. Built with the inspiration of insects' compound eyes, FlyCam uses an array of cameras positioned such that a full 360 degree viewing area is assured. Arrays typically use four or five cameras, although using more cameras will ensure higher video quality. The FlyCam pictured below in Figure 5

uses eight cameras, and the overall size is quite small- the array is only 11 centimeters or 4.2 inches tall. FlyCam arrays must be built as small as possible to reduce the effect of parallax (Foote).

Figure 5: Fly cam. (http://www.fxpal.com/PapersAndAbstracts/papers/foo00a.pdf)
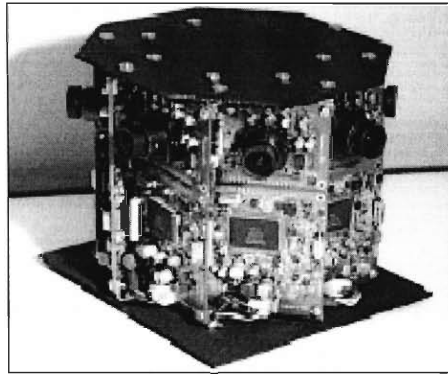
2.3-6 Virtual Objects

The other form of virtual reality is object-based. That notion was mentioned briefly above, where interactions in a virtual tour with objects can be achieved. However, object interaction is thematically different from panoramas. Panoramas allow users to look in different directions as if they were walking, but object interaction allows the users to control the object as if it were in their own hands. This provides the user with another virtual experience.

Obviously, objects that that are intended for interaction must look like the original object. An image that only portrays depth is insufficient. Lighting, as well as geometry and color, are the prime determinants of realism for objects. One method of simulating light on a virtual object is known as *ray-tracing*. Light waves from the viewer's perspective are plotted as they reflect off walls, mirrors, etc. and finally strike the object at varying angles and intensities. This is an extremely tedious task, and this method does not account for light refracting through surfaces. *Caustic shadowing* is an addition to traditional ray-tracing techniques that plots the reflection, refraction, and concentration of light as it strikes opaque, translucent, or lens-like surfaces. Ray-tracing only determines where shadows are placed,

rather than considering the fact that light may do more than just reflect off of a surface (Caustics).

In addition to making an object look real, users can move an object so that multiple angles of the object view are possible. Known as object VR, this technology simulates the ability to hold and examine an object. This is done by stitching photographs of the object that wrap 360 degrees around the object. Typically, the object concerned is placed on a turntable, or equivalent. A mounted camera takes pictures at predetermined angular intervals. Similar to panorama image stitching, the resulting images are stitched such that seamless views of the object are available, 360 degrees around the object.

2.3-7 Virtual Environments

Another application of three-dimensional rendering is the creation of a virtual environment (VE) from a set of photographs. Imagine creating a video game that originates from your own home. In this game, you can interact with objects just the way you can in real life. You can open doors, move furniture, or turn on a light. A virtual environment simulates the interaction between user and surroundings. A group from the University of Manchester has devised a method of creating a virtual environment from a set of photographs.

Before this environment can be created, the cameras that took the photographs must be calibrated. Working backwards from panoramic image creation, the location of the camera when the pictures were taken can be specified. After the locations are confirmed, an outline of the room in question is created. After the outline of the room is completed and surface textures are re-employed, parameters governing the rotation of doors, function of light, and other interactive qualities can be integrated into the VE (45).

3.0 Methodology

There are several ways to utilize technology for the creation of virtual tours. Each technique, however, has unique characteristics, which could make it more or less suitable for a given scenario. In addition to understanding this technology, we needed to understand the specific characteristics of the Danish National Museum and the particular exhibit. This provided the information to determine the most suitable solution. Once all of the concerns were defined, decision-making techniques were utilized in the selection of the most suitable technology for presenting images of the room. Furthermore, we identified useful supplements to the primary imaging technique in order to produce a valuable touring system. The final step was to develop a prototype to demonstrate the chosen technology system.

3.1-0 Onsite Interviews

To supplement our background knowledge of virtual touring technologies, we obtained details specific to the site to direct our focus on the museum. In doing so, we worked closely with our project liaison as well as other staff members. Museum executives will be presented with our project and prototype upon its completion in order to decide if the system will be implemented. The desires of the executives are, however, well represented through the concerns of the museum staff.

3.1-1 Initial Interviews

The first interview was with our project liaison Karl-Johann Hemmersam, who is head of the education department, because he was our primary contact at the museum. Through an unstructured and non-standardized interview, we clarified the goal of our project and formulated a contract of expectations. A summary of the information gained will be discussed in the next chapter and other interviews will be treated in the same manner

throughout this chapter since the style of our interviews remained constant. We found that the unstructured and non-standardized interview format was most effective in allowing the interviewees to provide us information at a comfortable pace.

The next interview of our initial interviews was with Berit Elgaard who works in the Knowledge Center within the museum. This interview was very useful to us because our project is sponsored by the same department of the museum and thus would have a similar style and set of objectives.

3.1-2 Technology Related Interviews

Due to the high level of computer, Internet and electronic technologies involved in the project, we sought local experts in these fields for their knowledge. Such experts included the museum's Webmaster as well as staff from the Photo Studio and Audio Visual Department. The first in this series of interviews was with Steen Mortensen, the Webmaster of the National Museum's current website.

The interview with Mr. Mortensen familiarized us with common Internet concerns, both server-side and client-side. He gave us information about the user interface as well as Internet speeds, which was very important information in the determination of the most suitable solution. We also questioned Mr. Mortensen about the available computers, network configuration and Internet connection at the museum. If the museum's network was not highly developed or lacked server capability, some of the potential solutions such as WebCam broadcasting would not be well suited to the museum.

In addition to information regarding the museum's technological status, we also had some more practical considerations regarding photography or video in the exhibit. For this reason, we held an interview with Michael Bjørn, the manager of the audio visual department at the museum. Also, we were introduced to Weng Lee from the museum's photo studio who

had made the most recent attempt to operate the digital camera to be used for prototype construction. These findings were important not only for the production of our prototype but also for the possibility of future implementation of our project at the museum. Since cost is a serious concern for the virtual tours, it was important to know if pre-owned equipment could do the job and hence reduce expenses.

3.1-3 Interview Regarding the Exhibit

As mentioned in the previous sections, there are definite concerns for the exhibit with some of the technology systems. Depending on the specific method, there could be a significant amount of interference caused by video or lighting equipment installed within the exhibit. We discussed these concerns, as well as others, during our interview with Vibeke Andersen Møller, the historian who designed the three room apartment displayed within the "Histories of Denmark 1660-2000" exhibit. The primary focus of our project work is to show the exhibit, but integration of supporting information is just as important in order to make the virtual visit a valuable research tool. Ms. Andersen Møller identified all of the key elements in the rooms for which we needed to provide extra information. That information, in full, would be completed in detail if the museum decides to implement our project. General information regarding artifacts in the exhibit was gathered to be implemented into the prototype.

3.1-4 Exploring Individual Rooms

A preliminary examination of the rooms was deemed necessary, as potential problems can be foreseen. The style of the room is called Rococo, which is discussed in **Appendix C**. There are many objects in the room that needs to be described on the website. To integrate

these objects with the website in an effective manner, background knowledge about the artifact is required.

3.2-0 Decision Making Methodology

Upon the completion of our interviews and examination of the specific exhibit, we compiled all the information in order to make a decision. This decision involved choosing a technology system that best met all of the criteria and desires of the museum. Within the technology system, we expected to have three components working together to provide a high quality virtual tour. The central component of the tour was intended to be a realistic view from within each room. Detailed images of objects in the rooms as well as an abundance of factual information and stories would support this feature. Since our greatest concern was the selection of the technology for the primary image, we decided to utilize a decision matrix. In order to find the best fit solution, bias had to be eliminated from the decision-making process since it is possible to become fond of a particular solution and have a tendency to favor it over others. This fondness for one solution could have prevented us from realizing the unique qualities of other options. Fortunately, a non-biased selection of a product or a system can be made with the support of a decision matrix.

3.2-1 Setting up the decision matrix

A decision matrix uses numerical methods to score and rank options objectively. It has a format similar to a multiplication table where a horizontal row across the top of the grid lists the separate products or systems. A vertical column on the left side of a grid lists requirements or specific criteria by row. The top row of products could list different brands or types of equipment as well as general methods or techniques.

The first step in producing our decision matrix was to compile a list of potential solutions. The second step was then to list all concerns or criteria, which would eventually be used to evaluate the different products. After the primary row and column were each filled in, we then had to determine the relative weights or importance's of each criterion because some concerns were of more or less significance than others. Mathematically, the designated weight of a given concern multiplies scores to inflate or reduce its influence in the total score. The relative weights of concerns can be determined in a number of ways.

3.2-2 Matrix Evaluation

When the matrix was completely set up, we started the scoring process. Each option was scored on a specific scale to measure its performance in light of a concern or required criterion. Criteria such as cost are easily represented with numbers because they are already of a quantitative nature. Qualitative issues, such as reliability or ease of operation, are not as easy to represent with numbers so careful consideration was given to the ranking options.

Once the scoring system was determined, the matrix was ready to be completed. Each product was given a score indicating if or how well it met the requirement in the corresponding row. After the scoring was complete, each raw score was multiplied by the appropriate weight to produce a weighted score. When the matrix was completely filled, each product was given a total score by summing all of the weighted scores in its column. The product with the best score was then considered the best solution. In the case of some options, the final scores were close and could not be taken as definitive answers since there could be uncertainties within the relative weights and sub scores. These uncertainties can limit the decision matrix as a quantitative tool, meaning that a final decision can only be supported, not determined, by its results. In order to make our final decision, we had to utilize our expertise and understanding of our situation in addition to the results of the matrix.

3.3-0 Building the Prototype

After using a decision matrix to help determine the most suitable technique for providing the primary image within the technology system, we began building a prototype website to demonstrate the solution. The primary focus of the prototype was to show images of the exhibit rooms using the selected technology solution offering pan and zoom features. In order to do this, we had to select both the hardware and software necessary for the capture of the exhibits as well as the online display of the images. For the prototype, utilization of museum resources was essential in an attempt to work with a zero cost budget. In addition to the primary images, our prototype needed to demonstrate the other components that completed the system as well as the basic features of the website. These selections, as well as our interview findings and decision matrix results, will be discussed in the next chapter.

4.0 Results

After carrying out the interviews, we had enough information when combined with our background research to decide on a suitable solution. As explained in the previous chapter, we prepared sets of questions and concerns in order to enhance the utility of each interview. We then extracted the most useful and relevant information from each interview, and used that information to help complete our decision matrix. The results of our decision matrix provided strong support for our selection of a suitable technology for virtual touring. Detailed accounts of the interviews can be found in **Appendix E**.

4.1-0 Results of Interviews

4.1-1 Practical Concerns

The concern of cost was brought up at every single interview and listed as the first and foremost concern of the museum. Our liaison, Mr. Hemmersam, told us that due to cutbacks, any future implementation of our project would be given a budget of approximately 8,500 Danish Crowns, which is about $1,000 USD. This immediately helped us determine that we were going to have to rethink the idea of any sort of live feed imaging. The hardware itself for these procedures far surpassed the given budget. Mr. Mortensen, the Webmaster, agreed that the cost of live feed imaging would be very high. Although the museum's present server could handle the transmission of live images from the three rooms, the addition of more cameras would be limited by available bandwidth. Increasing the available bandwidth would be a costly procedure.

When we mentioned our cost concerns for live feed imaging, Mr. Bjorn, from the Audio and Visual department, brought up several other points about it. His first comment was that since there is no motion in the room, live feed video would be pointless. He also

mentioned that there would only be one user controlling the camera at a time, and people would not be interested in waiting in line to use it.

Another important factor that Mr. Bjorn and Mr. Hemmersam introduced in their interviews was the necessity to keep distractions at a minimum level in the actual exhibit. Our goal was to make the rooms accessible to users outside of the room, but in doing this, we did not want to disturb the view of visitors. Mr. Bjorn pointed out that in order to use web cameras or fly cams, the hardware would have to be located within the exhibit. The rooms however, are very small and it would be difficult to conceal any kind of camera as well as wiring and lighting.

In conjunction with cost, Mr. Hemmersam mentioned that the museum wanted to be able to reuse the technology that we developed in other exhibits. This could save time and money for the museum since it is not possible for the museum to develop a new viewing system for each exhibit. Ms. Elgaard also stressed the importance of this factor to us. She told us about the Klunkehjem exhibit, located just down the street from the museum, where the museum could utilize our technology system. This exhibit is a Victorian apartment that museum visitors can not enter due to preservation concerns, but the museum would like to be able to display it online.

Another factor connected to cost was making use of hardware already owned by the museum. We learned from the photography department that the museum owned a new digital camera as well as tripods that could be used to create panoramic images. Mr. Bjorn said the museum did not already own any live feed cameras but the AV department did have lighting equipment available. Mr. Bjorn also told us that the museum *out-sources* when purchasing hardware or hiring photographers. Although the museum has several photographers in house, none of them are experienced in the field of panoramic imaging. They would have to train themselves or hire professional photographers to do this.

4.1-2 Website Development

For every possible viewing method, some web development would be necessary. According to Mr. Mortensen, several animated virtual tours have already been created by people within the museum. Ms. Elgaard showed us several of these programs and pointed out the cost effectiveness of using a technology system that could be implemented by museum staff. Any kind of images, whether panoramic or live feed, would have to be displayed on a website. Mr. Mortensen stated that fortunately, there are several people employed within the museum who are capable of creating websites with these kinds of insertions.

4.1-3 Website Concerns

Image quality was also a very important factor and was discussed in several interviews. In our first interview, Mr. Hemmersam stressed the importance of being able to view with detail everything in the room. There are several intricate objects and decorative components in the room such as the wall and ceiling carvings. Making these components of the room viewable is a central motivation for the project. Any technology that could not show these small details online would not be of use to the museum. Ms. Elgaard said that she believed real pictures would create a realistic view of the room. This would have been realizable by the live feed camera, or panoramic imaging methods.

Also related to image quality, transmission reliability was mentioned several times in interviews. Mr. Hemmersam said that it was necessary for the user to be able to access the website each time that they tried. He told us at our first interview that the primary viewing audience would be members of the general public in Denmark over the age of fourteen. Mr. Mortensen predicted that most of these would people would be accessing the Internet via relatively slow dial up internet connections. If the touring system required a lot of loading

time, most people would not be able to access the site from their homes. Having live feed imaging would require a faster internet connection but panoramic imaging and still images could both be viewed without problem from a dial up connection.

Ms. Elgaard also informed us about the basics of the format of the museum's current website. Web pages at the museum are done in a layering format which was a helpful guideline for the creation of our prototype. The first site that the viewer visits would show an object from an exhibit with a short text containing general information, and then a few pictures. If the viewer finds this intriguing, he or she can choose to go on to the next layer and study the discussions, analyses, or debates about the object in view. The third and final layer of the site would contain a full text on the subject, with links to relevant information, literature, and articles.

Ms. Vibeke Andersen Møller helped us find information in order to follow the museum's website format. She is the specialist for our exhibit, and met with us the day of the photo shoot. Ms. Andersen Møller offered several insights into Rococo Style and specific pieces in the exhibit. This helped with the creation of Appendix C. The specific stories on the room also helped with the texts of hotspots found in our prototype.

4.1-4 Future of the Website

Mr. Mortensen also told us a little bit about future developments in the museum's website. He said that the museum was currently working on a new website. There will be German, English, Spanish and Italian translations for it, but they would not have as much detail as the Danish version. He said that whatever work we did in English would probably not be used on the actual website, but the ideas and processes that we left behind would be important to creating the Danish site.

4.2 Completing the Decision Matrix

The structural layout of our decision matrix is a generally accepted format. The selection of weights and scores, however, required much more careful consideration in order to produce accurate and non-biased results. The first issue we had to consider was the relative weighting of each concern or criterion. Issues such as cost needed to have more influence on our decision than less important matters such as ease of installation. There were, however, several criteria that were of similar importance to others, making it difficult to give definite priorities amongst some issues. For this reason, we implemented a weighting system that consisted only of low, moderate and high ranks of importance. These levels were assigned values of one, two and three respectively so that the most importance concerns could have scores more than three times the value of low level concerns. Using this system, we assigned each of our matrix criteria a suitable weight. This was based on our knowledge of the museum's desires and concerns as revealed during our interviews with staff. Cost was given a weight of three because it was clearly the primary concern for the museum. There were several concerns, which were of less importance than cost, but all had similar importance so they were assigned weights of two. These concerns included: reusability, use of pre-owned equipment, interference with the exhibit, image quality and transmission reliability. The least significant considerations given values of one included: ease of installation, required network speed and required bandwidth. These selected weights are shown in the completed decision matrix found in **Appendix D, Figure 1**.

The next step was to score each of the technology options on its performance with respect to individual criteria. In order to assure that each option was given equal consideration, we needed a way to standardize the scoring process. This led to the development of a scoring sheet using a scale of one to five, where five was the best. In addition to the scale, we constructed a scoring worksheet that assigns scores to each concern.

Constructing such standards helped to assure that options were scored on an absolute scale rather than by comparison. This was necessary because it is far too difficult to compare multiple options all at once in any decision making process. Many details are likely to be forgotten so this is precisely the purpose of a decision matrix. The final scoring key can be seen in **Appendix D, Figure 2**. With the scoring sheet on hand, we were finally able to score the options. Though this process required careful consideration in deciding scores, it was made significantly easier because of the scoring key. These final scores can be seen in the completed decision matrix in Figure 6.

Figure 6: Completed Matrix

Considerations	Weight		Robotic WebCam	Wtd.	Panoramic Still Image	Wtd.	FlyCam	Wtd.	Virtual Room	Wtd.
Initial Cost	3		1	3	5	15	2	6	1	3
Reusable for other exhibits	2		2	4	4	8	2	4	5	10
Use pre-owned equipment	2		1	2	5	10	1	2	3	6
Ease of Installation	1		1	1	5	5	1	1	5	5
Exhibit Interference	2		1	2	5	10	1	2	5	10
Image Quality	2		3	6	4	8	3	6	2	4
Transmission Reliability	2		2	4	5	10	2	4	5	10
Required bandwidth	1		1	1	5	5	3	3	4	4
Required Network speed	1		1	1	5	5	3	3	3	3
	TOTALS			24		76		31		55

4.3 The Final Decision

With the characteristics and desires of the museum well understood, we were able to utilize the results of our decision matrix in making a decision. The final solution is a system comprised of three main parts. One critical component of our chosen technology system is the incorporation of factual information regarding the objects found within the rooms of the exhibit. This assortment of text information is essential for making the virtual touring system a valuable resource for gathering information about the exhibit which cannot be accessed during a real live walk through the exhibit. Panoramic still images were determined to be the most suitable technology solution for providing the primary images found in the virtual tour. In addition to the primary images, up-close and detailed images of objects within the rooms are an important supplement. Image quality is typically sacrificed with the implementation of virtual-tour technologies, such as Internet video or panoramic stitching systems. Panoramic images provide an excellent sense of being in an environment with very reasonable image quality, however there are limitations caused by the depth of focus in the camera when images are collected.

As most people look around in an environment, the lenses in their eyes naturally change focus so that any object of interest will be clear. When any image is captured on a camera, only one focal length is recorded, thus making refocus impossible. Computers allow users to zoom in on portions of these images, but this magnification is most effective if the image is already an up-close view. This slight loss of detail is common to practically all digital imaging techniques and can only be avoided through the use of optical zoom on live transmission images. The scores in our decision matrix reflected these technology characteristics, and though panoramic imaging did not have the highest possible score for image quality, there were far more factors where its scores were excellent.

Panoramic imaging is the most suitable method for virtual touring for many reasons. This method allows for perfect conservation of the exhibit that is to the benefit of museum visitors. Panoramic images need only be collected once in a photo shoot and the hardware such as cameras, tripods and lights can then be removed without a trace. Additionally, the sort of cameras used for panoramic imaging can be operated wirelessly, allowing complete mobility throughout any exhibit or environment. When served on a web page, panoramic images do not require broadcasting or high speed network and Internet connections since the image is accessed by the user only once, then explored by navigating within the image. The user is free to explore any panoramic they choose without having to wait in a virtual line to gain control of a camera. Users at home with dial-up modem connections can enjoy the rooms as well as the people with high speed connections. Panoramas never show the museum as being dark or closed or have people blocking the camera. For these reasons, panoramas have recently become very popular for virtual tourism and the quality of images is continually increasing as well as the necessary stitching software.

5.0 The Prototype

Due to the visual and technical nature of our virtual touring system, we determined that a prototype or sample would be the best way to demonstrate the capabilities and functions of this system. The following sections discus the development of the prototype as well as the content and structure of the sample website. In many cases, we used the same type of equipment, software and procedures that should be used in future implementations. For the prototype, utilization of museum resources was essential in an attempt to work with a zero budget. This made excellent use of pre-owned equipment so as to save money for the museum and showed that although our prototype was a zero-budget trial run, the real process could be quite inexpensive as well.

5.1 Getting the Hardware

The first step in our prototype development was the selection of suitable hardware such as cameras, tripods, a panoramic head, and lighting equipment. We decided to use digital camera technology because images can easily be transferred to computer for stitching. Furthermore, we already had two digital cameras available for use, one privately owned camera and one owned by the museum. With this abundance of equipment, we decided to use both cameras when shooting the rooms to provide more options during the prototype design. The photo shop at the museum has a wealth of photography equipment, but they do not have a panoramic head, which would ensure that all pictures in a panorama are perfectly aligned without parallax. The lack of a panoramic head immediately hampered our chances of creating a spherical panorama that would best display the rooms. Furthermore, both digital cameras have mounting fixtures which are offset from the lenses, thus making more trouble with parallax. To correct for the offset, we purchased an inexpensive sliding plate used to mount the museum's camera to a tripod. The privately owned camera was fixed to another

tripod using an improvised strapping technique. Finally, we arranged to borrow lighting equipment from the audio visual department in the museum on the day of our photo shoot. In addition to taking the photographs, we also needed to do carry out stitching processes on a computer in order to produce 360 degree panoramic images.

5.2 Finding Software

The privately owned digital camera that we used came with a software program capable of single row stitching, producing 360 degree panoramic views. This program however, only accepted images from a specific brand of camera, so we needed another stitching program to process the images from the museum's digital camera. To do this, we searched the Internet for free software packages that would do the job.

Since we could not purchase specialized panorama software because of time and expense constraints, we had to look to freeware and demo versions of software to do the stitching of our images. Finding a suitable program was not very difficult because we had stringent requirements for the software. The program(s) that we were to use had to be able to stitch images taken from multiple rows, with sufficient vertical sweep to capture the designs on the ceilings and floors.

Furthermore, we needed software that would allow us to embed 'hotspot' link into the panorama. A program called PanoTools, by Helmut Dersch was the only program that could stitch the images the correct way. Unfortunately, PanoTools has a difficult-to-use interface, so we had to use a program called PTGUI, known as a front-end package. PTGUI uses the applications in PanoTools while providing the controls in an easy-to-use graphical interface. Unfortunately, the PanoTools suite cannot embed hotspots into the panoramas so in order to do this, we used IBM's HotMedia. This software is a free authoring tool for creating

presentations of interactive media. After installing the program, we found that imbedding hotspots into panoramas is a primary function of the program, and the process is simple.

5.3-0 The Web Page

In accordance with the information obtained in interviews with Ms. Elgaard and Mr. Mortensen, we created a sample website. These interviews can be found in Appendix E of this report. Although our website was created in English, we followed the format that was explained to us in order to accurately preview any future website.

5.3-1 The Program

Microsoft Word is software known and used all over the world. It allows a user to create web pages using a Web Page Wizard, with which the user can create a single web page or an entire web site. The user can add existing Web pages and Word documents to the Website. Several pages can be designed in *Word*, and then linked to each other. Linked pages are created by having one page that is created in a source file and inserted into a destination file, while maintaining a connection between the two files. The linked pages in the destination file can be updated when the source file is updated. Hyperlinks are colored or underlined texts that when clicked on, take the viewer to another linked page. Pictures can easily be inserted by choosing the menu option "Insert," followed by "From File." In our case, pictures were taken with a digital camera, and then moved from the disk of the camera to the desktop of the computer. When the web site is being viewed, the user sees them as they would in *Internet Explorer*. The author of the page can open the file and make changes to it in *Word*.

5.3-2 The Website

The main page consists of the title of the exhibit, the table of contents, a picture, and some general information about it. Several of the museum's web pages have a table of contents similar to the one created for this site. It is found in its own frame on the left hand side of the window and contains all of the links for the entire website. The picture on the opening page was copied from the museum's current website, and shows the layout of the rooms in the original house. The general texts found on this page and throughout our prototype were copied from signs found at the actual exhibit, which are written in both English and Danish.

At the bottom of the default page, the viewer is given the choice of links to either "TAKE A VIRTUAL TOUR", or "LEARN MORE". The first link takes the viewer to the virtual tour page. The second link takes the viewer to a site with information beyond that found on the initial page. The "LEARN MORE" page offers information on the Copenhagen fires, the owner, and the apartment itself. At the bottom of each page, the viewer is given the option to view the other rooms.

5.3-3 The Virtual Tour

The first page of the virtual tour is a menu for selecting a room to enter. There are individual sites for the salon, the bedroom, and the cabinet. If for example, "The Salon" is chosen, the viewer taken to a site with the panoramic image of the room, and some brief text on it. There is also a link at the bottom of each page to take the viewer back to the menu.

5.3-4 Panoramic Images

Two types of panoramic images were made available to users on our prototype website. The first image provided for each room is a simple panoramic image displayed

across the width of the screen. In addition to this, a link is also provided which takes the user to a Quicktime Viewer. Within this viewer, the user can move the cursor up, down, left and right to browse the picture. The user can also click on the mouse to zoom in or out. In both typed of panoramics images, hotspots are indicated to the user by a change in cursor shape.

5.3-5 Hotspots

A hotspot is a designated area on a picture that is used as a link to another page. Within the completed panoramic images, we imbedded hotspots where the user has the option to click objects to access more information on that particular artifact. The linked page displays a picture from our collection of object images obtained during the photo shoot and is accompanied by short texts which give explanations or interesting stories about that artifact. In future implementations of this virtual touring system, much more detailed information would be incorporated into the website. The hotspots were created using free software from the Internet which allowed us to designate areas of the images around objects in the rooms.

5. 4 Concerns for the Rooms

Before entering the room for the photo shoot, we examined the rooms to anticipate problems regarding the construction of the virtual tour. Once such problem that existed in all of the rooms was capturing both furniture situated on the floor and the designs on the ceilings. To capture these designs, we would need a software program that would support multi-row stitching. Since the rooms are also dimly lit, a system of positioning extra lights without interfering with the images was necessary. Some concerns could not be resolved, such as security equipment and permanent spot lights which cannot be moved and will be displayed in the panorama unless they are edited out.

The Cabinet and Bedroom also provide great challenges. Due to the long, narrow shape of the rooms, focal lengths of the images will not be uniform for the panorama. Care must be taken so that the induced parallax is minimized. Also, many objects, are covered with intricate details that can only be viewed through the use of object panoramas or multiple still pictures. For example, the dresser in the bedroom has engravings on all visible sides. Since each side is unique, the ability to view all sides will magnify the grandeur of the furniture in the apartments.

5.5 The Photo Shoot

After obtaining the required equipment, we were prepared to capture images. Our liaison set up a date for us to have a photo shoot within the secure exhibit. On Monday, April 15th, while the museum was closed to the public, we were allowed into the exhibit rooms to take pictures.

Once our supplemental lighting was in place, we were ready to take pictures. Jared used the museum's camera in an attempt to gather images for a spherical panorama. Since we were not certain that the free software from the Internet combined with our minimal photography experience and improvised equipment would produce high quality panoramas, we constructed a back-up system. Blake took pictures with the privately owned camera for single row panoramas and object images. During the photo shoot, Megan discussed the exhibit and the artifacts in the exhibit with exhibit designer Ms. Andersen Møller.

Starting in the Salon, Jared positioned the tripod in the very center of the room with the height of the tripod adjusted to approximately one-half the distance to the ceiling. The camera was pointed down as far as the tripod legs would allow, and pictures were taken at 30 degree intervals until the light stands interfered with the pictures. The procedure was repeated, tilting the camera upwards at 30 degree increments. When the pictures on one half

of the room were completed, the lights were repositioned so that the other side of the room could be completed. These steps were repeated for the Cabinet. Jared, however, did not take pictures intended for panorama construction within the bedroom due to time constraints. Fortunately, we were able to collect images for panoramas from all of the rooms using the private camera.

5.6 Stitching the Images

After the pictures were taken and imported to the computer, the process of stitching the images began. After a short while, it became evident that the multi-row pictures taken with the museum's camera were insufficiently accurate for PanoTools to stitch with good results. Although the sliding plate centered the lens of the camera in one dimension, there was nothing available to center the lens in the other dimension. Additionally, the rotation of the camera in the vertical plane worsened the parallax between images of different rows. Fortunately, the single-row stitching program used with the private camera was able to produce panoramas of appreciable quality. Although many items in the room were not captured by these single row panoramas, a sense of being in the rooms is still conveyed. These panoramas also demonstrate the high quality of images that can be produced using digital cameras. As a supplement to these sample panoramas, views of the Cabinet and Bedroom were also taken from corners of the room providing a better view of the furniture and objects in these rooms.

The computer software that works with the privately owned camera has an option to create fully-immersive panoramic videos displayed with *Quicktime Viewer*. The program does not however, allow for the insertion of hotspots into these movies. To create movies with hotspots, we used free software to imbed links into long flat panoramas, which were

then converted to movie files. These movie files could then be shown using *Quicktime Viewer*.

Our group expected the sort of technical difficulties experienced during the construction of our sample panoramas. We were working with improvised equipment, inexpensive software, time constraints and lack of experience. As a result our prototype is only a sample intended to introduce the National Museum to the possibilities offered by panoramic imaging. The views provided by the single row panoramas indicate the quality of images that can be achieved with spherical panoramas given the proper equipment and practice. It is the spherical panorama that provides the most immersive experience for the user because the environment can be explored in every direction.

6.0 Final Recommendations

The prototype we developed demonstrates the effectiveness of our three-part system of virtual touring, however the panoramic movies are not of the highest possible quality. With professional photographers using the proper equipment and professional computer graphics designers using reliable software, panoramic images can be of much greater quality. While our prototype panoramas only offer one horizontal row of images, better equipment and software allow for the addition of higher and lower rows, which show the ceiling and floor areas as well.

6.1 Choosing the Final Hardware

The need for expensive stitching programs is lessened with improvements in the hardware used to take the panoramic pictures. Precisely aligned equipment allows the photographer to take steady and consistent shots, which are much easier for software to stitch together. Assuming the use of the museum's current digital camera, lighting equipment and tripods, the only required item remaining is a panoramic head. This device was discussed in Chapter 2, but **Table 1** lists some available models. We recommend the KiWi+ Spherical model because of its low cost and high functionality. All of this equipment can be purchased on the Internet for speedy shipment directly to the museum.

Table 1: Spherical panoramic heads.

	Price (USD)
QuickPan Spherical	779.95
KiWi+ Spherical	499.95
Peace River QuickPan	1040.99
Manfrotto QuickPan	Not listed
Source: www.kaidan.com	

6.2 Final Software

If the museum decides to implement our virtual touring system, it will be necessary that they have a panoramic authoring program. Since there is a great variety of these programs available on the market, we decided to again utilize a decision matrix in the selection of the best-suited program. A completed decision matrix for recommended software titles can be found in **Appendix D, Figure 3**. This decision matrix shows the two programs, *PanoTools* and *3D Vista Studio* as the two best options.

The *PanoTools* suite is free while 3D Vista's suggested retail price is 199 USD, approximately 1700 DKK. For the increase in price, *3D Vista Studio* provides a much more 'user-friendly' interface. To achieve good results using the *PanoTools* suite, a great deal of familiarity with panoramic photography and software is required. If the virtual tour is to be created by employees of the museum, an easier-to-use platform may be desirable. A great advantage with *3D Vista Studio* is the ability to embed hotspots within panoramas. Although *3D Vista Studio* only allows for two rows to be stitched together, these rows can be comprised of images in a portrait format, similar to the orientation of this page. With this software, only the areas directly above and below the camera will be left out of the final image.

6.3 Utilizing Museum Staff

Any professional photographer should be capable of gathering images for panoramas; however, there are experts in this field who the museum might hire to take the photos. One such professional is Mark-Steffen Gowecke who is based in Germany. He charges 300 USD per day plus travel and hotel accommodations. A drawback with hiring such persons is that their services must be booked each time the museum wants to take pictures and this can become expensive as well as tedious. Since the photographer would not carry out any further

stages beyond the photo shoot, the museum would need to complete the process anyway. Since there are many potential applications for panoramas at the museum, we believe it would be most cost effective and practical to complete the entire task using existing staff.

Regardless of skill level, the method will be the same, and as we discovered in making our prototype, even beginners can produce acceptable results. With a little practice, photographers working in the museum will certainly be able to capture suitable images for panoramic pictures as well as close-ups of objects. Those digital images can then be taken to computer graphics personnel who would use software to stitch and edit the images into panoramas. These panoramas can also be turned into movies that immerse the user with a viewer such as *QuickTime*. Descriptive texts about the exhibit can be compiled by exhibit designers and historians for use in the website. The final step is for the web page designers to place the panorama movies, object images and descriptive texts on a website. A virtual tour would then be complete having only required the services of existing museum staff.

6.4 Displaying the Images

There are two ways that we found to be most suitable for displaying the images which are demonstrated in our prototype. The first is a flat panoramic view. In this form, the viewer can see the entire 360 degree view at once. Currently, the museum uses a software package called "Zoom Function" which allows users to zoom in on paintings without reaching pixelation. The software "cleans-up" the image so that individual ***pixels*** are not visible. This zoom function should be made available in order for the user to see objects in greater detail, in addition to hotspots that will link the user to still images of artifacts. These same panoramic images, with the same functions, can also be converted into a movie file in programs like *3D Vista Studio*. This movie file can be viewed with *QuickTime Viewer*. *QuickTime* is used all over the world, and is both MAC and PC friendly, which would allow

for the most online viewers to see it. Both of these options can be viewed in our prototype. With the hardware and software recommended earlier in this chapter, several upgrades can be made to viewing quality.

6. 5 Future Possibilities

There are exciting possibilities for the future with panoramic imaging. With the steady rate by which technology progresses, it is likely that digital cameras and images will improve significantly in the coming years. Panoramic software will also improve with increased computing power and growing public interest. This software will correct for distortion and keep images clear, thus providing realistic touring experiences.

Our prototype includes still images of the objects within the room, linked through embedded hotspots within the panoramic images. These images are simple close up shots, which do not require extensive resources or cutting edge technology. It is, however, already possible to create object panoramas, which provides the illusion of picking up objects and examining them from any side. Furthermore, these object panoramas can be placed within the panoramic image, allowing the user to explore artifacts as if they were actually walking through the room.

To further enhance the reality of the tour, multiple panoramas can be linked to one another so that the user can move from one room to the next by clicking on an embedded hotspot. This prevents the user from backing out of QuickTime to move from one room to the next.

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Glossary

Applet: A program that is executed inside of another application such as a Web browser

Bandwidth: A measure of the volume of information that can be transmitted over an Internet connection

Browsers: Programs used to navigate and view pages on the Internet

Client Pull: When a browsers requests new images from a WebCam server

Caustic Shadowing: A method of simulating light refraction, reflection, and concentration from the light source to the objects in question.

Dynamic IP address: A temporary IP which can be different for each time an Internet connection is made

E

Fixed IP address: An IP that is always the same

Field-of-view: The area that is swept horizontally and vertically by an image, measured in degrees.

G

H

IP: An Internet address assigned to a specific computer

ISP: Internet Service Provider

J

K

L

M

Network: Group of computers linked through a common hub which is then connected to the Internet

Nodal Points: A set of points where light rays cross and emerge at the same angle, relative to the lens's axis.

O

Pan: Rotating a field of view to the left or right

Panorama: An image that provides 360 degrees of view about a certain point.

Panoramic Head: A rotating mechanism that prevents parallax from occurring in a set of panoramic pictures.

Parallax: A result of not ensuring that images produced in a panoramic set are not along the same nodal point. This causes problems when images are stitched.

PnP: Plug and Play device. A PnP device can be plugged directly into a computer through standard computer ports

Projection: Relates to the shape of the surface on which the image is displayed

Resolution: Image size determined by product vertical and horizontal pixels

Ray Tracing: A method of simulating light on an object that simulates light properties from the point of view of the camera.

Rococo Style: A popular form of interior design style found in the 18th century. It was characterized by its asymmetric patterns, found in a rectangular frame.

Streaming: A continuous flow of single images thus creating a movie

Server: Computer or device on a network that manages resources such as Internet access for other computers on the network. This server could be the Internet Service Provider's hard drive or a web site that hosts your display page and it is responsible for providing data service to web page visitors.

Server Push: When a WebCam server continually provides fresh images to a browser

Stitching: The process of combining pictures to create a seamless panoramic image.

Tilt: Rotating a field of view up or down

USB: A standard socket found on the back of most computers.

Video Capture Device: Converts electronic camera signals to digital format
W
X
Y
Zoom: Magnifying a field of view

Appendix A: The National Museum of Denmark

Covering over 10,000 years, the National Museum is known as Denmark's authority of cultural history. Evolving from the Royal Cabinet of Curiosities (c. 1650) and "a royal commission for the safe-keeping of antiquities," the National Museum (1892) currently holds a number of properties that provide evidence to the way people lived in and around Denmark. Special exhibitions throughout the year focus on varying subjects. The Children's Museum provides a medium by which learning can be interactive. Other activities, such as concerts, lectures, and theatre make the National Museum a true cultural center.

Increased accessibility to the museum's exhibits is a high priority and is fitting with Danish culture. As a country with one of the highest numbers of museums in proportion to its population, the people of Denmark clearly place importance on knowing their own heritage and cultural identity. Since an extensive renovation, and modernization in 1992, the museum has become increasingly computerized (Discovering Denmark 150-152). This trend illustrates a desire to utilize modern technology for improving cultural and historical education. The museum wishes that its exhibits will supplement current knowledge and inspire new ideas concerning the understanding and interpretation of cultural history. With this knowledge, visitors should be able to identify links connecting Danish history with European and world history.

Appendix B: Networks and Internet Connections

Telecommunications is the movement of digital information, including data, video, and voice information from one point to another by means of electrical or optical transmission systems. Networks are a huge part of telecommunications. A network is a series of points connected by communication circuits. There are three main parts of a network. The first is the server, which is also known as the host computer. This computer stores all information that can be accessed by the other computers connected to it, which are called clients.   The client is the actual input/output hardware device at the end of the users communication circuit. This provides clients with access to the information. The circuit is the path between clients and the host through which all of the information travels.

There are several different kinds of networks, including LAN, BN, MAN, and WAN. A local area network is a small group of computers, usually located close together. In several LANs, the circuit is shared, ,and the clients have to take turns getting information. A backbone network (BN) is often a group of LANs put together. BNs have a quicker data transmission rate, and are usually spanned over a wider location than LANs. A metropolitan area network connects LANs and BNs. A MAN can span up to 30 miles, and has a very fast transmission rate; 64 kilobytes per second. Several government and military companies use MANs. Wide area networks connect MANs and BNs. WANs are the fastest way to communicate data, and they often utilize satellites or microwave towers.

Two other terms associated with networks are intranets and extranets. An intranet is similar to the Internet, but it is only open to members of a group. Several companies have their own intranets, where only their employees can access information from it. An extranet is similar to an intranet, except some outsiders are given special permission to access the information also. These people usually have a user ID and a password. In a LAN, the circuit is physical because wires connect one computer to another. Otherwise, there is a logical

circuit, which refers to the transmission characteristics of the connection. An example of this is called a T1 connection. T1 does not refer to the physical wire, but how fast data can be sent. The faster the data can be sent, the easier it is for clients to view information online.

Appendix C: Rococo Style

Rococo style is found primarily throughout interior design work rather than in an architectural sense (Blakemore 262). It is characterized by complex, linear motifs with an asymmetrical, and yet balanced twist (Goetz 161). Natural, flowing forms are used, and usually set in a rectangular framework (Blakemore 235).

During the early 18th century, a new attitude emerged in France after King Louis XIV's reign (Blakemore 206). This attitude focused more on relaxation and pleasure. As a result, several apartments found throughout Europe became smaller and more comfortable in an effort to provide an intimate place for conversation. The Rococo style apartments were most popular among the newly rich, the aristocracy, and the court.

The term Rococo stems from three different words. The first is barocco (Baroque), which was the popular style before Rococo (Aronson 358). The second and third words are rocailles (rocks) and coquilles (shells); popular designs in the gardens of Versailles during this time period.

At the beginning of the Rococo trend, styles were graceful and playful (Norwich 358). Objects were characterized with light surface ornamentation in an effort to lead the eye away from its rectangular joints. Light pastels became popular in interior design, along with ivory white, and gold. Rocks and shells were popular designs found in the Rococo style along with cascades of water, scrolls, flowers, masks, dragons, and monkeys (Blakemore 262).

Several objects during this timer period were tall and slender (Goetz 127). Chairs sometimes could be found with asymmetrical crests on the center of the back rail (Riley 92). Rococo decorators often used mirrors to decorate the furniture. Vases, clocks, tureens, and wall cisterns were sometimes found in the form of fruits and vegetables (Goetz 115).

Veneering was a popular form of surface decoration at the end of the Rococo period (45). Veneering was the cutting of a design into a curved piece of furniture, such as the

drawers in a chest.   This intricate design, along with heavier ornamentation of objects,

started after 1750, and paved the way for the neoclassical movement.

Appendix D: Decision Matrices

Figure 1: Matrix Layout

Considerations	Weight	Robotic WebCam		Wtd.	Panoramic Still Image		Wtd.	FlyCam		Wtd.	Virtual Room		Wtd.
Initial Cost	3												
Reusable for other exhibits	2												
Use pre-owned equipment	2												
Ease of Installation	1												
Exhibit Interference	2												
Image Quality	2												
Transmission Reliability	2												
Required bandwidth	1												
Required Network speed	1												
	TOTALS												

Figure 2: Scoring Key

SCORING SHEET					
	1	2	3	4	5
Low Cost	$5,000 +	$3,000 - 5,000	$1,500 - 3,000	$500 - 1,500	$0 - 500
Portable	Perminant Mounting	Equipment left in rooms	Mobile tripod	Computer	No Equipment
Reusable	No other		Some ways		Many ways
Use pre-owned equipment	None owned		Half owned		Everything owned
Ease of Installation	Very Hard	Difficult	Average	Straightforward	Very Easy
Exhibit Interference	Major Distraction	Significant	Some	Minor	No Distraction
Internet Access	Not able		Can Be		Easy to access
Image Quality	Very Low		Average		Very High
Transmission Reliability	Very Low		Average		Very High
Required bandwidth	Very High		Average		Very Low
Required Network speed	Very High		Average		Very Low

Criteria	Weight	D Vision Works D Joiner	Weight-ed	Image Assemb-ler	Weight-ed	LM Stitch	Weight-ed	PanoTools	Weight-ed	PT GUI	Weight-ed
Multirow Stitch?	3	1	3	1	3	1	3	1	3	1	3
Spherical projection?	2	0.8	1.6	0	0	0.8	1.6	0.8	1.6	0.8	1.6
Output image formats	2	0.8	1.6	0.8	1.6	0.4	0.8	0.8	1.6	0.8	1.6
Hotspots	2	0	0	0	0	0	0	0	0	0	0
Cost	3	0.1	0.3	0.8	2.4	0.9	2.7	1	3	0.9	2.7
Object Movies	1	0	0	0	0	0	0	0	0	0	0
Sound	1	0	0	0	0	0	0	0	0	0	0
Totals	14		6.5		7		8.1		9.2		8.9

Criteria	Weight	Reality Studio	Weight-ed	Realviz Stitcher	Weight-ed	Hot Media	Weight-ed	3D Vista Studio	Weight-ed	QTVR AS	Weight-ed
Multirow Stitch?	3	0	0	1	3	0	0	1	3	0	0
Spherical projection?	2	0.8	1.6	0.8	1.6	0	0	0.8	1.6	0	0
Output image formats	2	0.8	1.6	0.8	1.6	0	0	0.8	1.6	0.8	1.6
Hotspots	2	0.8	1.6	0	0	0.8	1.6	0.8	1.6	0.8	1.6
Cost	3	0.4	1.2	0.1	0.3	1	3	0.5	1.5	0.2	0.6
Object Movies	1	0.3	0.3	0	0	0	0	0	0	0.3	0.3
Sound	1	0.3	0.3	0	0	0.3	0.3	0.3	0.3	0.3	0.3
Totals	14		6.6		6.5		4.9		9.6		4.4

Figure 3: Software Matrix

Appendix E: Interviews

Meeting with Karl-Johann Hemmersam
Head of Education
26.03.02

Mr. Hemmersam first specified that the primary audience of our website will be people in Denmark. Although the rest of the world will probably have some kind of access to this website, the most important goal is for people in Denmark to be able to see this site from homes and schools. This website will also be accessed from within the museum. More specifically, the website will target the general public. General text will be useful for anyone that is interested, and more specific, detailed information will be attainable to those interested in further research. Although there will not be too much of a distinction between different age levels, the site will be most understandable to people over the age of fourteen.

Like Ms. Elgaard, Mr. Hemmersam pointed out that the Danish National Museum is the leading museum on Danish history, and it is their mission to make as much of this information available as possible to the public. The museum has a very efficient research department, and they are now striving to bring in different kinds of technology that will help increase the user interface between the Danish National Museum and its potential visitors. Websites are considered points of interaction between these two groups, and the more points of interaction, the stronger the user interface. These websites will also be helpful in attracting potential visitors to the museum. They "give a taste" of what the museum has to offer.

Mr. Hemmersam next spoke about the website layer format that we also heard about from Ms. Elgaard. In addition to the format that we know of, Mr. Hemmersam would like the Rococo style theme of the apartment apparent. This style description is found in Appendix C.

We asked Mr. Hemmersam what he felt was the most important features of our project were, and his first answer was cost. He also stressed the importance of picture

quality. It is the small details of the room, such as wall carvings and ceiling designs that add to the reality of the room. High quality photos will be necessary to preserve these details. Mr. Hemmersam also spoke of our project something that the museum would really like to be able to use in more than one exhibit. Our project is to be a kind of template that the museum will be able to reuse elsewhere. One place that they would like to do this is at Klunkehjem, a Victorian apartment down the street from the museum that visitors are also not allowed in due to preservation concerns.

Mr. Hemmersam explained to us that people like to read articles that give advice about life and how to live it, or how other people live their lives. This exhibit kind of plays into that human curiosity. It shows how people lived their lies during this time period, and the kinds of styles and themes that would be found then.

Ms. Berit Elgaard
The Knowledge Center
March 20, 2002

Ms. Elgaard first provided us with some printouts from the museum's webpage on the Internet. Printouts included two pages in Danish on Klunkehjem, and four pages in Danish on the histories of Denmark, which is where our exhibited is located. Ms. Elgaard also provided us with a book on Klunkehjem in English. We established the three rooms within the Danish histories exhibit as our primary concern.

Ms. Elgaard said that the new focus of the museum is using technology to improve the user interface. The National Museum of Denmark formerly held the position of being very innovative and technologically inclined, but in the past few years that standing was pushed back because research became the primary focus. The museum would like to gain this standing once again, so they are trying some new methods. Ms. Elgaard showed us some interactive websites directed towards young children, such as "Would you like to go on a

Pilgrimage?", and one where the viewer can create their own tour from their favorite objects. Our project of displaying the Rococo rooms online is going to start in that one section of the museum, but hopefully will be able to be used throughout the museum at some point in order to increase the public interface.

The first thing that Ms. Elgaard stressed was that all of the museum's web pages are built on a database structure. Most objects in the museum have been photographed and can be found in digital format on ten CD ROMs, in Ms. Elgaard's possession, or if a person has a username and password, they can access this database from within the museum. It is not the intention of the museum to make this database open to the public. People that are working for the museum by designing web pages can access this database, and use pictures on the site that the public can view. Any still pictures that we would use to supplement an image of the entire room could be attained from this database.

This database helps the museum with their new web page design. The museum is trying a new format with each page. The new web pages are layered. The first site that the viewer goes to would show an object from an exhibit with a short text containing general information, and then a few pictures. If the viewer find this intriguing, they can choose to go on to the next layer and find either one or a combination of discussion, analysis, or debate over the object in view. Ms. Elgaard stressed that teachers in the knowledge center want interesting stories in this second layer, not just a series of facts. If an object, such as a chair, has a story behind it, the viewer would enjoy this. The former manager of the museum stressed the importance of research, and they have a lot of information on each of the exhibits, according to Ms. Elgaard. The third and final layer of the site would contain a full text on the subject, with links to relevant information, literature, and articles.

Ms. Elgaard gave us a lot of interesting information about the teaching that the Knowledge Center does. The Knowledge Center is concerned with teaching people about the

different things in the museum. They focus on all age groups. Brochures are written by the combined efforts of research experts, and people in the Knowledge Center. Some brochures are even written differently and given to different age groups. We saw an example of this with the Brazil exhibit brochure; the first was for 12 year olds, and the second was for 16 year olds. Ms. Elgaard informed us that any descriptions that we need for a website that would work with our camera pictures have probably already been written by the same people that do these brochures, and if not, that is who would write them. They also write the descriptions that are presented with the actual exhibit.

We asked Ms. Elgaard what she would tell us to keep in the back of our minds throughout our project, giving cost of the project as an example. Ms. Elgaard agreed with cost, but stressed to us that technical equipment and software is available. She mentioned being familiar with programs such as Flash, Dreamweaver, and QuickTime. The computers in the Knowledge Center were compatible with all of these. Ms. Elgaard also stressed that so much of the information that we need is already completed, such as the interesting stories about objects, the object descriptions, and the object database. She also mentioned the importance of themes in their exhibits. Some of the exhibits throughout the museum can be seen from different views. Some of these views include man versus woman, and child versus adult. These varying viewpoints open the audience's minds to different ideas on what life was like for different people. The Knowledge Center can help to determine the best theme for an exhibit.

Ms. Elgaard introduced us to Petra, a student from Holland that is working on an online project. Petra is using a program called Zoom, which can zoom and pan on a picture while maintaining an excellent quality. She was using this in conjunction with Dreamweaver, a website design software. Ms. Elgaard also gave us contact information for Per Enggard, who is in charge of the object database.

Meeting with Michael Bjorn
April 10th, 2002
Audio Visual

The first thing that we asked Mr. Bjorn about was the wiring found near the exhibit. There are outlets inside and outside of the exhibit, so if cameras needed to be installed it would be possible, however, there would be several wires going through the room and that would cause distractions to the exhibit. Internet wire could be run through it, although there are no ports there right now. Mr. Bjorn did not think that live video of any kind would be a good idea because there is no motion in the exhibit. There is nothing that changes, so there would nothing to watch, just a user looking around the room. He also pointed out that there could only be one camera user at a time, and he didn't think that was very efficient.

Mr. Bjorn also told us that the museum out-sources when it comes to buying cameras. Instead of dealing with specific vendors, like Sony or Panasonic, they have a list of stores that they buy from with discount rates. We needed a piece of hardware for the tripod in order to maintain a steady focal point, and he gave us the name of the store. The piece of hardware was ordered for the photo shoot.

Mr. Bjorn also offered some lights for our photo shoot that was April 15th. The room is dark, and we were not sure if the lighting would be sufficient for the photos. He said that he was not familiar with panoramic photos, and they would probably have to hire a company to come in to take the photos if the needed a professional job for their official website.

Steen Mortensen
April 5, 2002
Web-Master

The first thing established at this meeting is that Mr. Mortensen has some networking experience, but we should definitely have an interview with the network group here to get more precise information.

He did share this some useful information on this topic though. First of all, the museum hosts its own server. The internal network is a 100 MB Ethernet server. The external server hosts only a 2 MB connection. Mr. Mortensen also said that most people around Denmark still use a dial up connection. The museum's connection can be upgraded at anytime, although it costs a lot of money, if there is a demand for it. He also pointed out the ability to put things on a different server. It is the clients connection that needs to be thought of. This brought up the question of using live broadcasting. Mr. Mortensen said that live broadcasting is possible, and he would estimate its capacity to 5 or 6 frames per second loading. One user could control the camera at a time, and it would not require much bandwidth. He noted however, that it is very costly, and keeping a low cost is very important for this project.

The second thing that we established is that the Object Database is comprised of ONLY flat and still images. Mr. Mortensen also pointed out that we should meet with the Exhibit Coordinator to discuss more about that.

Discussion concerning the webpage and our project followed. Mr. Mortensen is familiar with panoramic images, and uses a copy of Interactive Imaging Suite to create panoramic images and virtual tours. He said that it is important that the user does not have to download a program in order to watch the virtual tour, like Flash. That turns away interest. Mr. Mortensen also said that we should look at Real Player. With Real Player, the user can look at the amount of bandwidth that is available before using it.