Virtual Tours for Museum Exhibits

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This paper outlines the technological requirements and the steps necessary to create a virtual tour for a virtual museum exhibit using QR Codes. This system was developed for the Gilcrease Museum in Tulsa, Oklahoma and was tested in two separate exhibits. The components of virtualization include: images of each object for visualization; object labels and metadata about the objects in the exhibit; extended object and artist information; code generation to link the physical artwork with its virtual representation; and finally the virtual tour. Virtual tours enhance the accessibility and expand the life of an exhibition. Virtual tours allow for shared experiences and support collaborations.

Images of each object provide the visual content of the exhibit. Object labels contain standard metadata including title, artist, date and place of creation, accession number and date, and credit line. Extended object and artist information includes textual descriptions and interpretation that help museum visitors understand what they are seeing. Images, copy and extended information combined represent the virtual knowledge about a particular object.

A two-dimensional QR Code is generated for each object on display to link the physical object with its virtual representation. QR Codes were selected for this project because of their burgeoning use among mobile devices and smart phone users for a variety of purposes. In-museum or remote visitors can scan an object's QR Code to gain a portal into the expanded virtual information provided beyond the object label. The virtual tour is accessed through Tour QR Codes which link the visitor to items in the exhibit. The Tour QR Code can be generated via an interactive kiosk which allows visitors to search for objects or subjects of interests, or it can be generated by the museum staff or teachers for remote access. The QR Code-based virtual tour becomes a permanently accessible tour for the public; it extends life of the work used to create the physical exhibition, and over time, becomes a virtual library of the museum's exhibitions. The system is adaptable and allows curators, docents, and visitors to expand the informational content of the exhibition through time. Through this technology, an exhibition can continue to grow, provide more kinds of information, and provide interactive elements that are beyond the scope of the usual three dimensional exhibitions. By sustaining the exhibit on the website, each exhibition potentially becomes an ever growing source of reliable information about the exhibit's topic.

Virtual Tours, QR Code, Shared Virtual Experience.

1. INTRODUCTION

The technology requirements and the steps necessary to create a virtual tour for a museum exhibit using QR Codes are outlined in this paper. The Gilcrease Museum in Tulsa, Oklahoma, was used to implement the system, (Gilcrease, 2012). Two separate exhibits were included in the testing.

Informational text is displayed in the object label and consists of the specific and well defined metadata for each object including title, artist, date and place of creation, accession number and date, and credit-line for the donor or lender. The object label is limited to about 20-50 words depending on the museum. The short word limit hinders the ability of a museum to convey the full story for any work of art. Conversely, long blocks of text in exhibitions tend to be ignored by most museum visitors.

The central technology is an interactive content delivery system to allow a museum to expand the information it offers to its patrons beyond the object and panel labels. The virtualization of a museum

exhibit includes: images of each object for visualization; object labels and metadata about the artwork; extended object and artist information; and code generation to link the physical artwork with its virtual representation.

Images of each object provide the visual content for the exhibit. Object labels contain metadata including title, artist, date and place of creation, accession number and date, and credit panel. Extended object and artist information is beyond what can be placed in an object label. This includes textual descriptions, style, ideas, provenance, and other interpretations that help museum visitors understand what they are experiencing. Images, object label metadata, and extended information combined, represent the virtual knowledge about a particular object.

An advantage of this interactive content delivery system is that the process of virtualization of knowledge about objects in the collection goes hand in hand with the creation of the search indexes used to support a query request (Porter 1980, Baeza-Yates & Ribeiro-Neto 1999, Berry & Browne 2005, Porter 2006, Manning, Raghavan, & Schütze 2008).

The system offers a way to store in virtual form an exhibit even after it is no longer on public display in the museum. In most cases an exhibit is constructed, objects are gathered from appropriate collections to augment the strength and appeal of the exhibit's message. Having already digitized the collection in the exhibit to construct indexes, the preservation of both the virtual exhibit and related information about its content becomes a straightforward process.

The virtual representation becomes permanently accessible to the public; it extends the work used to create the physical exhibition, and over time, becomes a virtual library of the museum's exhibitions. The system is adaptable and allows curators, docents, and visitors to expand the informational content of the exhibition through time. By sustaining the exhibit on the website, each exhibition potentially becomes an ever growing source of reliable information about the exhibit's topic.

1.1.Virtual Representation

The physical object is linked to its virtual representation through a two-dimensional QR Code generated for each object. QR Code stands for Quick Response Code, (Denso-Wave 2000). QR Codes are used because of their burgeoning use among mobile devices and smart phone users for a variety of purposes. A QR Code can be included in the object label panel for a given object and visitors can scan an object's QR Code to gain a portal into the expanded virtual information provided beyond the object label. Remote visitors can scan the same QR code for a given object and have access to the same virtual information.

1.2 Tours

A typical tour through a museum includes selected objects to experience. An interactive tour kiosk allows the visitor access to the system for the generation of a tour based on visitors' queries. It performs search engine queries to best approximate visitor interests. A generated tour consists of a list of objects suggested for the visitor to experience. Once a tour has been generated the system has the capability of creating a Tour QR Code to be accessed by a mobile device. The Tour QR Code could also be generated by the museum staff or by teachers for remote access.

Virtual tours can be accessed through Tour QR Codes which link the visitor to a selection of objects in the virtual exhibit. A typical QR Code encodes a link to the web server that produces the document containing the virtual information for the object – its URL (Uniform Resource Locator). The URLs are by themselves stateless -there is no memory of the transaction. To get around this, the encoded information in the Tour QR Code includes browser cookies. A browser cookie is used for the management system website to send state information to a user's browser and for the browser to return the state information to the origin site (IETF 2011). This allows the association of a tour ID to a cookie located on a device. Using that cookie, the device can track different art objects as their object QR Codes are scanned. QR Codes and browser cookies provide information for a visitor to view the history of any and all objects that they personally visited in a physical or virtual exhibit.

2. CONTENT DELIVERY SYSTEM

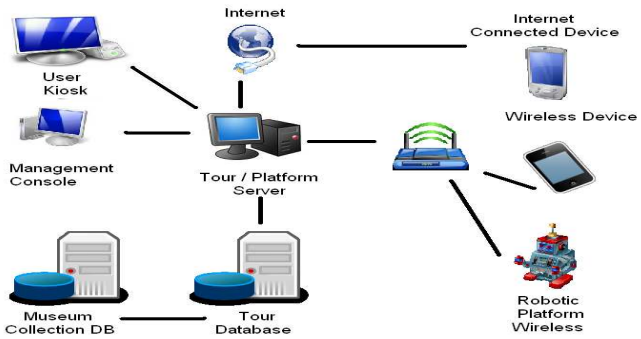

Figure 1: *Interactive Content Delivery System Diagram*

The interactive content delivery system has several components: Interactive Tour Kiosk, Web Portal, Database and Control Management Interface, (Johnson 2012).

The Control Management Interface oversees the interactive content delivery system and controls the other components of the system. Its components include Tour Management to assign or create new tours, Robot Control to control an autonomous docent guide, Search Engine controls to maintain or modify the indexing of the collection, as well as other components for managing key words and other features of the tour / search subsystem. From this interface it is possible to maintain the entire collection, modify the index of the collection, input descriptions and reviews of artwork as well as many other features such as tracking metrics about the museum visits and tours.

2.1 Tour Kiosk

The Interactive Tour Kiosk performs search engine queries to best approximate visitor interests expressed through a query. It can alternatively present the visitor with a list of key words that are significant for them to select those that match their interest. Then, the Kiosk generates a tour based on their selections. While it is not necessary to start with a tour in this fashion, it gives visitors the ability to customize their experience as fine grained as they would prefer.

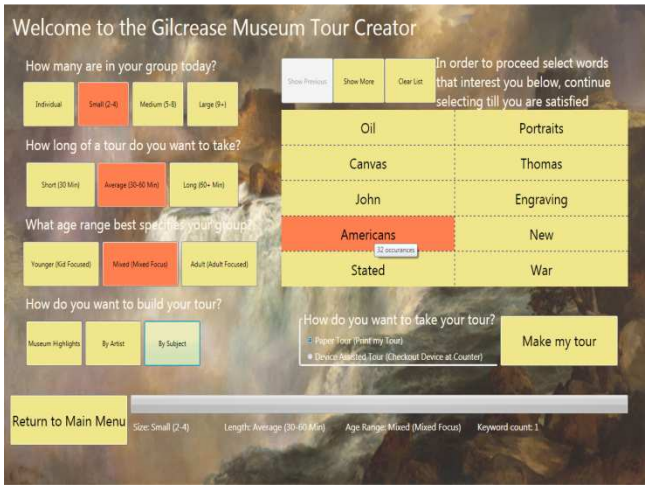

Figure 2: *Interactive Touch Kiosk*

This component leverages the museum's collection database of objects and artwork metadata with a search engine. The Interactive Touch Kiosk prompts the visitor for basic tour criteria: group size, age mixture (children, mixed, adult), chosen length of time allotted for this museum visit. It allows several ways to produce a tour. Pre-planned tours are available via 'Recommended tours.' This option offers tours based on themes or to showcase particular exhibits. 'By author' allows the visitor to search a list of authors and artists, and to select personal preferences. Alternatively the visitor can exploit the search engine capabilities by selecting from a list of all keywords that exist in the collection**.** For instance options such as 'Watercolor' or 'Mountains' can be selected refining the visitor's focus to see only water colored landscapes that contain mountains. This allows for extremely specific or generalized tours based on user selection as the visitor's interest.

Colonial Gallery
- Portrait of John Rowe - Robert Feke
- Mathew Clarkson - Ralph Earl

Entry
- Charles Wilkes - John Trumbull

Introduction
- FRANCES HOWARD, DUCHESS OF RICHMOND AND LENNOX - Cornelius Johnson

Jackson/Empire Gallery
- Joseph Polis (Porus) - Charles Bird King
- John W. Quinney - Charles Bird King
- Chief Justice John Marshall - John Wesley Jarvis
- Henry Clay - Thomas Ball
- Stephen Douglas - George Peter Alexander Healy
- The Battle of Buena Vista - James Walker
- GENERAL D. ANTONIO LOPEZ DE SANTA ANNA - Alfred Hoffy
- The Battle of Molino Del Rey - Philippo

Jefferson/Exploration Gallery
- Jefferson Peace Medal - Unknown
- Washington Peace Medal - Unknown
- David Crockett - Childs & Lehman

Figure 3*: Sample Tour Generated by the system*

Once the user has selected their tour parameters, the system gives the option of a robot guided tour (if available), a mobile device assisted tour, or a printed map for self guided tours.

2.2. Web portal

The Web Portal resource serves mobile devices through HTTP access to dynamically generated web documents that are accessed via the QR Code generated specifically for each artwork. The Web Portal must be able to handle a variety of access methods, connection speeds, platforms and browsers. It must be able to dynamically adjust virtual tours and to provide information as visitors request it. The Web Portal should be able to allow visitors to access "Curator's Notes" and the curator's insights on artwork or objects. Streaming audio and video to augment a specific visitor's experience can be made available. It could allow for visitors to offer their insights. This information should be made available when requested while not distracting from the museum experience.

In order to develop a platform that suits the needs of the initial testing environment, the Gilcrease Museum was selected to gather requirements for the interactive content delivery system. In order to encapsulate the most time consuming portions of adding a collection of data to the interactive content delivery system, the system was developed working closely with the curator of the exhibit during the research and development phase of the exhibit. While it may be theoretically possible to

import the entire museum as a single unit, such a massive task is impractical and beyond the scope of this work. In lieu of this, the system was developed and applied on an exhibit by exhibit basis. This is both practical and reasonable as a test.

In today's society computer-based technology is commonplace; email, phone communication, calendars, texting, and web surfing are standard on almost every smart-cell phone. Leveraging this technology to augment and enhance an experience requires not only an understanding of what's available but how best to deploy the technology to meet with visitors' unique sets of preferences and requirements.

The dilemma for the museum is how to provide a range of information to satisfy those of low or moderate interest as well as those with a high level of interest in the subject without overloading the exhibition with massive text blocks of information. A key element may be having the information easily accessible but not physically visible. The interactive content delivery system with QR Code technology can resolve the dilemma.

3. VIRTUAL TOUR SYSTEM

Once a tour has been generated the capability of sending the tour to a mobile device such as a smart phone is made available via the Tour QR Code. This paper discusses the application of QR Codes. However any general 2D code that meets the requirements could be used. The requirements are large capacity, high speed scanning capability, small compact print size, and availability of readers for a large variety of mobile devices.

3.1 QR codes

Figure 4: *QR Code of Gilcrease Museum Web Portal*

A QR Code is a two-dimensional barcode. It was created in 1994 by Denso Wave**,** a Toyota subsidiary to track vehicles during manufacturing, (Denso-Wave 2000). It was designed to be decoded at high speed and to have a large storage capacity. The code consists of dark colour modules arranged in a square pattern on a contrasting colour background.

The QR Code is defined by an ISO (ISO/IEC18004) standard. Denso Wave holds the patent rights on QR Codes, but has chosen not to exercise it. The term QR Code itself is a registered trademark of Denso Wave Incorporated. The use of QR Codes is free of any license restrictions.

QR Codes are specially designed bar codes that store information encoded in a matrix barcode format. The information encoded can include any kind of data, binary, alphanumeric, Cyrillic, etc. QR codes storing Uniform Resource Locators (URLs) appear in magazines, on signs, on ads, on or near objects to provide additional information through web pages. Anyone with a mobile device that has a camera and the correct QR code reader application can scan the image of the code to open a web page in their mobile's browser.

Each piece of artwork in the collection can be assigned a uniquely identifying QR Code encoded with a corresponding web link. Additionally, uniquely identifying QR Codes are produced for each tour. Thus, there are two types of QR codes supported in this interactive content delivery system, one for each object and one for the tour.

3.2 QR Code for Objects

In the interactive content delivery system the encoded URL is a special link to a web server that has the museum identity code – the accession number assigned by the museum - for a virtual knowledge of the object. By scanning a QR Code next to an object, a museum visitor can connect to the webpage that displays additional information about the art such as detail descriptions including the history of the artist/artwork or interpretation provided by the museum curators. With this system video and audio can be linked; not normally available on the standard object label.

Visitors could potentially provide their own reflections about the objects they have experienced which could be included in reviewers' comments. Museums generally maintain the right to filter visitor comments. Over time the knowledge base of the interactive content delivery system can grow to include comments not only from experts, curators, docents, but from the visitors themselves. It would provide a richer search environment for tour key words in the exhibit.

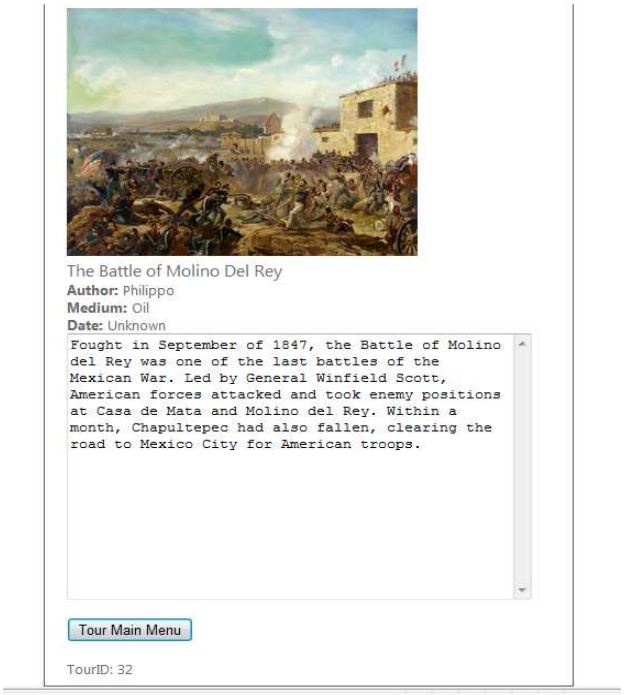

Figure 5: *Sample Object Web Document*

3.3 Tour QR Codes

A disadvantage of using URLs to encode in the QR Codes is that by themselves they are stateless. Thus, the encoded information in the Tour QR Code includes browser cookies. This allows the association of a tour ID to a cookie located on a device. Using that cookie, the device can track different objects as their QR Codes are scanned. This allows tying all the objects visited on a tour to a single device. This is the foundation for the mobile application. QR Codes and browser cookies provide session information which in turn affords a mechanism for a visitor to view their history of art objects visited which they scanned.

The Interactive Tour Kiosk can also generate the Tour QR Code which can be scanned by the museum visitor to most mobile devices. It contains their Tour ID. Visitors can dynamically adjust their tour from the comfort of their own personal device. It will allow them to see additional information on their own time and their own order. It also allows the visitor to take their tour home for future use.

Any visitor that is attracted to an object in an exhibit at the museum can scan the QR Code next to that artwork. This action causes the interactive content delivery system to automatically include it in the tour assigned to their device. When a visitor scans any QR Code without a pre-assigned Tour ID in their device, the interactive content delivery system is robust enough to handle such a request by automatically creating a new tour and assigning it to the device. The interactive content delivery system can support either method for interaction while inside the museum exhibits. Whether a visitor would rather start a tour based on pre-selected preferences or going directly into the galleries the interactive content delivery system is capable of handling and modifying tours as it gathers information about the user's likes and dislikes. When a visitor scans any QR Code not in their tour, the interactive content delivery system can provide suggestions of other items similar to ones just scanned.

4. VIRTUAL EXHIBITS

One of the features that grows out of the need to catalogue collections for exhibits is the ability to preserve the effort that goes into making an exhibit. A typical exhibit in a museum has a fixed time frame before the space is cleared to make room for new exhibits. All elements of the exhibit including the images, the text, and the object information can be stored within the interactive content delivery system, which allows archiving of past exhibits. By allowing the curators, designers and other pertinent museum staff to enter information before an exhibit, the museum preserves a virtual copy of the entire exhibit for later use –the virtual exhibit. A virtual exhibit consists of a tour QR Code that contains all the items selected for a particular exhibit.

This process also allows the museum staff to address issues of visitor clarity or interest that result from visitor surveys and comments during the life of the given exhibition.

The option to visit a previous virtual exhibit allows museum patrons to experience in a virtual form every object in that exhibit. Furthermore, as some of the items from this exhibit may have been dispersed to new display locations through the museum, they can be experienced physically by querying the list of artworks from the virtual exhibit with what's 'active' today.

Preserving former exhibits makes it much easier to develop future exhibits because all the information is already within the interactive content delivery system and easily accessible. Carrying forward object information permits the preservation of the unique history of an object within a single exhibit but also broadens its meaning in newer exhibits.

This system facilitates the matching of objects with subject or themes and can dramatically improve the efficiency of a curator's research and development of preliminary object lists for exhibition development. It expands the museum collection beyond what's currently on display by allowing objects that are not on display to also be accessible to the public. As a tool for art research this dramatically expands avenues for exploration.

Traditionally, curators build exhibitions by working with consultants, in and outside the institution, to develop ideas. The curator's ability to select objects for the proposed exhibit is often limited by his/her knowledge of the collections or the robustness of the museum's database management system. This process allows the exhibit curator actively to engage consulting scholars, whether local or distant, in developing concepts and themes, and at the same, to bring the objects or works of art that support those ideas to the planning process at an early stage. The benefit is enhanced collaboration among the planning team and an expansion of the works or objects that can be connected to the exhibition's theme.

This offers the advantage of using virtual tours to augment school lectures and studies and other research opportunities because the information can be accessed at anytime.

A basic tour created by a teacher and provided to the students as a Tour QR Code for scanning would allow the students to individually scan objects QR Codes and add them to the group tour. This will become a shared experience as all other students would now have the same virtual objects which were added to their common group tour.

On the other hand, if the teacher sends the students to the museum to select appropriate objects relevant to their topic, the student could scan the objects' QR Codes. On the first scan the system would create a Tour QR Code assigned to their device and it would add other objects to their tours as their codes are scanned. Virtual Tours allow archiving of existing exhibits as well as facilitating long distance exploration of the virtual collection.

4.1 Exploration of virtual collection

The interactive content delivery system also allows the museum to create tours and send them out for people unable to reach the galleries due to distance or physical capabilities. This is one of the many benefits that have emerged through digitizing the collection and making it available via virtual exhibits. Having created a tour for a specific topic such as a lecture on the civil war allows a curator, docent, or art teacher to give these codes out to students at the museum or to post them on the museum website allowing virtual museum tours to students in remote locations across the country or the world. The students can use their devices to scan the Tour QR Code and gain access to the same virtual information a local visitor receives. This ability broadens the exposure of the museum beyond its walls and allows it to showcase unique or focused course materials that meet specific teaching guidelines with very low cost for the school or distance learning program in their classrooms.

The remote access and the Tour QR Codes together provide a portal to not only broaden the interactive content delivery system but potentially to allow users to give their interpretations of the artwork to enhance the key word index. While still requiring curatorial approval, it could give visitors a way to provide their own knowledge, insights and interpretations.

This technology provides a portal for museums to participate over social networking. Over time, greater access and interactive participation among museum visitors may create a dedicated museum community that benefits the visitors and the museum.

5. CONCLUSION

This paper describes an Interactive Content Delivery System for a museum to expand the information beyond that which is displayed in the object labels and text panels in museums exhibits. For practical reasons, museums can only display limited metadata associated with the object. The system has several components: Interactive Touch Kiosk, Web Portal; Database and Control Management Interface.

The Interactive Touch Kiosk performs search engine queries to best approximate visitor interests. It can produce a tour based on their selections. Pre-planned tours are available via 'Recommended tours.' This allows for tours based on themes or to showcase particular exhibits.

The Web Portal serves mobile devices through HTTP access to dynamically generated pages that are accessed via a QR Code generated specifically for each object. The QR Code is included in the object label. Once a tour has been generated, it can be uploaded to a mobile device via a Tour QR Code. The encoded information in the Tour QR Code includes browser cookies to get around the stateless nature of URLs. This allows the association of a tour ID to a device. The device can keep track of different objects as their QR Codes are scanned. This allows tying a single device to all the objects visited on a tour. This is the foundation for the mobile application.

Any visitor that sees an object on exhibit at the museum that attracts their interest can scan the QR Code next to that artwork. This action will cause the interactive content delivery system to automatically include it in the tour assigned to their device.

The option to visit a previous virtual exhibit allows museum patrons to experience in a virtual form every object in that exhibit. Furthermore, as some of the items from this exhibit may have been dispersed to new display locations through the museum, they can be experienced physically by querying the list of artworks from the virtual exhibit with what's 'active' today. Virtual Tours archives previous exhibits as well as facilitates long distance exploration of the virtual collection.

Virtual tours allow for shared experiences and support collaborations.

The interactive content delivery system also allows for the museum to create tours and send them out for people unable to reach the galleries because of distance of physical impairment. The remote access and the Tour QR Codes together provide a portal to broaden the interactive content delivery system and to allow users to provide their interpretations of the artwork to enhance the key word index.

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