

# Palmera An Information Augmented Museum Visit Device

by

**Xingchen Wang**  
B. Arch (1999)

Tsinghua University  
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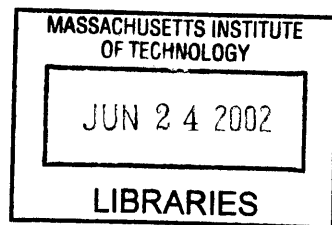
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Department of Architecture, Feb. 25th, 2002

Certified by

\_\_\_\_\_  
William Lyman Porter  
Norman B. and Muriel Leventhal Professor  
of Architecture and Planning  
Massachusetts Institute of Technology  
Thesis Supervisor

Accepted by

\_\_\_\_\_  
Nancy Jones  
Administrator for Professional Programs  
MIT, Department of Architecture  
Julian Beinart, Professor of Architecture  
Chairman, Department Committee  
on Graduate Students



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The readers of this thesis are

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**Hiroshi Ishii, Ph.D.**  
**Associate Professor of**  
**Media Arts and Sciences**  
**Tangible Media Group**  
**MIT Media Laboratory**

---

**Julie M. Dorsey, Ph.D.**  
**Associate Professor of Architecture and**  
**Computer Science and Engineering**  
**Massachusetts Institute of Technology**

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**Abstract**

This thesis tries to develop a new museum guide device with the combination functions of digital cameras and palms as a tool that maps information onto digital images to support a real-time contextualized learning that goes beyond separate out-of-task-context learning and existing museum guide modes. In order to perform a self-directed, interest-triggering learning process, one needs to gain information from both personal experiences and museum databases. By keeping a continuous personal experience between different journeys, an individual could bring his own knowledge and history into relation with museum databases to support a dynamic information access during museum visits and after the visits.

However, existing guide devices and their applications do not fully exploit the potential of real-time learning generated by wireless and mobile technology. This study proposes a tool, which encourages personal-controlled learning during museum visits by mapping dynamic information layer into physical space. The visitor gets object-oriented knowledge and a coherent experience through the exploration into the information space with the movement in the physical space both real-time and after the visit.

Thesis Supervisor: William Lyman Porter  
Title: Norman B. and Muriel Leventhal Professor of Architecture and Planning

## 1. Introduction

This thesis tries to develop a hand-held museum guide device consisting of palm and digital camera functions to enhance museum visits by providing the user with context-aware information. With digital information registered onto physical artworks through landmarks and hypertext formats, the palm-camera captures the location and the pointed linkage of the landmarks and superimposes them on the visual image. This allows user interaction with the information database to support real-time situated learning. This learning process is recorded by the palm-camera in an imageMap format consisting of the visual image and the history of user interaction to allow further study after the visit. As a personal palm organizer, this tool also constructs and stores an updated personal "experience bank" so that the user can refer to experiences of previous visits. In short, this tool should be able to help the visitor to bring his own knowledge and experience into the visit, access needed information dynamically, and record the learning process for future use.

Based upon prior work on the hypertext information database developed by museums and mobile devices, this thesis explores a user-friendly interface that encourages personal learning and a coherent experience of museum visits.

### 1.1 Overview

Museums are cultural institutions that preserve and exhibit valued records of social, scientific, and artistic accomplishments. To visitors, museums are physical spaces containing objects that carry knowledge and information that visitors can obtain through their navigations.

What a visitor gains from a museum visit can be very modest if he/she does not understand the objects or themes of the exhibit. It does not do anything to help the visitor's knowledge construction and deepen his reflection level, except for the authentic impressions formed at the exhibition.

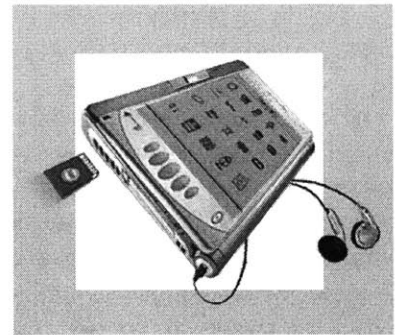


Figure 1. Proposed prototype

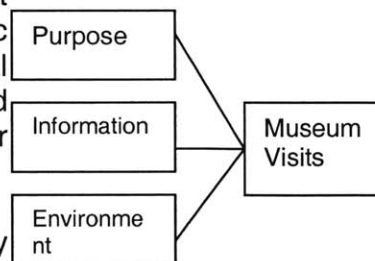


Figure 2.  
An coherent experience

In order to understand a particular object, a visitor needs to have access to some basic knowledge of the object, either through his/her personal memory or other information tools. In addition to that, an extensive real-time exploration of related personal and public information would allow the visitor to obtain an in-depth understanding of the museum exhibition.

People take pictures or make sketches or annotations during museum visits to keep a continuous memory for later recall. This record-keeping is important for review of museum visits and future study, because it connects the authentic impression of the visit and the further reflection that takes place after the visit. However, a mere picture uncomplemented by understanding or reflection does not say much itself. A sketch or a note without connection to the visual record loses its integrity as well. One has to put in great effort to organize pictures, sketches and annotations after visits to make an extended memory of the actual visits, which would offer a comprehensible base for further study.

Furthermore, for future museum visits, it is hard to bring the materials as references. While the development of mobile devices allows users to bring personal databases into all places, this feature has not been exploited in museum visit scenarios.

Research on visits to museums shows that people go to museums for different purposes: floating, focused and challenging [Leinhardt, Tittle, Knutson 2000]. Floating means that visitors are open to any experience and information and have few preconceived ideas as to what the exhibit is about or will mean to them. A focused purpose means that visitors have a clear idea in going to a particular show to expand their understanding of a particular art form or to learn a specific thing. Challenging means that visitors want to force themselves into an unfamiliar situation to learn.

Visitors with different purposes have, accordingly, different interests in museum objects and related information. Information presentation needs to respond to these various interests to efficiently and effectively to support visitor's learning processes.

Only a good combination of information, purpose, and environment can provide a coherent, engaged response to a museum object and an integrated experience for after-visit review and further study. The possibility of dynamic learning whenever needed is crucial to enable the visitors to get the keys to understand and, therefore, form a coherent experience from the museum visit.

The existing museum guide systems fail to support the potential for an extensive real-time learning process. This thesis will address the problem and propose an alternative system to meet the demand.

## 1.2 Problem Statement

The task is to provide a tool that allows the visitors to gain an in-depth understanding of particular museum objects they are interested in engaging with and, furthermore, to support the coherent recording of the learning process for further study.

This would require the system to have two important characteristics. It should be able to prepare the information as registered to objects in physical space in order to support contextualized learning. It should also be able to meet the dynamic demand for engagement with information from the visitor regardless of the various locations of the individual inside the museum. In short, the system should reflect the learning process as both mobile and context-sensitive.

Hypermedia format information provides an opportunity for exploration into a broad field of information from one small starting point. Thus it makes it possible to register the information onto different objects in the digital medium. Existing museum databases exploit this advantage and approach different applications based on this feature; for example, online museum tours allow virtual visitors to extensively explore information about objects in digital forms. However, in actual museum visits, a visitor does not have the opportunity to access basic information about a museum object or to engage in an extensive exploration of it when he/she is physically in front of the object. How to register object-based information onto physical space and how the visitors can view it in physical space to start the



exploration forms the first set of questions to be resolved in this research.

Mobile technology developed handheld devices to provide users an opportunity to access information anytime and anyplace. This would help to fill the need for a dynamic access to both personal and public information. However, to be useful to the user, the information content and presentation, and also the interaction between information and users, should take into account the context of use. How the information was presented via mobile devices could be context-sensitive for the user, and furthermore how the user exploration through the mobile device could be recorded as coherent memory for future use, informs the second set of questions in this research.

### 1.3 Purpose

The challenge of offering museum visitors an information-augmented visit and a further study connected to the actual visit rather than separately is the main purpose of this thesis research. Two aspects are important for this augmented visit experience: first, the interconnection of the authentic environment with more extensive and flexible information access; and second, the continuous support of the process of reception by the same media to further study and future visits.

Research on museum experiences shows that visitors come to view exhibitions with their own "entrance narrative" that allows them to make meaning from museum objects as they look through the lens of their own personal experiences and identity [Doering & Pekarik, 1996; Falk, Moussouri & Coulson, 1998; Silverman, 1995]. This expansion of meaning and the "attainment of a full perception", defined by John Dewey as "aesthetic experience", requires the visitors to have "appreciative understanding" of the artist's and curator's accomplishments. To be able to do this, visitors need sufficient background knowledge, which requires a learning process. [Dewey, 1934]

Studies on learning show that learning embedded in a task context is more effective and efficient than learning organized before the task accomplishments [Norman and Spohrer 1996]. "Situated learning"[Suchman 1987] and contextualized learning [Lave and Wenger 1991; Vosniadou 1994] would help people to acquire the knowledge necessary to understand a situation without switching mentally to a separate learning activity.

Since learning in context is sometimes time-limited, the more detailed after-context learning experience would also be enhanced and supportive to future situated learning if a connection to the situated learning experience were made. In a study of six art museums in Europe with 561 visitors, the surveyors found that two thirds of the visitors used information media about the museum exhibition after their visits [Oppermann and Specht, 1999]. It is also true that many people take pictures of objects they are interested in (when allowed by the museum) for a personal record and future reference. The opportunity of offering a hybridized record rather than a plain visual image would support more extensive learning after the visit.

Both research fields confirm an information-augmented museum visit as a promising learning experience. In addition, the potential of an after-visit connection to the learning experience can be enhanced by on-site learning efforts by the visitor as a context if the visitor has more extensive access to information bases and more time to engage with the learning.

## 2. Background

A preliminary study of the current context, related work and underlying theories and technology solution has been performed and some clues for the design of an alternative system to enhance the museum visit have been formulated in this thesis.

### 2.1 Context

A museum visit is a three-way communication between the visitor, the physical space containing objects, and the related information that the visitor engages with. There exist a wide range of information media that visitors can access either in or outside of the visit.

#### 2.1.1 *Traditional museum guide tools*

Traditional museum guide tools that most museums now exploit include paper media, audio media and human media in the form of tour leaders. The relevant aspect of these guide tools, in the context of this thesis, is the level of usability from the point of view of visitors. Through an examination of the visitor engagement with the information through the aid of these tools, some criteria for a user-friendly interface design has been gained.

Maps of museums and signs inside the physical environment, which direct the users, are tools to aid visitors in space navigation and are less related to the learning process of visitors compared to other tools that focus on information related to the exhibition. The navigation inside the physical environment is not the main concern of this study, and the focus will be on the tools related to visitor engagement with exhibition-related information.

Paper media – Catalogues of general information and leaflets about specific objects or themes of the exhibition  
Catalogues of museum exhibitions offer the visitor both a general overview of the exhibition and extensive information about exhibition objects. However, the linear organization of information makes the real-time exploration of information very difficult, especially for time-limited visits. It is more suitable to be used in after-visit study.

Leaflets available in individual rooms complement information on labels attached to the exhibits to give visitors more specific information. This tool offers information concerning the context that is object-oriented

but it does not support cross-referenced information for user extensive exploration.

#### Audio media –audio guides with indexed information

Similar to leaflets in paper media, audio guides work in conjunction with index labels attached to exhibition objects but do not support extensive exploration. Their advantage compared to paper media is that they do not interrupt the visitor's navigation inside the physical environment. For this reason, they are becoming more common and are generally preferred. They hinder, however, the person to person communication in a group-visit scenario. [Refer to the museum study by Areti Galani ]



Figure 3. Audio Guides

#### Human media – tour leaders

Visitors listen to human guides to learn while on a group tour. They also listen to “expert” friends when an accompanied visit is available. These are preferred tools that visitors like to use according to the above-mentioned study by Oppermann and Specht. However, a group tour leader offers the lowest common ground so that the information can be understood by all. The uniqueness of an individual exploration of the information is not supported in this tool, and it often creates a dilemma between wasting personal time by listening and losing needed information by not listening.

An accompanied visit by an “expert” friend (for example, a curator or artist) is more personal and effective, but this opportunity is very rare for the average visitor.

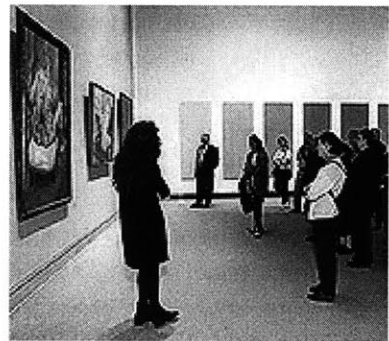


Figure 4. Tour Leaders

A personal extensive exploration of information is needed during a museum visit. A tool to support this should be able to offer both an easy exploration for the visitor and an extensive presentation of information in addition to its object-oriented information database. It should also allow a personal exploration that the visitor chooses “when” and “what” he needs from the information database.

### 2.1.2 Digital Medium—museum kiosks; museum and the web

Some museums use digital media to support user exploration both in the form of kiosk stations and on the Internet, and therefore they are able to present information object-oriented or theme-oriented. Both tools allow an extensive exploration of information but lack features to fill some important visitor needs.

**Museum Kiosks** – Some museums set up computer workstations to present information about the exhibition and general information about the museum in a digital format. Information is hyper linked and cross-referenced to allow extensive exploration. These workstations are located inside the museum as theme-related kiosks. Using this tool, however, would require the visitor to switch to a “study” mode from that of physical navigation of the exhibit. Also this tool does not support object-based situated learning because it actually separates the learning and the actual visit due to its physical location restriction. The recording of the visit is not supported by this tool either except that visitors can make sketches and notes on their own.

**Museums and the web** – Since the appearance of the first museum Web sites, hundreds of museums have established a presence on the World Wide Web. Most museums put general information and information about exhibition themes and objects on the Internet to allow off-site explorations. There are also many online tours and virtual tours constructed by museums to offer visitors a simulated experience of museum visits and a careful exploration of information based on the exhibits; for example, the National Gallery of Art designed different online tours to support visitor exploration. These tours can help visitors to learn about exhibitions in an extensive and simulated way, but can never replace an actual visit.



Figure 5. Museum Kiosks



# online tours

NATIONAL GALLERY OF ART

WHAT'S NEW

HELP

FEEDBACK

SEARCH

SITEMAP

SHAW MEMORIAL

MAILING LIST

planning a visit

the collection

exhibitions

online tours

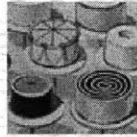
education

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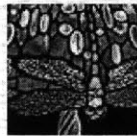
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["Watson and the Shark"](#)



[Horowitz Collection](#)  
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Figure 6. Online tours supported by the National Gallery of Art

## 2.2 Related Work

This digital era has inspired numerous approaches for using computer technology in museum exhibitions. These approaches include both an interactive real-time guide using mobile devices and an extended experience record using the Internet. An overview of these developments was done by Susan Amirian to examine the status of technology and digitization activities in museums. [Amirian, 2001] These developments offer ample design clues and evaluations for this thesis research; these will be addressed below.

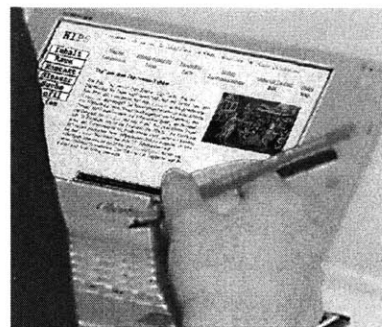


Figure 7. Hips Prototype User Interface

However, research on the use of mobile computing technologies and applications in museums normally focuses on the museum side. Current developed systems aim to provide visitors with an enhanced personal experience inside one museum. The continuous and coherent knowledge and experience construction of visitors during many of their museum visits is not enhanced. There are also other issues that museums need to deal with, such as the cost of such systems for museums, the maintaining of such devices by museum staffs and broken or stolen devices.

### 2.2.1 HIPS project and other mobile museum guide development

The Hyper Interaction with Physical Space (HIPS) project was a collaboration by three universities: the University of Edinburgh, the University College of Dublin, and the University of Siena and other research groups from Italy, Germany, France, and Norway.

With “integration of hand-held computing with wireless communication and positioning technologies”, Hippie, one of the prototypes, was designed within the HIPS project. The prototype includes a mini-laptop that uses infrared technology for location identification, wireless LAN for data transmission, a touch screen and headphones for user input/output. With an audio presentation as the main output, auxiliary visual presentations complement the understanding of the audio information. The system selects and presents information in an adaptive way by evaluating the visitor’s movement in both physical space and information space.

The design of this prototype and its interface explored several important design issues and theories for mobile museum exhibition guides, which include: situated learning, context-sensitive information system, nomadic

systems and adaptive information systems.

[<http://www.fit.fraunhofer.de/projects/hips/>]

The Hippiie project, along with other projects such as “cyber docent” inside HIPS consortium, confirmed that visitor experiences were enhanced through the use of mobile museum guides, which were also enjoyed by the users. However, “mass acceptance of the strategies may have lagged because the technologies necessary to support the systems were neither widely available nor affordable.” [Amirian 2001]

While there are many similar approaches to offer visitors an enhanced experience through mobile devices [refer to Amirian 2001], there are also other directions that researchers followed. For example, *Sotto Voce* is an electronic guidebook designed to facilitate interaction between companions and to help visitors engage with their environment. The main concern of this project is to “facilitate rather than hinder social interaction.”

[<http://www.parc.xerox.com/csl/projects/guidebooks/project.html>]

### 2.2.2 Projects on Extended Experience in museum visit

Recent uses of hand-held computers also are coordinated with Internet to enable the creation of a visit record that is accessible off-site after the visit. The Experience Music Project (EMP) in Seattle, for example, allows visitors to use hand held devices to both explore information about the exhibit and bookmark selections during the visit. After the visit, users can explore their bookmarks through the EMP web site once they input their museum ticket numbers. [<http://www.emplive.com/>] The Exploratorium also enables visitors to register a username to access their visit records, which are created during the visit through downloading information.

[<http://www.exploratorium.edu/guidebook/>]

Besides supporting personalized museum learning experiences, these tools also investigate opportunities to allow an extended experience for visitors’ deeper engagement with exhibits after the visit.

Although a connection is made through these tools, this connection uncomplemented by the visitor’s authentic impression of the exhibit is insufficient to form a coherent experience of it.



Figure 8. Experience Music Project web Interface



## 2.3 Theories and Technology

### 2.3.1 *Situated learning*

The idea of situated learning in the task context came from two keywords: situated action [Suchman 1987] and contextualized learning [Lave and Wenger 1991; Vosniadou 1994]. Studies and research on this theory show that a situation or a task is an important motivational and cognitive factor for successful learning and learning embedded in the task context is more effective and efficient than separate learning organized before task accomplishment [Norman and Spohrer 1996].

As situated learning is process-oriented learning, unsolved problems or incompletely understood situations in the process would need further learning support. This later learning has to take into account previous efforts of the learner [Mandl, Gruber and Renkl 1995].

Museum visits are attractive for a situated learning system because museum exhibitions can best be enjoyed when the visitor has access to information about an object when he is in front of the art object. The motivation to learn about the object real-time can be assumed to be higher than without the authentic impression of an exhibition object. This thesis wants to use the effect of situated learning to support an augmented visit experience.

### 2.3.2 *Motivation theory and other theories about "interest" concept in human behavior*

Motivation theories and educational psychology use the concept of "interest" to explain human behaviors. Motivation theory states that interest is a conscious direction to an object and issue, it determines the degree an individual is occupied with the object or issue by perception, by communication or by interaction. Educational psychology defines the dynamic character of interest as a condition for learning in that the readiness for learning depends on the interest of the learner, and the higher the interest is, the more effectively the individual learns about an object or issue. Other theories also showed that interest triggers perception behavior in a quantitative and qualitative way. [Refer to studies done by Oppermann and Specht 1999]

The concept of interest is important in museum visits because visitors do not have any predefined tasks during their visits, instead they face arranged attractions that do or do not catch their attention. This thesis explores features to respond to visitors' interests directly to offer visitors an effective learning opportunity.

### *2.3.3 Museum experience; museum and learning*

There exist a wide range of studies on museum experiences from solid descriptions of general visitor experiences to focused analysis about cognitive aspects. This thesis takes several theories as key beliefs to use as design principles.

G. Bell determined two main reasons of museum visits from his study on visitors – socializing and learning. [Bell, 1999] Focused on the latter, a research project, the Museum Learning Collaborative (MLC) is designed to study the processes and outcomes of learning in museums. With the same focus in its scope, this thesis constructed the design prototype based on various MLC studies on museum learning.

Museum visitors come to view exhibitions with their own “entrance narrative” that allows them to make meaning from exhibitions as they look through the lens of their own personal experiences and identity [Doering & Pekarik, 1996; Falk, Moussouri & Coulson, 1998; Silverman, 1995]. John Dewey defined this expansion of meaning as “aesthetic experience” [Dewey, 1934]. What visitors bring with them adds to their experience in the museum and helps to supply their side of the tacit dialogue [Stainton, 2001]. These inform the key feature for the design of the prototype, which is, to explore how an individual's own knowledge and history can be brought into his engagement with information drawn from the museum database.

A study on diaries of museum visits by Leinhardt, Tittle and Knutson (MLC technical report #04) revealed the cognitive patterns of visitors as description, analysis, narrative identification and weaving of all the three. These patterns are implemented in the interface design of the prototype to fill different visitor needs.

#### *2.3.4 Interface Design for navigation in information spaces*

While Jacob Nielsen determined hypertext information interfaces by a simple rule: its "look and feel", Peter Gloor proposed seven design concepts for interface design for navigation in information spaces. They are: linking, searching, sequentialization, hierarchy, similarity, mapping and agents [Gloor, 1997] and are exploited at different levels in the prototype interface design in this thesis.

#### *2.3.5 Real-time updated database mechanism and the Cookie concept*

A real-time updated database is built on a very simple mechanism. A Web server or a local application exploits an engine to read in user queries real-time and then writes data into the database using SQL. The Web server or local application read from this database to transmit updated information to users' browsers. This meets the requirements of both an updated personal database and a real-time museum database in this thesis.

Cookies are pieces of information generated by a Web server or a local application. They flow back and forth between the user's computer and the servers to allow user-side customization of information. This concept enables a personalized presentation of information in the prototype.

#### *2.3.6 Client-side ImageMap in html format*

Client-side imageMap in html (Hypertext Makeup Language) format is a very simple technology that it adds a map with coordinates and associated URL linkages to the visual image. This map, as one of the additional layers that digital images can take, is used in this thesis to store the coordinates of the information landmarks in the image and their associated URL addresses. With information nodes recorded as history and bookmarks during the visit, the image takes these nodes as additional layers attached to it and thus forms a multi-layer digital image as visit record.

### *2.3.7 History Mechanism in information navigation*

WWW browsers typically provide history mechanisms that allow people to select and revisit pages they have viewed previously. These mechanisms are very important in a hypertext repository of information to support users' navigation through the vast amount of information. Research done by Tauscher and Greenberg (1997) through empirical findings showed that 58% of WWW navigation are "revisits" while the design of history mechanisms are not effective to support these "revisits". Navigations through information space during museum visits require similar history mechanisms to record visitors' engagements with information and offer "revisit" opportunities for visitors. Taking design guidelines suggested by Tauscher and Greenberg, this thesis offer an alternative approach for recording history and reviewing history in a contextual way.

### *2.3.8 Registration of information onto objects and Code recognition—Infrared Technology*

Infrared radiation shares many common features as visible light. Its visibility through a photodiode or photoreceptor is similar to light captured by eyes. This enables the digital camera with infrared eyes to capture the locations of the transmitters and map them onto a digital image of the actual environment.

The transmittance of data uses two different intensities of infrared light to represent the 1s and 0s. This mechanism supports registrations of information onto objects through coding information addresses into 1 and 0s and decoding them after the camera sensors capture the signals.

### 3. Design Criteria

This thesis proposes a real-time information-augmented visitor tool for museum visits and names it “Palmera” since it is a device that combines the technologies of Palm and digital camera. It works as both a mobile interface for retrieving information and a device to construct the visit record for future use. This chapter lays down the design criteria for this device; they are based on three phases of the augmented information visiting process.

An initial attraction to particular exhibition objects triggers the visitor to engage with the objects and start the learning process; the device needs not only to respond to the interest of the visitor but also to offer potential suggestions.

An extensive exploration of both an individual’s personal experience and information drawn from museum databases requires the interface to offer different interaction functions to support different user needs.

After-visit study would need a base to start and the record of visit interaction encourages continuous study following the actual visit. Taking future visits as one of the after-visit study scenarios, the record supports the engagement with one’s own knowledge and experience as a personal database. The readability of the record comes from both the recording mechanism itself and the interface that sponsors review of the record.

### 3.1 Interest-based Learning

Museums are “free” environments in that visitors choose what they will engage with. [Schauble, Beane, Coates, Martin & Sterling 1996] It is also true in the learning process that visitors choose what information they want to learn.

However, in front of a complex and large information space, the visitor would not be able to use the information efficiently if the information presentation did not consider the context of the use. Although the user himself is most competent in specifying the context of use [Dzida 1996], he would still need to specify the correct information content he wants to see and learn about.

To help the user to pre-select and appropriately present information he is interested in, two tasks need to be performed – an information system prepared with a context-sensitive consideration, and a mechanism that would respond to the user’s interest and also suggest potential attractions to present appropriate information.

This thesis proposes a solution to both tasks through a “visible” digital registration of information onto physical objects.

#### 3.1.1 *Combination of physical and virtual exploration*

Museum information databases are normally constructed based on exhibition objects, while the visitor navigates the physical space with an object-oriented interest and engagement.

The tool exploits this common feature of visitor perception in both virtual exploration of the museum database and physical exploration inside the actual environment.

#### Mapping information into physical space

Two space models need to be taken into account before we start to examine the technology of registration of information onto physical space. Museum spaces are typically arranged in a linear model; this encourages the

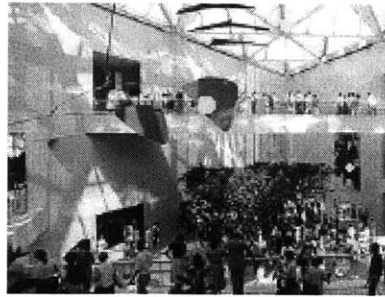


Figure 9. Visible Digital  
Registration of information onto  
objects

visitor to engage with one object at one time. There also exists in museums another larger scale space model, which allows the visitor see multiple objects at different distances. These two are not absolutely different because a linear space model also allows the visitor to view multiple objects from a distance or at a specific angle although the intention of the space arrangement is to help the visitor focus on one object.

Both of the space models are supported in this tool because the system registers the information on a single object and offers the same visibility of the registration landmark as the object itself through the Palmera device.

Based on museum efforts to collect an object-based digital information system, the mapping of information in physical space is actually mapping the URL address of information onto physical objects. Using researches on available technologies, this thesis proposes the following solution.

Through InfraRed Technology, an LED transmits the infrared signal as bursts of non-visible light. At the receiving end a photodiode or photoreceptor detects and captures the light pulses, which are then processed to retrieve the information they contain, in this case, the URL address of the information about the object inside the museum database. The coding and decoding is made by transmitting data using two different intensities of infrared light to represent the 1s and 0s.

#### Mapping code recognition into digital image

The combination of the possibility of the recognition of the code the infrared transmitter sends and the visibility of the signal on the digital image captured by the Palmera is crucial to user interaction with the information database.

Palmera with the infrared sensor captures the infrared imaging of the real environment and through its analysis and decoding mechanism, the tool is able to superimpose the URL address decoded from the infrared signal to the digital image with coordinates and linkage in an `imageMap` format.

### 3.1.2 Self-directed learning with needs and suggestion

With the above described technology solution, when interested in particular museum objects, the visitor is able to see the landmarks indicating the registration of information about the object (appearing as blinking dots) on the digital image. He is also able to go to the information addresses that the registrations point to by touching the blinking dots. This enables the visitor to easily control his information exploration.

#### Interest Triggered interaction

The concept of interest is important in a context of user self-directed behavior. However, it is very hard to model a visitor's interest to offer interest-sensitive information since it is highly dynamic.

Although there have been many efforts to design adaptive system to identify and predict the visitor's interest to indicate information selection and presentation, this thesis proposes an alternative solution, one which directly responds to the visitor's interest demands.

With initial interest in particular museum objects, the visitor uses Palmera to verify whether there is information registered about this object. The tool responds instantly to this demand through a check of available information landmarks. When confirmed, this tool enables the visitor to start exploring the information he needs through his interaction with the information database.

#### Objects-of-interest Suggestions

The visitor can also know if other potential objects-of-interest is available through Palmera. Suggestions of potential attractions appear in three forms: infrared indications based on purpose; a list of most visited objects at the museum; and personalized suggestions.

##### *Infrared indication based on purpose*

The introduction of purpose into the design of the interface is because defining the purpose of a visit would help to present information more accurately in response to the visitor's interests. The purpose is categorized as: floating, focused and challenging.

By default, the purpose is set to floating, which means that the visitor is open to all possible information. Accordingly,

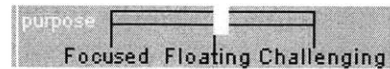


Figure 10. Defining Purpose

**Museum Recommendations**  
Most Visited Objects

**Waterlilies,**  
Claude Monet, 1900. Oil on Canvas. *The Impressionists*, Exhibition Hall VI (East Wing, 2nd Floor)

**The Circus,**  
Alexander Calder, 1925. *Vertical Constellation of Bomb*. Exhibition Hall II (East Wing, 1st Floor)

Personalized Suggestion

Figure 11. Objects-of-interest suggestions



all the registrations of information in scope will be shown on the digital image.

If the visitor sets his purpose as focused, he needs to define what his purpose is or choose from a list of ideas generated from an analysis of the visitor's personal database. Only information registration landmarks that are related to the purpose are visible under this condition.

Setting the purpose as challenging will result in a similar display except that Palmera creates the list of ideas for visitors from reading the headers of information in the museum database and then excludes those ideas recorded by personal database as focused purposes.

#### *List of most visited objects*

A list of most "popular" items is generally used in different websites. It offers the users opportunities to see what the majority of user are interested in and the users can take it as valuable items to engagem with. Amazon.com, for example, offer a list of top sellers as most popular books or softwares. Most users enjoy this type of lists and Palmer exploits this feature to offer visitors suggestions from the museum.

The museum database is dynamically updated in that an engine reads in visitors' interactions with information in the database and updates the visiting rates of information. The most visited objects are chosen based on this visiting rate. Their basic introductions and locations are presented in the interface as suggestions of potential attractions from the museum.

#### *Personalized suggestions*

Personalized information suggestion is also a common feature that most commercial websites use. Amazon.com will keep a "cookie" of the user to record what books the user has bought. Based on this "cookie", Amazon.com will suggest personalized book lists when the user returns.

Palmer also executes a local application to read the personal database and generates a "cookie", which is sent to the museum database via the local application. The museum database reads the "cookie" that contains basic personal data and generates suggestions based on the visitor's interest and background, which are contained in the "cookie".

### 3.2 User Interaction Interface

Palmera enables the visitor to start real-time exploration of information and the second phase would require the tool to offer an interface to support possible user interactions in the information exploration.

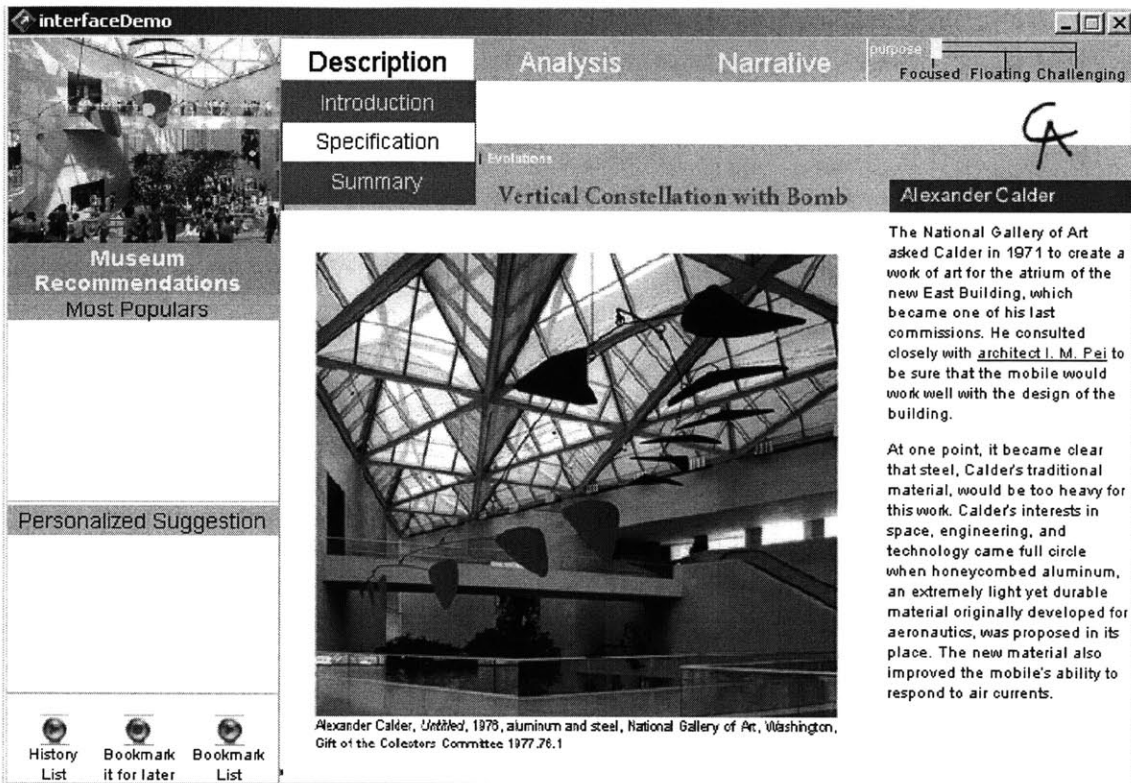


Figure 12. User interaction interface

To make the exploration easier and also to make use of the current museum database, this thesis proposes a WWW browser mechanism as the interface to present information and allow user interaction because it is a familiar experience for the user and thus does not require effort to learning to use the tool. Also it would most efficiently use current museum databases, most of which have already been published on the WWW.

The engagement with information is represented in three categories of "cognitive tools" [Greeno, 1996] based on the engagement between visitors and exhibits, and another level of interaction based on information navigation.

The cognitive tools are description, analysis and narrative identification. Description represents information directly related to exhibit objects, and visitors can read introductions, specifications with different parameters and theme summaries about objects. Analysis is the second tool that visitors use to focus on details, components and various features of objects; they use comparison, difference, and curiosity search methods to extensively explore the objects. Narrative Identification is used as a tool for making meaning from objects in museums. Using this tool, visitors can learn stories attached to some analytic features and also make notes and sketches as a “dialogue to self” to organize their own ideas and thoughts. Another level of interaction focuses on user navigation activities inside the information space. This interaction level is inherited from WWW browser mechanism to offer visitors an easy way to navigate through the information space.

Description	Analysis	Narrative
Introduction	Comparison	Story
Specification	Difference	Notes
Summary	Curiosity	Sketches

Figure 13. Cognitive tools

The screenshot shows a web interface for a museum exhibit. At the top, there are three tabs: 'Description', 'Analysis', and 'Narrative'. Below the tabs is a navigation menu with 'Introduction', 'Specification', and 'Summary'. The main content area is titled 'Alexander Calder' and features a photograph of a mobile sculpture. To the right of the photo is a text block describing the artist and his work. The interface is designed for user navigation and information access.

Figure 14. Description of object — Introduction, specification, and summary

### 3.2.1 Description

Descriptions of objects are normally static information including an introduction; specifications; and a summary of exhibit themes. Although visitors’ engagement with exhibition objects goes far beyond descriptions, this static information offers a basic interpretation of the objects to support more meaningful engagements.

An introduction of an object will be set as default to be first shown on the presentation of information. People can choose from pull-down menu for specifications and theme summaries. Specifications of objects (such as author, year, material, style, theme, working methods, form, construction, pattern, etc.) were defined by curators when they collected information about the objects. Technically, the information in the museum database will have a header that reads in all the available specifications for one particular object. This setup also supports comparisons by visitors between different object information. Finally, theme summaries bring the visitor up a level from object-oriented to theme-oriented information.

### 3.2.2 Analysis

When visitors use analysis, they focus on a particular object and inspect its component parts in detail through comparing it with objects in their memories, looking for its most different features and formulating questions about details of its design or creation to consult the museum.

#### Comparison

With a personal database stored in Palmera, the visitor can easily refer to objects in his past experiences. Because comparison is an important analytic method, this tool supports user to compare the object they currently engage with to other objects that they have engaged with. The parameters of objects to be compared with come from headers of information, which contain specifications of objects. The visitor can define what features they want to compare by defining the “mixers” in his “knowledge bank” window to enable the tool to automatically select related objects from his personal database. An automatic generated “mixers” list is used by default. Also the tool enables the visitor to find a particular object by keyword searching.

#### Difference

Most distinguished parameters of an object that are different from average exhibit objects are important in the process of learning about the object. For example, in his work *Untitled* (1976), Alexander Calder exploited the use of light materials, which were never used in other works of his Mobile sculptures. Palmera calls these parameters “difference” and assumes that curators of museums would offer this “difference” information about objects that visitors can learn through changing the analysis interface to “difference”.

#### Curiosity

Besides descriptive data and the comparison and difference features based on them, visitors would also need to consult the museum systems for detailed formal art analysis, for example, the color design of a painting, the form design of a sculpture or the background of a modern artwork, etc. Palmera concludes these questions as “curiosity” and offer the chances that visitors are able to see answers to such questions by the museum and also enter questions for the museums to be analyzed.

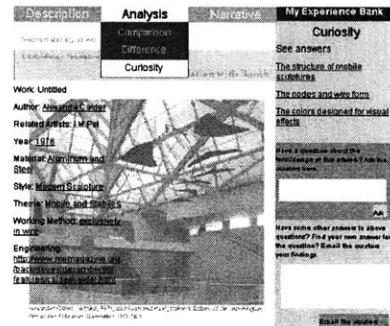


Figure 15. Analysis tools – Comparison, difference, and curiosity

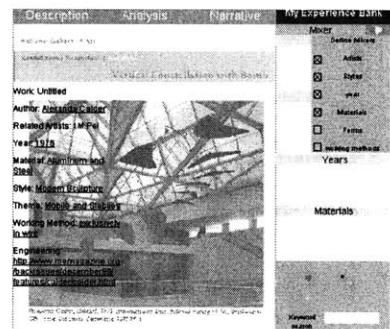


Figure 16. Mixer Define for Comparison

### 3.2.3 Narrative Identification

By means of narrative identification tool, visitors can either learn stories about objects in real life, which are closer to their own lives; or draw meanings or interpretations of objects out into their own reflections. This cognitive tool, which is used by visitors to shape their own museum visits, adds to the identity of who the visitors are.

#### Stories

Stories defined here are related to museum objects but are not direct information about the objects. They are usually attached to some analytic features of objects. They are interesting to some visitors that they possibly enrich their knowledge. Such stories include families of artists, friendship between artists, stories about the design process, etc. For example, there exists in the Alexander Calder exhibition in the National Gallery of Art, a story about how Calder found "Mobile" as the name of his sculptures. These stories are offered as a function of "Story" in Palmera to help people to make meanings from objects.

#### Notes and Sketches

Notes as "dialogue with the self" [Mead, 1934] are able to record personal ideas and thoughts inside the context, and "may reveal patterns of relationships between ideas that were not evident when the concepts were stored internally". Palmera supports context-based notes that when the visitor feels need to annotate some information, he just highlights the information and chooses "note" from pull-down menu to activate the annotation input window. And the annotation would be added as an icon to the selected information in the visitor's personal database.

Sketches are mind maps or concept map that people make to help their reflection. "Usually such maps are constructed informally by simply sketching them on paper." "An individual can use a concept map as a tool for re-organizing his or her own personal structure." [Ware, 2000] Palmera uses the touch screen feature of Palm to enable this activity. Sketches are also attached to the information they are related to.

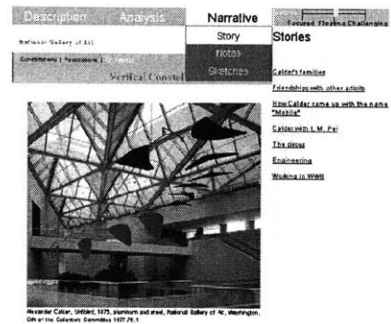


Figure 17. Narrative Identification – stories, notes and sketches

### 3.2.4 Navigation Interaction Level – History and Bookmarks

Information is not the only goal of a museum visit and the time of a visit is limited, so a connection to after-visit more extensive information exploration is important. This connection would allow the visitor to efficiently use his time in the museum and to be able to perform future studies based on the actual visit when he has time. Studies on WWW navigation show 58% of an individual's pages are revisited [Tauscher and Greenberg 97] and this also confirms the necessity of a connection.

Current history mechanism of WWW navigation (back bookmark and history) is not a satisfactory one in that it provides revisitation systems in a fragmented, un-integrated manner. This thesis tries to develop a better interface for the visitor to retrieve his exploration history including bookmarks and visited information nodes in an easy-to-manipulate way.

Bookmarks are made in the context rather than an after-visit organization. The action needed for bookmark in this interface is only a simple click rather than a pull-down menu selection and a dialogue popup. These bookmarks are intended for future study because of the time limit of the visit and the easy access to them is important as well, which will be covered in the next chapter. Basically, the interface offers two functions – make bookmark and view bookmarks.

Histories, as visited pages, are indicated by changing colors. A list of history is also organized automatically according to the context, which is, which object is the information related. The interface contains a "view history list" button for visitors to retrieve their visit history.



Figure 18. History and Bookmark tools

### 3.3 Coherent Experience

The discussion of collective memory includes two steps: the record of visit experience during the visit and the use of this personal record in further study and future visits.

#### *3.3.1 ImageMap plus history of visit*

The interface chooses visual image as the bottom medium to contain multiple layers because a picture is a natural medium for visit record and also an image itself records the authentic impression of the exhibit very well than plain texts.

An imageMap in the html format, perceived by the visitor as a digital picture, is actually containing the hyperlinks the Palmera captured during the visit.

The visit history is recorded using navigation browser history mechanism that visited pages are taken into history list saved on the local disk of the Palmera automatically and bookmarks made by users are saved as a bookmark list on Palmera disk as well. The visitor can also make notes, which will be saved as layers of icons inside the information pages.

#### *3.3.2 Further study after the visit and future visits*

The visit is recorded in different digital images. After visit, the visitor can connect Palmera to a computer and Internet for future exploration. The software installed on the computer is very similar to digital camera software in that it will show thumbnails of images in the software window and allow the user to rearrange the images in different organized categories.

The interaction with the thumbnails will pop up navigation browser with connection to the museum's web site and this interface is the same as what the user has in his Palmera.

In future visits, selected thumbnails of images will appear in "my experience bank" in the user interaction interface of Palmera when the visitor chooses "comparison" or "difference" to activate the experience bank.

## 4. Design Prototype

### 4.1 *Proposed Design*

#### 4.1.1 System Design

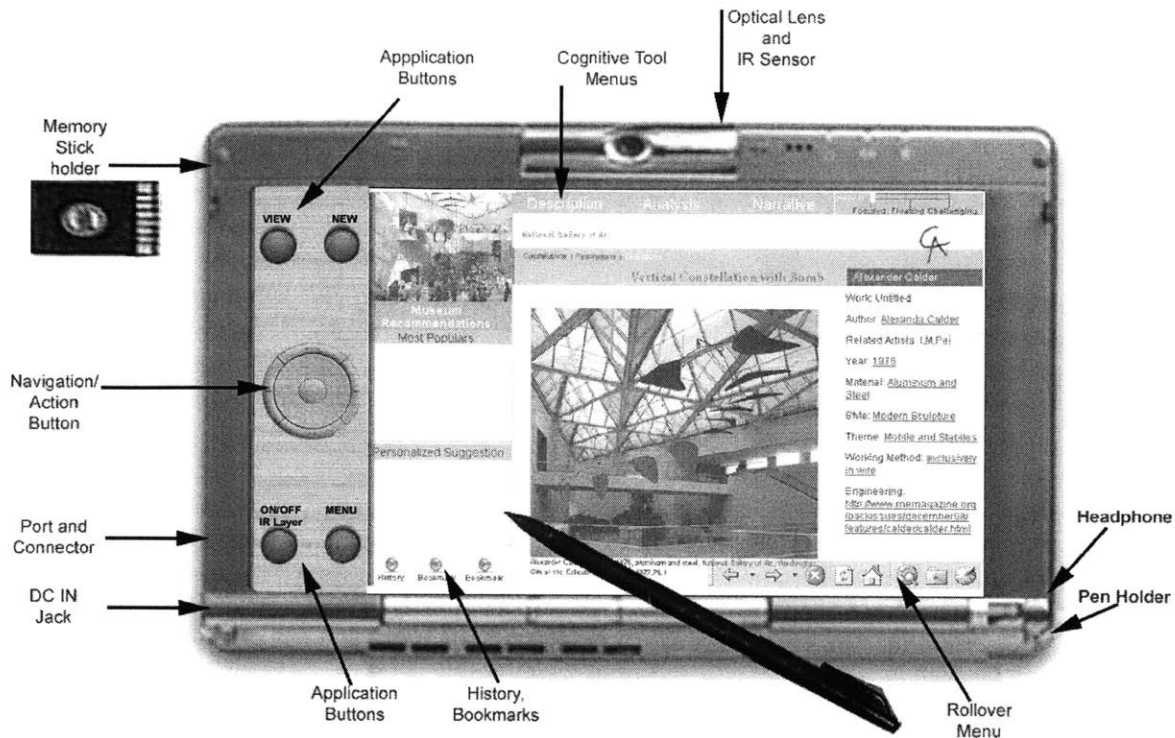
The system is formed of a personal owned Palmera, a museum database with a Web server or a similar local SQL application, and infrared LEDs attached to objects for information registration. There are two solutions to construct the system. One is wireless LAN network and the other is inside-device communication between the user and the museum database through the downloading of the database. The wireless network solution is clear in its technology level but is more expensive than the second solution. The thesis will describe the second solution but support both solutions.

Upon entrance to a museum, a visitor can download the museum database to his Palmera. The engagement with the museum database becomes local on Palmera. The “cookie” that contains personal data is generated and stored locally. Also an engine attached to the museum database stores the track of user queries. Palmera downloads from the local stored museum database the information pieces that the visitor engages with and writes them into its personal database. When the visitor leaves the museum, the museum database stored on his Palmera is unloaded along with the track record. The museum Web server reads in the track record and updates the museum database server.

If museum database is too large for Palmera hard drive space to hold, the use of wireless LAN network should be considered.



#### 4.1.2 Device Design



The prototype is designed in both hardware and software scopes. The device is a combination of digital camera and palm with infrared sensor and infrared decoding mechanism. The functions as downloading information, connecting the device to Internet, taking pictures, zooming in/out, viewing pictures, new snapshots and switching on/off of the infrared layer are supported by the hardware features from both digital camera and palm. The software in the device mainly concerns with the information content and presentation, users' interaction during information exploration and the record keeping mechanism.

The proposed interface works on both physical interactions and digital information exploration. After downloading the information from the museum database, the visitor can start exploration of information by previewing the physical space in Palmera when he finds his interested objects. Blinking points in the previewed image indicate the landmarks of information registration on the objects, which are shown based on user verification of his purpose. The infrared signals sent from different museum objects are captured and decoded by Palmera. It then superimposes the coordinates of the infrared signals on the 2D image

and maps the database addresses that the signals point to as hyperlinks onto the image. After taking a picture, the visitor can start with interacting with the hyperlinks mapped on the picture.

The information presentation exploits WWW navigation browsers and the suggestions from the museum database about “most visited objects” and personalized potential attractions are also inherited from successful commercial web site experience. Visitors’ engagement with information is enhanced within the context based on three cognitive tools – description, analysis and narrative identification. The navigation inside the information space is enhanced by a rollover menu, which is similar to WWW browser navigation toolbar, and history and bookmark buttons. The record of the navigation in the information space is kept in the way it was created. So for after-visit review, the user can easily access his visiting record including his notes, sketches, questions, bookmarks and visited pages. One piece of record is generated for visitors’ engagement within every imageMap and is stored in personal databases with a thumbnail image.

The device is based on the convergence of the mobile device technology, Infrared Wireless link technology, WWW navigation mechanism, improved history and bookmark mechanism and electronic annotation technology.

The design iterations were done through building user scenarios that have been categorized as on-site information exploration and after-visit extensive study.

Handwritten notes at the top of the page, including the word "Palmera" and some illegible scribbles.

#### 4.2 Application/Scenarios

Palmera has been developed to support both real-time explorations and after-visit extensive study. The tool has been tested through building user scenarios that are described in two phases.

1. On-site information exploration: The tool is used to quickly respond to visitors' interests to support a self-directed interest-triggered visit. The time limit and the visitors' physical movements make the exploration a quick and key knowledge learning about the objects.

The intent of this User Scenario:

Direct response from the system for the visitor's interests; Personalized suggestions and collective suggestions

Cognitive tools supporting user interactions with both personal experience and museum database; Record-keeping supporting visitors' further study: bookmark and history

2. After-visit careful study: Here the visitor has the "time", "mood" and "environment" for a careful, extensive exploration about the objects he saw and was interested in during his visit. He also has a personal database, which consists of the pictures with his visit record superimposed, as his base for a continuous research following the one he did in the museum.

The intent of this User Scenario:

Readability of the visit record

Coherent memory from the actual visit

Extensive exploration environment: connection to Internet

##### 4.2.1 User scenario 1—On-site Information Exploration

###### Part I: Focused Purpose

An architecture student from GSD has come to the National Gallery of Art for a visit. He is interested in both the exhibition and the architecture design of the east wing by I. M. Pei. In his Palmera, he specified his purpose as focused. In the pop-up window, there are some purposes generated from his past experience with an analysis of the museum database of NGA. These purposes include modern sculpture, modern painting, renaissance painting and architectural design, from which he could choose.

He chooses "modern sculpture" and "architectural design" because he knew from advertisements that there are two

modern sculpture theme exhibitions at this time – Alexander Calder and Henry Moore and that is why he traveled from Boston to NYC.

He starts to use Palmera when he is in the main lobby. In the preview on the screen, he sees that several architectural elements and a sculpture hung from the ceiling have registered information. He decides to take a picture that includes all the objects. Using the navigation buttons of Palmera, he reads short messages about each object on the picture. He realizes that the sculpture is one of Alexander Calder's works through the message. He decides to learn more about it. By clicking the selection button, he changes his view mode to exploration.

He sees on the left of the screen, there are suggestions from the museum about most visited objects, among which are Calder's sculpture *circus* in exhibition hall IV on the second floor in *Alexander Calder* series exhibition, Monet's painting *Japanese lotus* in exhibition hall II on the first floor in *Impressionist in the 20<sup>th</sup> century* theme exhibition, etc. There is also "personalized suggestion" that two sculpture theme exhibitions and a documentation film about I. M. Pei are shown in the museum.

A picture about *Untitled*, the sculpture offered by the museum and an introduction are shown on the screen as well. He navigates through several functions to see its specifications, stories about Calder, its most distinguished features compared to other sculptures by Calder. Then he remembers that he saw one of Calder's works in Harvard museum and he wonders how the comparison of these two would be. He clicks on "comparison" and in his "experience bank" window there are several objects that he visited before. He chooses the one he thinks about and the interface becomes a comparison of these two objects. Thinking it might be interesting but need time to explore, he bookmarks this comparison and finishes the exploration about this object.

Thinking that he has spent too much time in the lobby, he bookmarks the other objects in the picture and heads to the second floor to see Alexander Calder theme exhibition.

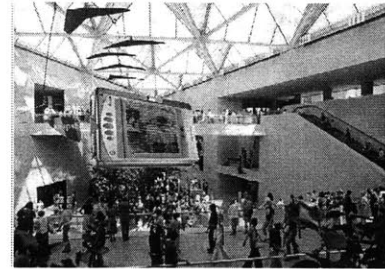


Figure 19. Take a picture of the Untitled

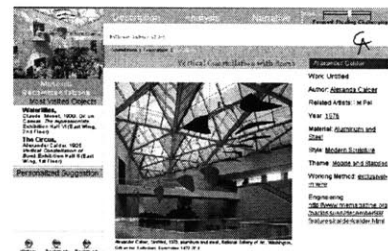


Figure 20. Exploration of information about the Untitled

## Part II: Floating Purpose

A professor goes to the National Gallery of Art on a Sunday for just a casual visit. She is open to anything that captures her attention. On the second floor, she is in the Alexander Calder theme exhibition and is looking at Calder's *circus*. With curiosity how these figures are made, she uses her Palmera to take a picture of them and uses "curiosity" menu to see some illustration and explanation about this artwork offered by the museum. A short video is played to show how Calder manipulates these puppet figures to make a simulated circus show. After looking through all the information pieces under this menu, she thinks she still has not understood Calder's intention of making these figures. She inputs "what was Calder's purpose or intention to make this circus?" as a question for the museum. After that she bookmarks this question, puts down some other thoughts as notes and sketches for herself for a later research on this object.

### 4.2.2 User scenario 2—After-visit review of visit record

#### Part I: Continuous study from the actual visit through Internet

The professor goes to her office on campus on Monday. During lunch break, she remembers she still has several questions unsolved from the museum visit on Sunday and she would like to use the Internet to find the answers.

She connects her Palmera to her computer and downloads the several pictures, which she took in the museum. She clicks on the thumbnail of the circus picture and the picture is opened in an Internet Explorer window. The same interface, as what she has in her Palmera, appears when she clicks on the landmark of circus in the picture. She opens her bookmark list and finds the question where she put a bookmark on Sunday and her notes and sketches appear in the right window when the question appears. She searches the Internet for related information and finds several pieces of information that might be helpful. She sends them to museum curators through the "send an email" function in the interface with her original question attached.

#### Part II: Show and share experience to other people

The architecture student wants to do a little presentation to his studio friends about this museum visit when he goes

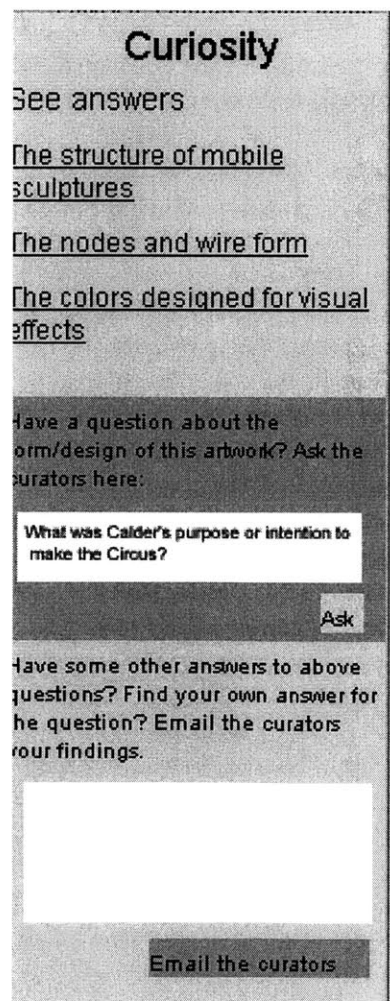


Figure 21. Formulate questions and off-site further study

back to GSD. He shows digital pictures from his visit to his friends and when they are interested, he shows some more interesting visual illustrations to them. When they ask questions, he can always refer to the information attached in the picture to find answers. When one friend asks him if he has seen the circus, he says he did. But then he could not find a picture that he took about it. Remembering that he looked at the information about the circus when he was exploring information about Untitled, he finds the picture of Untitled and look at its history list and find the information node, a video clip to show his friends.

These scenarios have been made to highlight how both an on-site exploration and an off-site research could be done through different functions of Palmera and therefore a continuous personal experience is kept and extendable for future visits.

## 5. Discussion

### 5.1 Technology Scope

#### 5.1.1 Information Navigation and database development

Research on Information Architecture has suggested that successful information architecture should enable the users to easily access the information they require and the database owners to maintain and manage the information. The cost for a user to find appropriate information in an information space often includes user's frustration and time. The information architecture technology is still under developed and so is the database development technology. This thesis tries to offer a case study for both technologies in a way that it touches both areas.

#### 5.1.2 Communication with different museum databases

Museum databases are constructed based on different programming languages and standards. This makes it difficult to use a personal device to communicate with different databases.

However, most databases developed are SQL-compliant in that nearly all relational database management systems (DBMSs) support SQL. SQL is a Standard Query Language for requesting information from a database. In 1986, ANSI approved a rudimentary version of SQL as the official standard, but most versions of SQL since then have included many extensions to the ANSI standard. In 1991, ANSI updated the standard. The new standard is known as SAG SQL.

To be able to fulfill the communication task between a personal database and different museum databases, a local application should be able to utilize this common feature of databases and be either JDBC or ODBC-compliant.

In its scope, this thesis has not been able to research into a compliant application program, but provides the base for future research.

Java Database Connectivity (JDBC), a Java API that enables Java programs to execute SQL statements.

Open DataBase Connectivity (ODBC), a standard database access method developed by Microsoft Corporation. The goal of ODBC is to make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data. ODBC manages this by inserting a middle layer, called a database driver, between an application and the DBMS. The purpose of this layer is to translate the application's data queries into commands that the DBMS understands. For this to work, both the application and the DBMS must be ODBC-compliant -- that is, the application must be capable of issuing ODBC commands and the DBMS must be capable of responding to them. Since version 2.0, the standard supports SAG SQL.

*(Definition from  
www.webopedia.com)*

## 5.2 Future Developments

### 5.2.1 “Accompanied” visit

The possibility of collecting different visitor's visiting records by museums to offer visitors views of other visitor's experience is included as a future development feature of Palmera. Different scenarios could be imagined to use this function. Curators' visit records, artists' visit records could be kept as “classical records” for the visitor to inquire. Average visitor can choose to upload his or her own “experience bank” for sharing.

The possibility of “seeing through others' eyes” or an “accompanied visit” is enabled in those scenarios using Palmera and is offered as an opportunity for future research.

### 5.2.2 Augmented Reality

It would be interesting to explore the possible feature of this tool as an augmented reality device. 3D located landmarks on one object would allow the museum to annotate information onto the object to offer more detailed analysis.

### 5.2.3 Business model

In the preparation of information part, the museum does not need to put too much effort in the museum. A lot of museum databases are constructed object-oriented in that the information in the database is registered onto objects already. The registration of information onto objects only needs infrared technology with low cost.

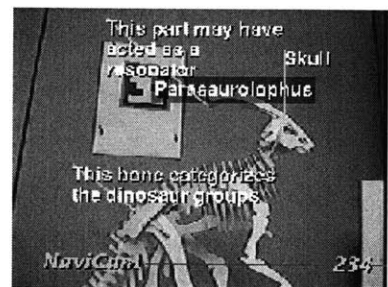


Figure 22. Augmented Reality Illustration, (By Rekimoto, J. *Matrix: A real-time object identification and registration method for augmented reality*)

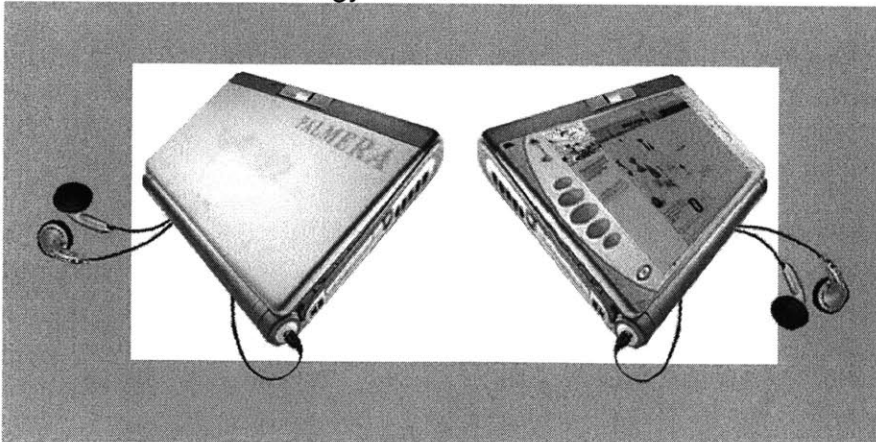


Figure 23. Possible business model for future development



The handheld device as a personal museum visit device would be a possible business model that could be developed as a product. There exist a wide range of studies on how to alternatively use Palms besides an electronic organizer. The combination of digital camera and palm with infrared imaging analysis technology would be a possible product model.

#### 5.2.4 Path recording and hybridization of navigation inside physical space and information space

This thesis does not exploit the feature of physical navigation guide in museum and in a complex and large museum architecture, it might be interesting to explore this feature to offer the visitor dynamic "You are here" map and possible path suggestion.

This would require the system able to locate the visitor inside the physical space.

As an additional layer to the visit record, the path of the visit inside the physical space might help the visitor to recap his visit experience more detailed in the physical navigation record. And the hybridization of navigation in both physical and information space would offer the visitor a more coherent experience.



Figure 24. Museum Navigation guide feature

## 6. Conclusion

There is a clear and promising opportunity to augment a museum visit with accessible personal experience and information drawn from museum databases. This thesis showed that the digital interface provided by the digital camera and mobile handheld technology could be transformed into a tool that supports the continuum of the personal learning process during museum visits. The proposed tool – Palmera -- is a device combining camera and palm organizer functions with an application that responds to visitors' interests, purposes and personal needs; supports visitors' interaction with information on different cognitive levels; and records visit processes in personal databases to support further study and future museum visits.

As a theoretical framework, this thesis has not constructed a museum database to fill the different cognitive needs of the visitors. Nor has a dynamic personal database been constructed on such a device. This thesis has suggested the needed features for a hand held personal visit guide in this theoretical framework and opened the door to further thought and related features by future researchers. For example, museum curators could do research on a dynamic museum database to support different user curiosity needs.

The focus of this thesis is on the augmentation of contextualized information for visitors from both personal experiences and museum databases. And the key feature of the Palmera tool is to keep a continuous personal experience database. This enables an individual to bring his own knowledge and history into relation with that of museum databases to support dynamic information access during museum visits and after the visits.

Though this thesis focuses on a system to augment personal learning through their engagements with contextualized information, the tool offers the potential for being a social interactive interface. When personal databases are connected to museum databases in a more active way, different visitors' experiences can contribute to the public to generate a collective experience for visitors. The thesis in its scope has not attempt to research into how visitors' interactions with the museum information database can contribute to a collective, dynamically updated information database to support more adaptive information presentation for the single visitor, but provides information on which further research could be based.

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