A Location-aware System using RFID and Mobile Devices for Art Museums

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Abstract

Emerging location-aware mobile technologies are being applied successfully in cultural environments. Different technologies, such as RFID, WiFi, and so on, are being applied to allow mobile devices interact with the environment. This paper describes a system based on both active and passive RFID which support the automatic positioning of mobile devices in art museums. This proposal results especially useful to provide location-aware information avoiding the need for users to manually select the desired information they want to see. This proposal has been successfully proved for the location and positioning of PDAs.

1. Introduction

Mobile technologies are present in our daily life and their use seems to be restricted to support phone calls or to organize our work schedule. We think that these devices can be used in different scenarios, for instance, in cultural environments. Modern museums offer visitors different devices to guide them and enjoy their visit. Often, these electronic guides provide visitors with audio information about the pieces exhibited in the museum in several languages.

The introduction of new technologies in cultural environments has enriched the way in which art objects are exposed to visitors. However, these technologies have not been as successful as audio guides in the past because these guides keep being the most popular device to guide users inside museums.

Positioning systems are common in software applications related to geographic information. An interesting challenge is related to the fact of how to locate a mobile device inside buildings, for instance art museums.

This paper defines a conceptual model for a museum to support an automatic positioning system based on a well known technology such as RFID.

2. Conceptual modeling for location-awareness in cultural spaces

One of the primary tasks related to the design of location-aware mobile software for museums is the definition of a conceptual model.

We think a museum entity is conceptually composed by, at least, two types of information, the Catalogue Information and the Environmental Information.

Catalogue Information is related to museum registry and it is stored according to defined structures and procedures that museums should follow to accomplish international standards [5]. Usually, this information is available in electronic format and is described in technical language. We focused our efforts on defining a model that represents the information surrounding a piece instead of the piece itself. We called this information as “environmental information”.

Any art object or piece exhibited in a museum is wrapped by extra information depending on the exposition environment; for example, the piece physical place. So, a central item of our model is the Space. A piece must be exposed into a Space and it also has a Space associated to it.

Pieces are usually exposed within a container. This container may be represented by a showcase (if it...
contains small objects) or a frame (in case of a painting), or anything that is able to contain a piece. A Space is also associated to one or more graphical representations, resources and identifiers.

An overview of the conceptual model is depicted in Figure 1.

An interesting thing to point out is the fact that the Identifier entity allows the system to be isolated from the specific technology used to locate an object in the real world (RFID, WIFI, etc). Besides, this object may be also identified by one or more Identifiers; so it is possible to use different positioning and location technologies at the same time to improve the system precision. For instance, you can use RFID to identify a showcase and a code bar to identify a piece within the showcase.

Another important issue to point out is the fact that, although a museum may have a media repository associated to its catalogue, this information is not always appropriate to be exposed to public in general [9]. Usually, it is expressed in technical language and should be adapted to ordinary people. So, in order to adapt this information, we created the Resource entity that represents the content that is ready to be exposed to visitors. This content may be images, audios, videos or texts. These resources should be also customized in different languages in order to fit users’ needs.

Pieces are not the only spaces that may have information related to it. Often, rooms, floors and even the building provide contextual information about the pieces they contain.

Thus, a museum is a cultural environment that may be physically organized in one or more buildings. A building is divided into floors and a floor is divided into rooms. In a room we can find terminals. A terminal represents a device that can be placed into a room. It can be a showcase or a panel.

As we mentioned before, museums usually have information about the catalogued pieces. These pieces are exhibited in containers. However, there is some intangible information that is not catalogued, for instance descriptions of temporal events or geographical characteristics. To solve this problem, this information is provided to visitors through panels. Panels contain graphical information regarding events that do not have any physical representation in the exposition.

Sometimes, large showcases are divided into regions to organize pieces in groups to improve the information understanding. Each region is represented by a section that groups related pieces in some way. As a consequence, pieces are contextualized according to defined criteria providing a context for each group.

Pieces are physically represented by the PieceRepresentation entity. It relates the physical space in which the piece is settled with the information related to the piece.

The only linking point between the catalogue and the environmental information is established by the relationship between PieceRepresentation and Piece. Thus, we decouple the piece physical representation (modeled by PieceRepresentation) from the piece technical information (modeled by Piece). And decoupling these entities we can adapt our conceptual model to any kind of pieces.

The GraphicRepresentation class is the graphical representation of a space. Depending on the visitor’s point of view, a space can be seen from different perspectives. We have defined two ways of visualizing spaces: Internally and Externally.

The Internal representation is used to show the space itself (for instance a floor, building or room map), while the external representation depicts the space from its container’s point of view. This feature allows the system to manage two abstraction levels of information providing the user with accurate information but avoiding information overload.
3. Positioning mobile devices in cultural spaces

The desired functionality of the system includes the use of context aware information to provide a richer user experience. Additionally, we integrate our solution to a software application currently running in the museum (the catalogue application).

The positioning subsystem is responsible for giving the PDA an identification to locate the device according to a relative or absolute position. The automatic database synchronization subsystem is responsible for maintaining the coherence between both the internal and external databases. As internal database we mean the database that may be already installed in the museum containing the pieces catalogue and, eventually, a media repository. An external database refers to our specific database to support the positioning subsystem, the information to be displayed to visitors, internationalization issues and so on.

Figure 2 shows both active and passive RFID tags and a PDA including a RFID reader.
detect the position of the user in the museum and retrieve the correct information according to the PDA location within the museum reducing in this way the user clicks on the PDA, as he does not need to select anything at all.

The variety of positioning systems available in the market made us to define a system separately from the hardware employed to locate users. Thus, the client program running in the PDA can receive information from the environment in many ways: infrared sensors, active or passive RFID tags, Bluetooth, WiFi devices or any other system available now or to appear in the future. This way, the client sends the location information to the server and gets back the requested information according to the PDA location.

The main advantage of this system is the possibility to interact with the environment in three levels of attention.

3.1. Interaction at different levels of attention

In this paper we are discussing the user interaction according to different levels of attention required for the user to operate the system.

We have defined 3 levels of attention and, in this section, we discuss different ways of implementing them based on novel and well-known technologies.

3.1.1. The lower level. The lower level of attention allows the user to perceive the periphery with almost no attention from him/her. So the user can perform other activities without paying attention to the periphery. However, he or she can be aware of interesting events that may occur nearby them.

For instance, suppose that a group of people is visiting a gallery while they are talking, and they may come across with an important masterpiece without noticing. In such case, the system can alert the visitors about the event taking visitor’s attention to prevent them from missing it.

The technological approach to tackle this problem is based on active RFID tags and readers. When a PDA is close to an interesting point, the user is notified about it and the information related to the point is automatically retrieved from the server to the PDA.

3.1.2. The medium level. The medium level of attention takes more attention from the user in order to get the information about the different objects because he or she has to perform an explicit action (or gesture) to retrieve the information about a piece or space.

For instance, if we are watching a showcase and we want to get some information about a specific piece, we have to place the device near the piece label (or mark) to retrieve extra information about it.

In this case, the technique requires the use of passive RFID tags that are detected by the reader at 5-8 cm from the tag (that is hidden by the label or mark).

3.1.3. The higher level. The higher level requires even more attention from the users than the previous levels. It requires the user to point with a device to an object or label in order to retrieve the information about an art piece or space. This kind of interaction is not as natural as the other alternatives, but it provides a good method when the information is not easily reachable due of distance issues.

Suppose that we would like to retrieve information about an artifact that hangs from the roof. In this case, the user points the device to the objective and retrieves the information about it.

In order to implement this alternative, IR technology is used because the directional characteristics of this kind of light are worth for this purpose.

3.2 Space granularity

Space granularity is based on the idea that spaces can be seen as a tree where each node represents a space and the edges represents the composition relationship.

The Root is the space that contains all the spaces which we are going to provide information of. On the contrary, Leaves are objects that cannot be divided into other ones -in the spatial aspect- to get information. They usually are the art objects.

The interaction techniques described above will be applied to get information about spaces according to two granularity levels: coarse grained and fine grained (see Figure 3).

3.2.1. Coarse grained spaces. In coarse grained spaces the system is able to perceive the location of the user according to a space position. So, the lower level of attention may fit this situation. Thus, the most suitable technology to be used is the active RFID. The environment provides mobile users with the information of the periphery using tags while mobile software detects these tags and recognizes art objects (for instance, a statue or a masterpiece) allowing users to download additional information about it.

3.2.2. Fine grained spaces. Fine grained mode is used to identify objects when the user position is not precise enough to retrieve information about it. In this case we may use passive RFID or infrared according to the situation. Thus, we are applying the medium or higher level of attention of the user.
An example of this situation is the selection of a piece among a set of them placed in a showcase.

Figure 3. Granularity Levels

3.3 Additional considerations regarding the proposed solution

An important aspect to note is the possibility of using passive and active RFID simultaneously. In this situation a hardware problem may appear. Most of the current commercially available PDAs have only one Compact Flash slot, if any; and RFID readers are only available in this format for PDA. Therefore, we may use a Compact Flash hub in order to get active and passive RFID reader working together.

This solution also encourages the application portability. In order to achieve it, we have proposed an architecture to support portability among mobile devices by designing it as general as possible.

For instance, interface portability is an important issue to take into account when designing portable device software because of the fast development of this technology.

As result of this evolution, mobile devices such as PDAs and Smartphones are turning desktop offices into mobile offices.

Another important issue regarding mobile devices is the communication protocol. In order to keep it as compatible as possible, the information is managed using XML through an HTTP connection.

Finally, in order to receive information, the mobile device sends the location information to the server. Then, it receives the client requests and fetches the related information from the database sending it back to the client. As a consequence, this information is displayed on the client screen.

4. Conclusions

This paper introduces a novel interaction model to retrieve information for museums and art galleries using mobile devices and RFID technology (although different technologies are also supported).

We start describing a conceptual model that supports information retrieval independently of the location technology used to identify the user location or interest.

The system allows the user to retrieve information according to three levels of attention avoiding this way the need for users to make manual selections in the PDA to get the desired information. The lower level of attention allows users to retrieve information without having to pay attention to the surroundings. Finally, the higher level of attention requires the user to point with the device to the object in which he is interested.

Two granularity levels regarding space are also introduced to apply the interaction model described.

Additional considerations have been taken into account to ease and improve some of the most complex aspects concerning this system, such as communication protocol and portability.

5. References


