An Indoor Locator Application for Academic Libraries

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Abstract

Finding a book inside a large library can be quite a challenge when one is not familiar with the library infrastructure. This paper tends to find a solution for this problem. An indoor locator application for an academic library is presented. This application, which will be deployed on a smartphone, will guide users to the books they are looking for. Two paper prototypes were made to test the usability of this scenario, one with a map view and another one that uses QR codes. The usability tests showed that both applications could be an added value to the user experience of the library visitors. The prototype with the map view however did get the preference of the test users. After the paper prototype test an initial implementation must be built and tested using a similar usability test as used with the paper prototypes.

Keywords: *Indoor Positioning Systems, Android, Smartphone, Prototypes, Usability Tests, Academic Library*

1. Introduction

An academic library is a polyvalent place. Students go there to find books about their course topics, to consult journals, to consult world maps, to work on group projects or simply to study. The Arenberg Campus Library in Heverlee is the library of exact sciences of the University of Leuven. It provides books on mathematics, physics, computer science, biology, sports and architecture. Each book, journal or map has a placing number, based on the UDC classification scheme. When a visitor is not familiar with the classification system of the library, finding a book or journal can be a little tricky. The visitor does not know where to look for his book and asks a librarian for help.

This paper tends to find a solution for the problem described above. A smartphone locator application will be presented that will guide library users to the books they are looking for. This application will rely on existing indoor location techniques. Indoor positioning becomes more and more popular, since more and more research is dedicated to indoor positioning techniques. Smartphone usages is also increasing - with 42.6% in the third quarter of 2011 according to the International Data Corporation[5] - so there are more practical scenarios in which location based systems on smartphones can be used. Part of this paper also tends to prove that the presented scenario is an added value to the user experience of library visitors.

The remainder of this paper is organised as follows. In section 2, existing locator applications for the library are discussed and some indoor positioning techniques are presented. In section 3, an indoor locating scenario is presented that will help library users to find books inside the library. The scenario is tested by developing and testing two paper prototypes. These prototypes and the results of the usability tests are described in section 4. Next, in section 5, an initial implementation of one of the prototypes is discussed. The last part of this paper, section 6 describes further work and concludes this paper.

2. Related Work

2.1. Library Positioning Systems

At the university of Miami an augmented reality application, called ShelvAR [16], is being developed to facilitate and speed finding misplaced books and replace them on the right place. ShelvAR is an application made for use on a tablet or a smartphone. It scans the back of a dozen books at a time and detects which books are in the wrong place. Each book is provided with a tag that can be interpreted by the tablet's or smartphone's camera.

The ARLibrary [1] is an Augmented Reality (AR) application that localises books within the library. Optical markers are applied to the shelves in order to locate the position of a book. A computer, AR glasses and a panel to insert information about the book are needed to use this application. The user enters the title, author or a keyword to find a book in the catalogue. When the book has been found, the user will be able to see the location of the book through the AR glasses he is wearing.

2.2. Indoor Location Techniques

Nowadays, a lot of possible techniques exist to locate people indoors. In this section a subset of these techniques will be presented.

Near Field Communication (NFC) [14] is a short range communication technique. It is based on the Radio Frequency Identification (RFID) technology. An RFID tag has an emittance range of a few centimetres. To use NFC inside a building, a few NFC tags need to be distributed inside the building and an NFC enabled device is necessary to scan the NFC tags. The user who is looking for a specific location in a building holds his device near the NFC tag to get updated information on the road that has to be followed in order to reach the desired location.

QR Maps [6] is a combination of QR codes and Google Maps. It is not based on any wireless technology, so it is cheap to develop. The user needs to scan a QR code to allow the application to determine the location of the user. Together with the current location of the user, the destination is also depicted on the map. Whenever the destination is located on another floor, the nearest stairs or elevator is shown on the map. To get updated information about the path that needs to be followed, the user can scan another QR code.

WiFi fingerprinting [7] is a technique used to find the position of a user based on known information stored in a database. The database is filled with signal strength information about the different WiFi access points on different locations inside the building. To decide where the user is located, the user's device scans the environment and measures the signal strength of the WiFi access points that are within the device's range. The measured signal strength is compared with the entries in the database. The entry which is the closest match to the measured signal strength is returned as the location of the user.

Infrared technology [19] can also be used to locate people indoors. The users wear an infrared tag, which sends their ID to the readers distributed throughout the building. This system is not a very accurate system if the infrared light beam is disrupted by something, like a scarf or another object. Furthermore, the system is expensive to build, since a lot of readers are needed to increase the chance that an infrared tag is spotted by a reader.

To enable user positioning in a Bluetooth Location Network (BLN) [8] the users carry a bluetooth enabled device and a bluetooth badge. The BLN is composed of static bluetooth nodes, including one (or more) master node(s). The users enter the address of their badge in the Web/WAP servers, so the BLN can track it. The static nodes in the BLN send requests to the bluetooth badges of the users. When a node receives a response, it will store the address in its cache and send the information to the master node. The master node will then estimate the location of the badge by combining the information received from different static nodes. The location of the user cannot be determined very accurately, because the master node can only determine that the user is located somewhere in the area covered by the static nodes that received a response from the bluetooth badge. The response time of this system is also quite high. However, this system can be useful in situations where a user is expected to stay some time in the same room and where it is enough to determine the room a user is in.

Active RFID tags [10] are RFID tags with a battery. This battery makes it possible for the tags to send their signal over a distance of about 45 meters. Extra fixed location reference tags can be used for location calibration. With these reference tags, the location of the users can be determined more accurately. Passive RFID tags [17] are tags without a battery, so their emittance range is lower then the emittance range for active RFID tags.

In table 2.2 a summary of the discussed positioning techniques can be found.

3. Scenario

This section describes the scenario that is used to help library visitors find their way inside the library. The target users of this application are all people owning a smartphone who are not familiar with the library infrastructure and need help finding a book.

The application consists of two steps. The first step is adding interesting books to the list of books one wants to look up. To add a book, the user only needs to enter the title of the book and hit the search button; the author and call number of the book are optional fields. A request is sent to the library catalogue, which results in a response with detailed information about the searched book. When more than one result is available, the user can choose the result of his preference that will be added into the application. The next step is choosing a book to look up. The user simply selects the book he would like to look up from the list. Detailed information about the book will be displayed, like the location of the book

Technique	Range	Technology	Equipment
NFC	Short	RFID	NFC tags, NFC enabled device (reader)
QR Maps	N.A.	QR codes and Google Maps	Smartphone with camera to read QR codes
WiFi Fingerprinting	Long	WiFi	WiFi Access Points
Infrared	Mid	Infrared Light	Infrared tags and infrared readers
BLN	Mid	Bluetooth	Static bluetooth nodes, bluetooth badges
Active RFID	Mid	RFID	RFID tags with batteries, RFID reader
Passive RFID	Short	RFID	RFID tags, RFID readers

Table 1. Indoor Positioning Techniques

and whether the book is currently available or not. If the book is unavailable, the application will give the user the possibility to request the book. If the book is available, the user can choose to look up the book and the application will show him the way towards the book. When the user almost reaches the location of the book - so when he reaches the right shelf - the application will change to a camera view. In the camera view an overlay will show the user the approximate location of the book.

4. Prototype

To test the added value of the presented scenario, a prototype was created and tested. Although Sefelin, Tsheligi and Giller state in [18] that there is not much difference between the results from a paper prototype and a digital prototype, a paper prototype was chosen because that would be faster and easier to develop.

As de Sá and Carriço state in [11] and [12], some extra precautions need to be made to make the test results of a paper prototype for a smartphone application more valid. They say that it is not enough to just draw images and text on an A4 paper. To test a prototype of a smartphone application, the prototype need to have the look and feel of a real smartphone. Therefore, a paper prototype was made with the guidelines stated in the papers of de Sá and Carriço.

The smarthone is made out of strong cardboard paper. At the top, the cardboard smarthone is provided with a slot where cards can be easily and quickly inserted and removed. The cards are plasticized, to make the insertion and removal easier. Enough attention has also been spent on making the cards look like real smarthpone screens. The components and fonts looked like the components and fonts on a real smartphone, as can be seen in picture 1.

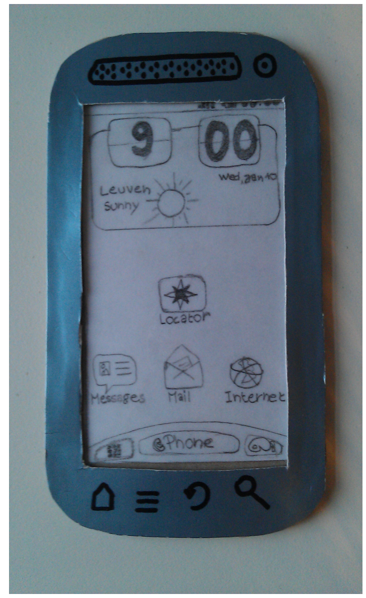

Figure 1. The prototype of the smartphone is made out of strong cardboard paper.

A separate card was made for each screen needed during the testing of the scenario. Two paper prototypes were made. The first prototype is a paper prototype for a smartphone application where a map is used to guide the user to the book. The other prototype is a paper prototype for a smartphone application where QR codes will help the user to find the book.

4.1. Testing the prototype

To make the experience for the test user as close as possible to the experience of a real application, the prototypes were tested inside the Arenberg Campus Library in Heverlee. Picture 2 is an overview picture of the created prototypes used during the tests. It shows all the screens that were needed during the tests. On the top left, the screens for the first part - searching for and adding a book to the list - are shown. These screens are the same for both prototypes. On the bottom left, the screen images of the paper prototype with the mapview are shown. The screens for the prototype with the QR codes can be found in the middle of the picture. The users were asked to perform three tasks using the paper prototype. At first, the user should open the application, see which books are already listed inside the application and add another book to the list. Next, the user was asked to find a book using the prototype with the map view. At last, the user had to find another book using the prototype with the QR codes.

Figure 2. An overview picture of the paper prototypes used during the usability tests.

During the test, the users were motivated to think aloud while completing the three different tasks. The benefit of think aloud is that one can get an idea of what is going on inside the test user's mind. It makes it possible to understand the reactions, confusions and problems a test user experiences during the test [13]. While the users were performing the requested tasks, their actions were also written down.

When the test users were ready, they were asked to fulfil a usability test [4] and answer some questions about the tasks they had to perform.

4.2. Prototype Results

A paper prototype test was done inside the Arenberg Campuslibrary in Heverlee. The partipants had to fulfil three tasks, as explained in the previous section.

In total, eight participants tested the paper prototype. Six of them were male, two of them were female. All participants were between the age of 21 and 23. Half of the participants visit the library a few times a year, the other half had never been in the library before. Since the application targets people who are not familiar with the library infrastructure, the participants were all ideal test subjects. It is also important to notice that only half of the test users owned a smartphone.

For the first task the test users were expected to open the application and see that there are already two books listed. Next, they were expected to add another book to the reading list.

No major problems occurred during the completion of this task, so this functionality does not need to be changed.

For the next task, the test users were asked to look up a book in the library using the application. During this task, the prototype with the map view was used.

The main problem with this task was that there was no indication on the map of where the user was walking. This was not a big issue in the beginning, when the route was easy to follow, but it became an issue when the right shelf had to be found. It was not possible to find the right shelf without counting them. This issue can be solved by dynamically indicating the location of the user on the map. This is relatively hard to do on a paper prototype, so it will be tested during the evaluation of the implemented application.

The last task was to look up another book in the library. For this task, the prototype with the QR codes was used. A few QR codes were hanged up on predetermined places. The users received directions on screen on where they should go and when they completed the instructions, another QR code needed to be scanned to get new directions. By repeating this process, the users will find the way to the book they are looking for.

There were quite a lot of issues with this prototype. At first the tests made clear that instructions can be interpreted in different ways, since not all users did the same thing after receiving an instruction. For example the instruction on the shelf was "The book is located on the 4th layer of this shelf". Some users started counting from the bottom of the shelf, while others started counting from the top of the shelf. It is clear that the instructions need to be unambiguous in order to provide a useful application, which was not the case during the paper prototype test.

Finding the QR codes also seemed to be a problem. There were only a few QR codes distributed in the library, so maybe this was because the locations of the QR codes were ill chosen. It might help to hang up more QR codes and let the users choose when they scan a new code, for example when they are lost or when they are unsure they are on the right path. More QR codes will raise the findability, but it might as well overwhelm the library visitors. More elaborated tests are needed to make a conclusion about the right solution to this problem.

A last problem was that in order to scan a QR code, the user had to push a button on screen to activate the camera mode. The button was located in the top right corner of the screen and most users did not recognise it as a button. They thought it was an icon to make clear that they were using the QR code prototype. The users expected that the application would switch automatically to camera view whenever they held their smartphone upright. Since it was clear that this was a desired functionality, this was already added after the fourth test.

After the test was completed, the users were asked to fill in a questionnaire about the prototypes they tested. They were asked to grade the map view prototype, the QR code prototype and the current system on a scale of 1 to 5. With an average score of 4.875, the prototype with the map view was the distinct winner. The current situation got an average score of 3.25 and the prototype with the QR codes received an average score of 3.125. Note that users who did not visit the library before, were not able to grade the current situation. The fact that the functionality of the QR code scanner was changed halfway the user tests, did not change the average score of the prototype with the QR codes. Similar grades could be found on questionnaires of test users before the change as on questionnaires of test users after the change. However, it is clear that there are some important issues with the prototype with the QR codes, since the current system got a higher score.

A System Usability Scale (SUS) of the two prototypes was also part of the questionnaire. SUS is a quick and dirty method to assess the usability of an application [4]. A SUS score can be used to compare the usability of both presented prototypes [3]. The average SUS score for the prototype with the map view was 91.25. The average SUS score for the prototype with the QR codes was 72.5. Although, the prototype with the map view got a larger SUS score, it does not necessarily mean that it will be a winner application once implemented. Even if the usability test of the implemented application equals the SUS score of the paper prototype, it does not mean that the application will in fact be accepted in the field [3].

4.3. Conclusion

Tests have proven that both the application with the map view and the application with the QR codes might be a viable solution for the problem stated at the beginning of this paper, because they received a high score on the System Usability Scale, but all test users preferred the prototype with the map view. Since no major design changes need to be made, a second prototype did not seem necessary and the implementation can get started.

5. Implementation

Before the implementation can get started, a choice have to be made whether to implement the first prototype - the one with the map view - or the second prototype - the one with the QR codes- or both. The test users all preferred the first prototype. On top of that, research has shown that consumers still are not very familiar with QR codes. A survey at the university of Bath in 2008, showed that only about 13% of the 1790 students that completed the survey knew what QR codes are [15]. The consumer survey from Chadwick Martin Bailey at the end of 2011 [2] confirmed that QR codes haven't raised much in familiarity, since still only 21% out of 1228 respondents have ever heard of QR codes. Even though the popularity of QR codes is raising, consumers still do not seem to feel very familiar with the concept. Therefore, the decision was made to leave the prototype with the QR codes behind and to focus on the implementation of the prototype with the map view.

Currently an initial implementation of the selected prototype is being built using the Android SDK platform. The implementation consists of two main parts. The first part is fetching information from the library catalogue to determine the location of the book. The second and most important part is the locator part, more precisely locating the user inside the building and guiding him to the book.

5.1. Part 1: Parsing the Catalogue

The first part of the application is fetching the needed information from the library catalogue. For this purpose, an API was implemented by an employee of Libis, a company that is responsible for information solutions for over 30 institutions, including the Arenberg Campus Library for whom the presented application is made for. The user enters the title and optionally the author and call number of the book he is looking for and the application will send a GET request to the catalogue, using the provided API. The response from the API can easily be parsed to get the different information fields about the books that were found in the catalogue. The result is parsed and shown to the user. When more than one result is available, the application shows all the results to the user and allows the user to choose one of them. The selected book is then added to the list of the application.

5.2. Part 2: Indoor Positioning

As already discussed in section 2, a lot of indoor positioning techniques already exist. A lot of companies even start to offer software for indoor location based applications. Google Indoors, BuildingLayar, Qubulus and Ericsson Labs are only a few companies that offer such software.

For the purpose of the locator application that is being implemented, the Indoor Maps and Positioning API that is offered by Ericsson Labs [9] seems to be the most interesting one. Their API offers three tools. The first tool is the Map Editor. With the Map Editor, a map can easily be created with the tools at hand. The second tool is the Maps API, which is used to integrate the created map into any Android application. The last tool is the Positioning API to enable indoor positioning.

6. Conclusion and Further Work

In this paper, an application is presented that will help library visitors to find the books they are looking for. Two paper prototypes were built to test the usability of the application. The first paper prototype was a prototype that used a map view to guide the users to the book. The second paper prototype was a prototype that used QR codes and simple instructions to guide the users to the book. Both prototypes were evaluated inside the Arenberg Campus Library. The usability tests concluded that both the application with the map view and the application with the QR codes can be an added value to the user experience of library visitors. The test users however indicated to prefer the application with the map view. Because of this, and because most people are not yet familiar with QR codes, only the application with the map view will be implemented.

Once the implementation of the application is finished, a usability test similar to the one for the paper prototype will take place in the Arenberg Campus Library to test whether the application can really be an added value to the library experience. Depending on these tests, changes will be made to the application or the scenario will be elaborated to provide more functionality.

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