



Mobile augmented reality applications for library services

Mobile AR
applications

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Abstract

Purpose – The purpose of this paper is to introduce mobile augmented reality applications for library uses and next generation library services.

Design/methodology/approach – Examples are drawn from museum and archives informatics, computer science applied research, and computer vision research as well as original research and development work from the Undergraduate Library at the University of Illinois.

Findings – Mobile augmented reality uses include augmenting physical book stacks browsing, library navigation, optical character recognition, facial recognition, and building identification mobile software for compelling library experiences.

Originality/value – The paper suggests uses of mobile augmented reality applications in library settings and models a demonstration prototype interface.

Keywords Mobile computing, Library software, Augmented reality, Computer vision, Smartphones, Mobile applications, Library systems, Mobile communication systems

Paper type Conceptual paper

Mobile augmented reality (AR) applications represent a profound opportunity for increased access to print and digital library collections. AR applications can deliver an engaging and interactive information experience. Applications that overlay graphical data are well suited for in-library engagement as well as off site real world interaction with library content.

These applications bring about a greater melding between the physical and digital environment. This interconnection is a desired feature in our era as many library resources exist digitally and many libraries maintain large legacy print collections and continue to offer access to both. In previous papers on location-based services using mobile applications (Hahn, 2011, p. 672) it has been asserted that location-based information causes a library collection to modulate dynamically, in real-time based on users needs and interests, incorporating the library's digital content and the web. What this article now adds to the literature of digital library location based services is the interactive combination of real and virtual with graphical overlays.

Azuma (1997, p. 2) writes that augmented reality systems “have the following three characteristics: 1) Combines real and virtual, 2) Interactive in real time, 3) Registered in 3-D”.

In order to be considered a truly augmented reality application, an app must interactively attach graphics or data to objects in real time, to achieve the real and virtual combination of graphics into the physical environment:

An AR system supplements the real world with virtual (computer-generated) objects that appear to coexist in the same space as the real world. AR can potentially apply to all sense, including hearing, touch, and smell (Azuma *et al.*, 2001, p. 34).



At this time, mid-2012, most augmented reality apps in libraries are currently in the research and development phase. The current state of mobile in libraries is such that many libraries now create and adapt their catalogs for mobile access. Mobile augmented reality applications offer much for the integration of library resources into users information environment. Libraries, through further research and development efforts, can continue to expand and extend the library presence in this environment through augmented reality applications.

Library digital resources and legacy physical environment combine to provide an exciting test environment for mobile augmented reality applications. This paper reviews the state of apps in higher education and museum settings and details library use cases for augmented reality applications.

Literature review

Mobile augmented reality applications exist in the sphere of mobile computing software. These are new to education, but growing in importance. The New Media Consortium's Horizon Report 2012 lists mobile apps on the "near term horizon" (impacting higher education settings in one year or less) indicative of a new service area for libraries to develop (Johnson *et al.*, 2012, p. 6). Furthermore, undergraduate students are highly connected to mobile interaction and have come to expect information in engaging and interactive modules.

Demographics on mobile application use from the Pew Internet and American Life Project, "Smartphone adoption and usage" (Smith, 2011) show that 44 percent of smartphone users are African-American and Latinos. The same study reports:

For several years, Pew Internet research has found that African-Americans and Latinos are more likely than whites to use their cell phones for non-voice applications such as using the internet, playing games, or accessing multimedia content. These differences extend to smartphone ownership as well, as 44 percent of black and Latino adults are smartphone owners, compared with 30 percent of whites (Smith, 2011, p. 9).

This signifies an important opportunity for librarians as they consider outreach and service options to meet the needs of diverse populations. Specifically, The Educause Center for Applied Research bulletin, "Learning through situated simulations: exploring mobile augmented reality", details the educational uses and pedagogy associated with historical and architectural lessons. These include situating a student in ancient Rome using graphical overlays (Liestol, 2011, pp. 7-8), and detail efforts to implement user generated content into graphical overlays of historical material (Liestol, 2011, pp. 8-10). The author notes that contextual learning such as this is not simply limited to domain material in history, "it extends to any discipline or subject matter that may benefit from making present what is absent, be it past, current, or future topics. The combination of the real and the virtual (what is simulated) also provides added experience and value" (Liestol, 2011, p. 11).

Within the sphere of situated augmented reality in museum informatics there are a number of approaches underway. A case study of the ARTours project by the Stedelijk Museum, Amsterdam reports the challenges and success of mobile augmented reality applications in cultural settings. The authors of this project note that AR applications "[...] allows cultural institutions to thrust their digitized artworks out of the database into the streets" (Schavemaker *et al.*, 2011, p. 2). The authors created app functionality that takes their digitized content and puts it into the geographic context it is associated,

which can be the place it is produced or the environment the digital copy is depicting (Schavemaker *et al.*, 2011, p. 2).

The City of Philadelphia's department of records runs an online digitization archive at <http://phillyhistory.org> and have partnered with Azavea to build an augmented reality app which overlays the historical photos onto the user's physical environment (Marcus, 2011a). Azavea has researched the geographic computing workflows that would allow the software to overlay historical images into the user's onsite experience in real-time and intend on providing prototypes for user's interested in engaging with the digitized collections in the physical real-world environment.

A recent research project by an AR computer science research group at Miami University, Ohio (www.users.muohio.edu/brinkmwj/ar/) showed the viability of AR software to help with shelf-based library work. An example of the prototype functionality is available here: <http://youtu.be/NgZVI630SsI>. While this project makes use of graphical overlays to organize shelves for library inventory control, we envision the use of graphical overlays for assisting users in ongoing dynamic and responsive research assistance while in the library book stacks. A number of original augmented reality use cases are detailed below.

Use cases

The following use cases and user models are advanced for possibilities of providing new and highly interactive library experiences. A few of these services such as the optical character recognition paired with suggestion database detailed below are in the research and development stages at the University of Illinois Urbana-Champaign, and prototypes will be online for these services within a year or less. The existing code base for these examples is available at our Minrva project Github space: <https://github.com/minrva>

Physical book stacks browsing

A use case for augmented reality applications includes the integration of digital library content into the physical stacks browsing experience. Consider a first time user to a library. Orienting in the book stacks is both a challenge and also an incomplete introduction to the totality of available services of the library. The new student may consider the physical book stacks to be the only available library resource. The new student is not aware of the digital items of the collections. With an augmented reality service in the library book stacks, the mobile app user can use the software to first identify the stacks that she is in (i.e. identify a subject area of "dictionaries"), and then the software will overlay a range of digital content to this physical presence, once the meaning and subject area of the shelf are identified by the software (Figures 1 and 2).

The student can also learn about historical circulations for any book that the augmented reality program is able to identify. The student could also then tap on her phone for more recommendations based on the identified book.

It is theorized that a mobile application such as this could meet time needs of students. The temporal constraints of new undergraduate students are not traditionally considered in the library's online services; particularly with regard to book level needs, i.e. the online public access catalog does not calculate what is available right now given the time of day.

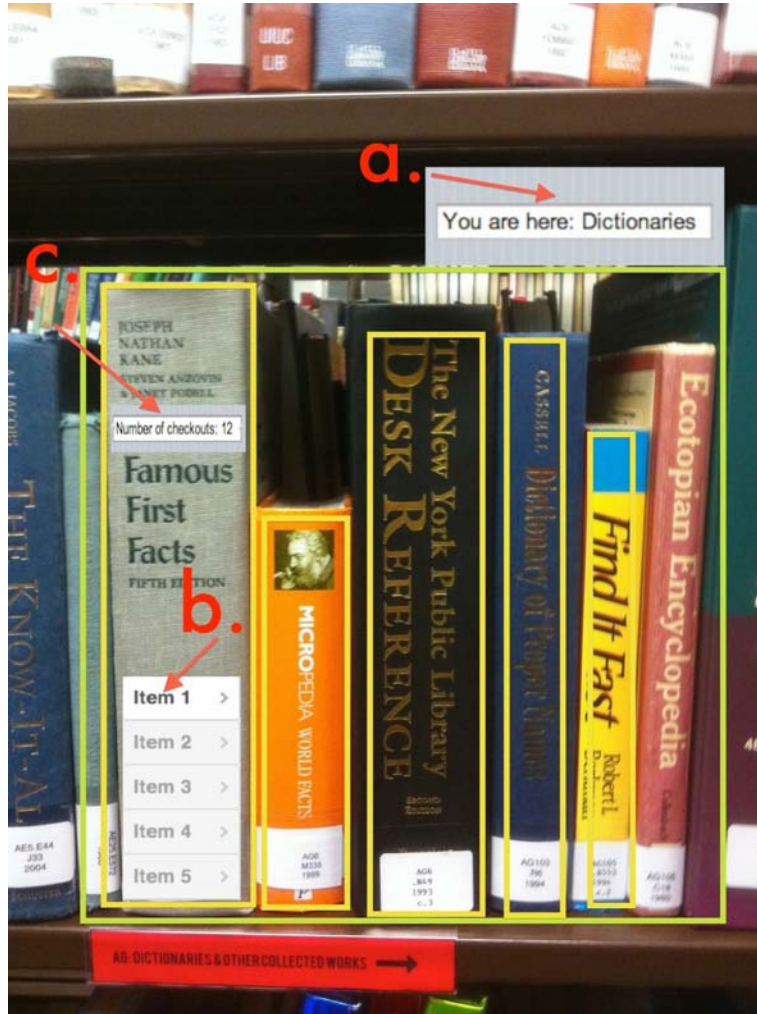


Figure 1.
(a) Subject of book stack set is identified by app index, and displayed on interface. (b) Recommendations (e-book, digital items, or databases) brought onto interface in real-time. (c) Popular books are indicated on title using circulation data from integrated library system historical circulation count (this can be a Z39.50 call or a pre-loaded circulation report database)

A mobile augmented book stacks application is quickly accessed from a user's smartphone and does not require users to enter a search query; it allows them to use their stacks location and smartphone as a query point for additional library information. No comparable digital collocation service yet exists in libraries, and no service can overlay access to the range of electronic resources to a person's location in the print collection. This service is possible in less than a year.

Library navigation

Previous research into mobile augmented reality interfaces has investigated the effectiveness of drawing attention to the environment using graphical overlays (Biocca *et al.*, 2007). This applied mobile augmented reality research is particularly relevant to



Figure 2.
Prototype interface as
student would view
through her smartphone
loaded with an augmented
reality application
(without explanatory
annotations)

the problem of library wayfinding. These wayfinding problems include understanding call numbers or other library specific numbering such as such as the shelf ranges or even the column number on the ranges that are typically utilized for inventory control. A basic study by Hahn and Zitron (2011) detailed these issues in the Undergraduate Library space at the University of Illinois. The study specifically focused on the first-year undergraduate students – students new to the research library system, and advanced possible mobile interfaces that could help alleviate wayfinding issues in book stacks.

The work of Biocca *et al.* (2007, p. 180) essentially advocates creating a kind of “attention funnel” for mobile and 3D interface. The advantages for such attention funnels are advocated specifically with regard to physical object selection: “Situations in which a user may be looking for a physical object in space; for example a tool on a

workbench, a box in a warehouse, a door in space, the next part to assemble during object assembly, and so on. The system can direct the user to the correct object,” other potential features for attention funnels in libraries include “navigation in near space (e.g. through aisles, etc.)”.

Researchers have studied mobile applications for collections based wayfinding, (Hahn and Morales, 2011, p. 419) and have found that mobile applications can draw the users attention to the environment in ways that aid a user in her path to a known item. Furthermore, researchers plan to study augmenting a wayfinding app with directional “tunnel” overlays that can draw student’s attention to the most important features of the stacks while they are navigating to a desired item in the library.

The functionality of such interfaces are essentially concerned with drawing targets to on object in the user’s view that require their attention. As the library wayfinding experience is a potentially overwhelming experience, such tunnels can help students to focus on the critical path to finding or even understanding a call number. The mobile augmented reality navigation tool for libraries will necessarily require the integration of scaffolded learning such that students can learn to become independent researchers over time.

There may be augmented reality applications to implementing tunneling techniques for comprehension in the desktop paradigm. As an example, consider augmented reality support for understanding vended databases. If students become confused with the digital library interfaces, interfaces that are accessed at a desktop in the library, they can hold up their cell phone to the confusing interface and the library help resource could then use its built in and already modeled help points to help the user navigate through what could be an already confusing search interface. Biocca *et al.* (2007, p. 180) details such attention funnels as helping with “Virtual Object Selection: An AR system may insert labels or 3D objects inside the environment. These may be within or outside the current view of the user. Attention funnels can cue them to look at the spatially registered label, tool or, cue.”. The learning implication for augmented reality support for interfaces is in need of additional research and development informed by actual user data on preferences for support.

Optical character recognition (OCR)

A research and development project underway at the University of Illinois Urbana-Champaign is developing a mobile application that allows students to scan the textual document and learn about relevant library resources to this document from their mobile phone. Student users of the app will have options to scan a course-assignment page or syllabus; scan a citation or bibliography; scan the contents of a book page; scan a shelf of books in the library. After scanning, the app will then provide users with suggested resources.

The mobile app will use modified OCR software and check a suggestion database to identify library resources that will support the assignment or topical interest; checking against a database of course reserves for the class and other relevant sources of data (course specific help guides); and suggesting library resources and research databases that are relevant; this information package can be viewed on the phone, or students will have the option of sending the information to themselves via email or other social networking platforms; as students value collaboration and social aspects of research.

There are a number of compelling uses for optical character recognition software in mobile augmented reality apps. Such applications could help users learn to read and understand what is read, learn another language and, also, help those users with vision impairment. The research and development lab staff at the Undergraduate Library are actively seeking grant funding to complete these applications that could significantly improve the lives of those with vision impairment, or those with functional illiteracy. These have always been the classic goals of libraries, and with the application of augmented reality tools, we are now able to achieve the aims of our traditional library mission.

Facial recognition

Open source software is available which can identify faces. There may be applications for this in library settings. Currently, library staff use a full workstation computer to connect to a scanner that scans the patron's barcode. The library's barcode scanners for scanning a patron ID may not be necessary, if a clerk can use a library smart phone in order to scan a patron's picture ID. The picture that is scanned will then do feature detection and patron recognition in order to charge out the patron's items.

These type of applications could result in cost savings for the library, as many of the transactions that are happening at the circulation desk do not require the full resources of a desktop computer. In fact these transactions could be handled with a small tablet computer loaded with library facial recognition software that will replace the traditional desktop paradigm.

Identify building services and collections

An augmented reality application that can identify buildings by simply holding the phone's camera up to the building could be particularly useful for a large university campus or institutions with multiple library sites. The user of this augmented reality app can use this to identify the name of the library building and the hours of the library building. It can tell users when it will be closing and overlay information such as current computer availability, technology availability or even seating availability in the library. The theoretical mobile augmented reality service here is using a software tool that performs feature point recognition algorithm in the app that identifies the library building and then connects with a database of services offered.

Computing requirements

This section covers the foundational computing techniques for bringing mobile augmented reality services online. One important consideration for mobile augmented reality applications is in the domain of computer vision. Computer vision is traditionally understood to be the computing required for camera and video input computation, however, a more basic way to discuss computer vision is the programming requirements for processing image or live video feed data coming from the smartphone's camera feed. Traditionally researchers in computer science with graphics, robotics, machine learning, or artificial intelligence specialties have been concerned with the area of computer vision.

Willow Garage (www.willowgarage.com) is the company has developed an open source software package, OpenCV, that enables a number of the theoretical use cases shown above. The source files and programming library for OpenCV are available at:

<http://opencv.willowgarage.com/wiki/>. A book length treatment on learning OpenCV is available by Bradski and Kaehler (2008). The proposed use cases require a computer vision solution for object recognition, pattern identification, and then using computer graphics such as OpenGL (www.opengl.org/about/) for overlying graphical help onto the camera view. Additionally, the augmented reality solutions described above require infrastructure. Included in this necessary infrastructure are the databases that provide recommendations or sum historical checkouts must be modeled and populated and made accessible to web technologies.

This computing infrastructure includes a database model that leverages the expertise of reference and instructional librarians. In some cases this modeled backend is theoretically a repackaging of already existing knowledge and help resources and, with mobile augmented reality applications, it can become more fully integrated into the student's information environment.

It is advised to make use of RESTful methods to building the apps. As an example of a RESTful method, consider the modern architecture of the web: a client such as your mobile web browser requests a page over HTTP from a server. The server sends the page by HTTP back to the browser. Augmented reality apps, for extensibility to other mobile platforms and mobile web services should be built using this common web-based architecture.

Research on web-based services to delivering AR data has been completed by researchers at Nokia (Belimpasakis *et al.*, 2010), showing the viability of a web-based approach for designing mobile AR software. Further, researchers in geographic information systems working to implement augmented reality solutions for cultural intuitions have advocated such an approach in their experimentation with the data modeling of mobile augmented reality applications (Marcus, 2011b).

Future work

In order to meet the challenge of the digital era in which access to both print and digital is of ongoing importance, there are two broad options for mobile augmented reality applications. The first option is for libraries to experiment with developing mobile augmented applications in-house, applying their information access expertise to this emerging domain. Library professionals may choose to internally develop services like the OCR recommendation services that researchers at the University of Illinois Undergraduate Library are pioneering. This involves setting up development environments for research assistants, as well as recruiting and hiring research staff who have the computing expertise to implement the experimental mobile systems.

A second approach is to use already existing projects outside libraries, but still provide programming application interfaces or APIs. As an example of a third party API, consider experimenting with a tool such as the Layar app: www.layar.com. Investigation into the data transformations within Layar is discussed by (Osheim, 2011). Developing library frameworks on existing computer vision libraries compiled in mobile platforms, like the OpenCV for Android project (<http://code.opencv.org/projects/opencv/wiki/OpenCV4Android>) is a time efficient strategy for developing functional prototypes. Already developed mobile augmented reality projects can be adapted to library uses.

There are hybrid approaches to mobile application development, where third party APIs can be incorporated into locally developed mobile computing applications.

Actively studying student, patron and staff preferences will help to get the library to a place where they can prototype augmented reality tools that are useful and used. There are a number of use cases and user needs that augmented reality applications help to address and iteratively assessing the mobile application prototypes with your user base is a way to ensure that computing resources and development time of the library will be effectively allocated. Augmented reality projects vetted by patron use preferences will help to ensure vibrant and compelling library services for the twenty-first century.

The twenty-first century library is a laboratory of experimentation and prototyping. Mobile augmented reality services described herein are starting points for developing next generation library computing services that are truly effective for meeting the information needs of users in a digital era.

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