Rapid Prototyping Mobile Augmented Reality Applications: a collections-based experiment for print, digital, and temporally modulated contexts.

Submitted by Jim Hahn, grant PI
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Project Partners

Mike Twidale, Co-PI, Professor, Graduate School of Library and Information Science. Over the two years of the grant Prof. Twidale consulted on shaping the formative user studies and providing input into prototype app functionality.

Most of the technical development came from students in the Department of Computer Science at the University of Illinois who provided original code and integration of the optical character recognition code into the app, under the direction of the grant PI.

Professionals in the Library IT department (Infrastructure Maintenance and Support) at the University of Illinois Urbana Champaign maintained the server with regular security patches and updates to keep the Tomcat based API powering the developed app stable and reliable throughout the grant period.

Overview

The augmented reality functionality explored in this grant utilized optical character recognition (OCR) software embedded into a native Android app. The app functionality allows users to take a picture of a library call number on a book in the Undergraduate Library book stacks, which then provides recommendations based on the subject area of the call number. The app can show users books that are normally shelved in the starting location but that are currently checked out. Outcomes of the grant include the availability of the Topic Space module within Minrva app on the Android Play store (https://play.google.com/store/apps/details?id=edu.illinois.ugl.minrva) and an experimental Backbone.js based Topic Space web app (minrva-dev.library.illinois.edu).

Changes

The grant had one schedule change: on June 28th 2013 we a one year, no-cost extension. The extension was approved August 2nd 2013. IMLS funds remained the same while the cost share increased to $4,172. The new end date of the grant was 9/30/2014.

Activities Completed During the Project

The key activities completed include development and release of an Android app, a corresponding web API, and a web app of recommendations based on item location. Grant staff

completed a formative user study utilizing observation and interviews of students using the app in the library book stacks.

- *Native Android App Launched: Augmented Reality app Topic Space now live as a module inside of Minrva app*

During the grant we were able to launch the Topic Space module included inside of the Minrva Android application. The Minrva app itself has over 500 installs from the Android Play Store. By selecting Undergraduate Library at University of Illinois location within the app, students will gain access to the Topic Space functionality. When a student is in the bookstacks she can take a picture of a call number and the app provides suggestions based on the item. The suggestions pull from LC subject classes and sum circulation of books within the Undergraduate Library collection.

- *Topic Space API*

In order to generate the recommendations data required by the native Android application we created new server side middleware that would combine several data sources into the app. The app required data from the Vufind searches to gather candidate recommendations, data from the Voyager Oracle Reports server in order to rank candidate recommendations based on popularity (sum circulations), a small SQLite table of stack arrangement in the Undergraduate Library supported suggesting items that were not near the student, but within the library. The middleware was packaged in a Jersey servlet running as a Tomcat web app.

- *User Study of Native Android Topic Space app (methodology attached)*

Utilizing formative evaluation methods, grant staff observed and interviewed students in the Undergraduate Library as they scanned items in the stacks and followed the Topic Space provided recommendations within the library. We collected formative evaluation of what students liked about the app, what they found confusing, and if they felt the app would be worthwhile to develop. These formative data are providing design input into future versions of the application, particularly in how the app uses optical character recognition, which was one of the primary “pain points” in the app toward usability.

- *Web based Topic Space Developed*

Utilizing the Topic Space API developed for the native Android app, student programmers were able to expose the suggestions within a web app for browser-based access. Development of the web app is available for the Undergraduate Library location at http://minrva-dev.library.illinois.edu/#loc/uiu_undergrad Students can receive ‘more like this’ recommendations from the web app after finding an initial item that they are interested in. After searching for any print item in undergrad, and navigating to the location information of that item, the student can then click the Topic Space button in order to receive the same suggestions that are available from within the Android app.

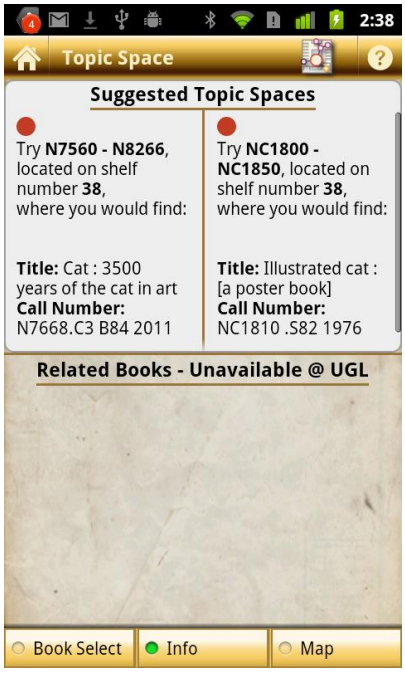
Project Results

Project goals and outputs of the grant are:

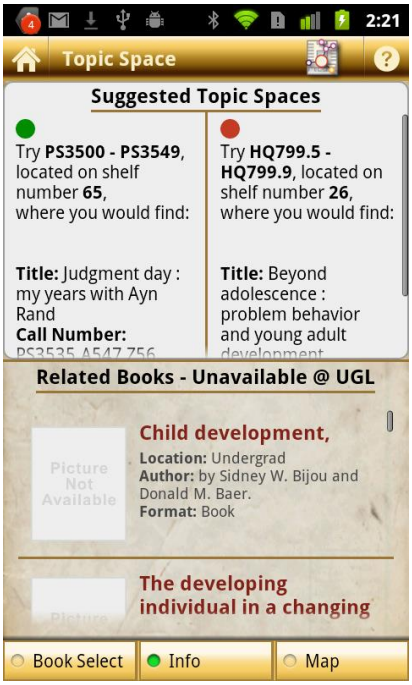
Goal 1: Computer Science students working with PI will create shelf recognition software for mobile devices that integrate print and digital resources into the on-site library experience and experiment with location based recommendation services. Researchers will study browsing and serendipity aspects in system features.

Output: The Topic Space software can recognize call numbers of an item when a student successfully takes a picture of the book (OCR is performed on that call number) and from this input the app is able to infer the shelf location of the user.

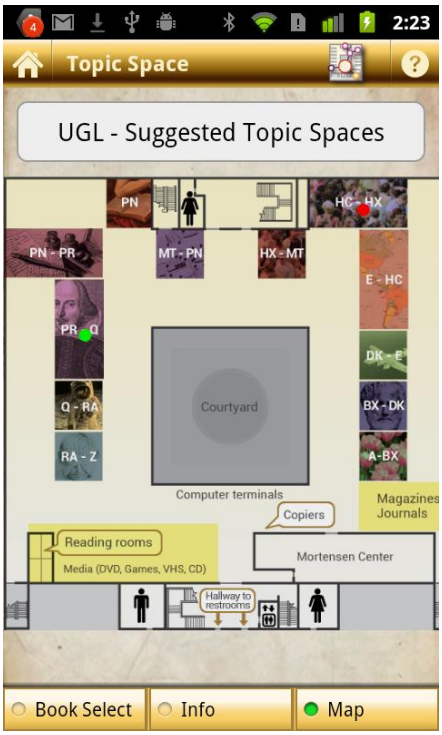
With this shelf location, the app recommends items of interest based on subject heading and circulations.



Students can also see books that are normally shelved here but that are currently checked out, (*displayed in the app as: "Related Books- Unavailable @ UGL"*) achieving one of the aims of Augmented Reality, which is to integrate digital information along with objects in the physical world. The value of this service is increased access to collections that may normally go overlooked.



These suggestions are also plotted on a map so that the user can be guided to the items in the building.



Goal 2: Hourly programmers and PI will create directional wayfinding support using AR graphics and incorporate into mobile software. Researchers will investigate the potential of creating a system that shows users how they are physically navigating an "idea space."

Output: Wayfinding support is available from the Topic Space module. The app plots two points on a map where the user can find related books to the initial topic. The app recommends general ranges of interest and targets a specific item within that range as well.
AR capability was utilized for bringing ILS data into the on-site browsing experience; however, the AR directional portions were not developed.

Overlaying graphics within the camera view for directional support was not developed because programming resources were devoted to improving Optical Character Recognition capture -- a component of the app that was weak at the start of our project but that has matured as we improved OCR training and alternative open source libraries for optical character recognition.

Goal 3: Co-PI will complete iterative rapid use studies of mobile software with library patrons and communicate results back to programming staff for incremental app design. This evaluation will communicate to the broader library field what works for mobile AR apps and what areas are

not working. At the completion of the use studies we will be able to specify what set of features are promising for adoption and what features are undesirable for this type of system.

Output: User studies of the Topic Space module were completed in the Spring 2014 and Fall 2014 Semester. Researchers approached students who were browsing the stacks to recruit for the app study. Grant staff gathered ideas for areas of improvement, as well as feature requests.

One of the biggest hurdles for students using the app was camera functionality, particularly to focus on the book in the stacks. Camera phones are not high quality, so their autofocus can take time to target the call number of the item. Since students expectations are for instantaneous scanning (as they would a QR code) we believe that future versions of the augmented reality app should necessarily rely on a quicker way of digitally identifying a book. The way we expect to do this is to use a barcode scanning software library, which will gather data about the book subject heading quicker than the OCR method, and be more precise. For libraries nationally without development resources, it is recommended to use third party software packages for any kind of computer vision development, since third party code has lower costs to develop and is generally more stable and tested than locally developed solutions.

Another feature request that we discovered while undertaking the user studies was the need to show the user where they are in the book stacks. The functionality of the app currently only shows the location of suggested books based on a scan, it cannot infer dynamically the location of a user's phone in real time. There are technologies we are looking into for achieving this, include using Bluetooth beacons from Estimote (http://estimote.com/).

Goal 4: Work with Library IT (Software Development Group, and the Infrastructure Management and Support team) to identify skills and technical infrastructure needed in order to make AR an ongoing part of technology in libraries.

Output: By developing a server-side API to power the suggestions, we were able to enlist the support of the Library's Infrastructure Management and Support department who are currently patching security updates in the RedHat server running the APIs. As is common practice in the SDG (Software Developer Group) we have also documented the web APIs in the library's micro-services wiki, ensuring that others could build off of this work, if desired. The skills required to continue AR development include middleware development so that multiple data sources (ILS checkout data, Subject Headings, Map data) can be combined into a data object consumed by the phone (or web app).

Goal 5: Make available the AR apps through the Library's mobile labs experimental apps area (http://m.library.illinois.edu/labs.asp).

Output: The link to the Minrva app (inclusive of the Topic Space module) is available as a link from the Library mobile labs experimental area.

- Publications and presentations are forthcoming

A publication of the user studies from the grant is in development. The formative user data are collected and analyzed, we are writing the article now, and have submitted a proposal for an ACRL TechConnect presentation in Spring 2015 at the ACRL 2015 Conference. We expect to submit the article to *Weave: the Journal of Library User Experience* or alternatively, the *Journal of Academic Librarianship.*

• **What's next?**

The grant work from developing Topic Space will continue by way of ongoing Library funding supporting student developers in the library. We are looking to enhance several other functions of the Minrva app with suggestions developed from the API. Further development of recommendations in the Scanner module of Minrva app may allow a more precise set of recommendations, since OCR is dependent on broad subject associations by LC letter or subject, and the scanner software package is designed to use interface directly with the subject areas of a bibliographic identifier.

Part of this project's sustainability plan will include keeping student developers active in development of "more like this" functionality within portions of the main library website. This will be investigated within the account login screen, where a user logs in to renew items or place requests. The single page web app could provide recommendations from the ILS account login -- since recommendations are powered by supplying an item's unique bibliographic identifier and user accounts are populated with bibliographic identifiers of checked out items.

The web app component (http://minrva-dev.library.illinois.edu) will be incorporated within a kiosk in the Undergraduate Library. By accessing the app from the tablet kiosk in Undergrad Library (e.g. selecting the Undergraduate Library location) users will have access to the same Topic Space suggestions as they would if they had taken a picture of the call number in the library bookstacks, thus continuing to support users access to collections they may not have been aware.

A key unexpected finding of this grant project was the ongoing research to pursue which we discovered by developing an API to power the native app. We have done some preliminary experimentation with ways to re-use the app data feeds in other mobile components, a library homepage, as a stand-alone web application. Our sustainability plan is to re-use, re-purpose, and extend the infrastructure from this project for improving collections, access, and discovery library-wide.