Augmenting Paper Maps

An exploratory study of the combined use of paper maps and mobile apps

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Introduction:

The latest trend in mapping and navigation is the use of digital navigation tools such as GPS, smartphones and numerous mobile navigation apps (applications). Some people think that the use of the paper map as a navigational aid is at risk of becoming obsolete. As examples, bound books, printed magazines and newspapers have all suffered as a result of the growing popularity of eBooks, digital magazines, and online news feeds. Many mapping companies have launched digital counterparts to their traditional products, but the user experience is usually limited to one or the other, and not a combination of traditional maps and mobile technology.

This study suggests that paper maps may have a bright future through combined integration of printed maps and digital navigation tools.

The concept was presented to the mapping community at the North American Cartographic Information Society's (NACIS) 2012 annual meeting, held in Portland, Oregon, on October 17-19, 2012. I chose this particular meeting to insure that there would be an audience of the nation's top cartographers, traditional map companies, and digital map application developers.

Objective:

The objective of this study was to explore the juxtaposition of digital mobile apps and traditional paper maps and to present images and a conceptual video simulating the user experience and user interface of a digital app that could interactively augment the data of a paper map.

Case Study:

Yosemite National Park was chosen as the test subject for this study because of its rich history in paper map products and the growing use of digital navigation in the National Parks. Throughout Yosemite, and other National Parks, visitors are exposed to numerous maps, including ones in brochures, official trail maps, ones at map kiosks and wall maps. A National Park of Yosemite's size, with year round traffic, also produces a lot of supplemental information to help visitors plan their day and learn of the numerous activities and current events in the park. The National Park Service (NPS) websites provides additional, supplemental information. (http://www.nps.gov/yose/index.htm)

As an alternative to needing numerous sources of information, this study looked at aggregating all of the data sources and overlaying the supplemental information onto the traditional park maps. By using new information technologies to combine the paper maps and popular digital devices, such as smart phones and tablets, this study introduced a new augmented experience that offers the speed and versatility of digital information and leverages the richness and accessibility of a traditional NPS map.

Research:

Research for this concept included the reviewing of paper maps and digital navigation tools, conducting informational interviews with end-users to understand their user expectations, and assessing the level of success of similar products and studies that use a combination of digital, location-based services and paper maps.

Materials Assessment:

Understanding the pros and cons of both paper maps and digital navigation applications highlights the unique benefits of each and the opportunities to combine functionality for uses not possible with only one.

This assessment included personal experiences in navigation using handheld paper maps and digital navigation smartphone apps. I have tested and critically analyzed numerous navigation apps for iPhone and iPad devices for three years. The conclusions in the Table 1 are generalized characteristics of the two mediums.

	Official Park Trail & Brochure Maps	Digital Navigation Apps
Pros	● Easy to carry with you ● Foldable ● Shared viewing	● Easy to use on the go ● Can support multiple languages ● Geo-location ● Dynamic content ● Searchable content ● Navigable ● Geo-tagging capabilities
Cons	● May not be available in multiple languages ● Out of date ● Generalized data ● Secondary information sources may be needed	● Small screens ● Relatively short battery life ● Poor sunlight visibility ● Not weather resistant ● Poor for shared viewing

(Table 1) This table summarizes the author's observations of the pros and cons comparison of using either paper maps or digital navigation applications.

Professional and End-user Assessments:

To develop an accurate understanding of user expectations, a number of informational interviews were conducted early in this study and follow-up interviews were conducted as the study progressed. These interviews were beneficial both in understanding the end-users' expectations and demonstrating a technically feasible integration of digital navigation and traditional map media.

Informational interviews were held with traditional cartographers, an NPS Ranger and GIS Technician for NPS, mixed media cartographers, smart phone and digital device app developers, and numerous end-users.

I spoke to Tom Patterson, Senior Cartographer at the NPS Harpers Ferry Center (HFC), to discuss the design criteria of NPS maps, including what information goes in, and what is left out. The discussions helped me understand potential ways that additional data could be delivered to the end-users and where the best opportunities for data delivery would be in the park.

I had numerous conversations with NPS GIS Technician Bill Kuhn to learn about the data that Yosemite National Park collects and how that data is used. These discussions were instrumental in understanding the various data feeds available in the park and how the technological capabilities of the park infrastructure could be used to create a better informed experience for the visitor.

Through conversations with mixed media cartographers, Nathaniel Von Kelso and Mike Migurski of Stamen Design, about their products, WalkingPapers and Fieldpapers, I was able to learn how they utilized QR coding and other markers for image recognition.

Developers for Farragon Geographics, Chimani National Park apps and Layar were all consulted to gain knowledge for developing a digital and augmented navigation experience for end-users.

Many end-users were consulted. They included traditional navigators who use map and compass, digital navigators who only use smartphones, and "wayfinders" who simply rely on the well-marked trails of a National Park. End-user interviews helped to draw conclusions about the level of interest in a combined map and app experience and about the amount of interaction, or "work", that would be acceptable to get the additional data.

Technology Assessment:

Researching other products and technical studies that proposed to combine digital navigation and paper mapping experiences helped to distinguish which technology and features are not suitable for the objectives of this study and also highlight the technology and features that would be interesting and useful to today's consumers.

The technology assessment included reviewing products and research that utilized early camera-equipped phones, digital sensors, infrared ink, and early experiments in image recognition software to interact with print maps. Modern smartphone applications that use augmented reality or social media were also reviewed to learn how mobile technology is used in augmenting information about a user's surroundings.

Augmented Reality (AR) is a visual tool with spatial roots. Information is overlaid in the user's field of vision when looking through a camera-equipped device. AR can be initiated by various means, including the following: identifying specific geographic locations using GPS, using a camera-equipped smartphone to scan unique markers, or detecting digital tags using special sensors.

AR has grown from "gaming" and viewfinder applications into powerful advertising tools as well as navigational aids. AR can be dynamic or static depending on the type of data presented. Dynamic data augmentation pushes real-time data, such as restaurant ratings, into the users' phone screen while they explore the environment around them with the phone's camera. Static data augmentation is when data and interactive elements are pre-programed to display when a user looks at a particular object such as an advertisement or a book. Some AR apps enable "static" billboard advertisements to come to life and alert a user of a special deal, or play a product video as users pass by. Another example of static AR in use is the children's book, *The Fantastic Flying Books of Mr. Morris Lessmore*, by William Joyce (http://morrislessmore.com/?p=bookPage), and the companion AR app,

IMAG-N-O-TRON, by Moonbot Studios. (https://itunes.apple.com/us/app/imag-n-o-tron-fantastic-flying/id534396897?mt=8), The *IMAG-N-O-TRON* iPad app enables the illustrations in the book to jump off the page and fly around the room, while a narrator reads along and the story envelopes the reader into Mr. Morris's fictional world.

Products and studies reviewed for the technology assessment included:

A 2006 study by Derek Rielly (Reilly, 2006) experimented with detecting digital tags that were placed on paper maps. Mobile devices equipped with special radio frequency identification (RFID) sensors were used to detect tags emitting a radio frequency signal when in the proximity of a sensor. The mobile device would then display additional information on the device screen about some area or object on the map.

Anoto Positioning Technology (Norrie, Signer, 2005) created a special pen device equipped with a lens to detect and read invisible dot patterns printed on a map in infrared ink. Based on the infrared dot pattern a separate mobile device linked to the pen would display additional information about an area or object on the map.

A 2009 investigation (Liu, Liao, Wilcox, Tonyd, Bee, 2009) added large, semi-transparent, abstract designs, called Embedded Media Markers (EMMs), to printed maps. Camera-equipped phones could recognize the EMMs on the map, but because the designs were so obvious they detracted from the overall aesthetics.

Johannes Schöning and others (2009) created a product called PhotoMap which could geo-reference any photographed map if the user walked to, and marked, the exact location of at least three points on the map. The product concept was sound, but required too much "work" by the end-user for the product to ever be widely successful in the consumer market.

Layar is a smartphone app that detects images such as magazine ads or billboards and animates the content using AR when viewed through the user's smartphone. Layar is unique from other AR applications in its ability to recognize a full static image instead of using markers, such as a QR codes. I found that the fine detail of content on the Yosemite National Park map was too complex for the app to recognize as a single image.

Wikitudes is a common AR app that projects information about an end-user's surroundings on the screen of a smartphone. This augmented data might show nearby restaurants with customer reviews or hotel rates and availability.

Stamen Design's WalkingPapers and FieldPapers websites allow users to print maps from OpenStreetmap with QR codes. The user can make hand written notes on the printout, then scan and upload it back to the system by photographing the printout. The website uses the QR code to recall the geographic location and orientation of the original position of the map to put the user's notes in the correct place.

Avenza PDF maps is a smartphone and tablet application that allows the user to access a large library of geo-referenced PDF (geoPDF) maps. In 2012, Avenza enabled map developers to create QR codes for maps so that the paper map versions could be scanned to download the Avenza app and the corresponding geoPDF map. For example, a user may see a QR code in a travel magazine ad or on a map on a sidewalk kiosk. Scanning the QR code would allow him to download the map to his device. Once the map is downloaded to his device the user can view the map and his own location with or without an active WiFi connection.

Social Media, including Facebook posts, Foursquare check-ins, Twitter, and Instagram, let users openly share information that could provide location context in a National Park setting. For example, a user might see a really interesting Instagram photo posting and want to make plans to visit that spot. Or perhaps, the user might read a tweet about bear activity in a certain camp and choose to steer clear of that area.

GeoRSS feeds (Geo-referenced Really Simple Syndication feeds) are commonly found in web blogs and used to publish frequently updated content. GeoRSS feeds add geographic coordinates to the RSS postings allowing a web service to pin-point the location of the event on a map. The National Park Service could use GeoRSS feeds from their website to push syndicated new postings to visitors throughout the park.

End-user assessments helped to determine how technology could combine the use of paper maps and mobile devices such as smart phones and tablets. It was clear that a successful product would need to be easily accessible and intuitive to the end-user, and low cost to implement for the map producer. Each product in the technology assessment was categorized by three criteria: Does the product utilize existing maps without requiring special and expensive printing techniques? Does the product leverage common hardware technology that is accessible to the general public? Does the product avoid confusing the user by designing user experiences that are technically understandable for the general public?

	Common vs Specialized Printing Techniques	Common vs Specialized Hardware	Common vs Specialized User Experience
RFID	COMMON	SPECIALIZED	SPECIALIZED
Anoto	SPECIALIZED	SPECIALIZED	SPECIALIZED
EMM	SPECIALIZED	COMMON	COMMON
Photomap	COMMON	COMMON	SPECIALIZED
WalkingPapers	COMMON	COMMON	SPECIALIZED
FieldPapers	COMMON	COMMON	SPECIALIZED
Avenza PDF Maps	COMMON	COMMON	COMMON
Layar AR	COMMON	COMMON	COMMON
GeoRSS Mapping	N/A	COMMON	COMMON

(Table 2) The table above shows a comparison of similar products to determine which utilize common versus specialized techniques, hardware, and user experience. The results show two products that meet the criteria of this project's objectives. The Avenza PDF maps and the Layar AR app both utilize common characteristics that are necessary for designing a successful product.

The technology assessment revealed that a successful product would need to be able to recognize which map the end-user is looking at, and more precisely, where on the map they are looking at. The product would need to consist of an online database component and a mobile application component. The online database would serve to match a specific map to the geographic data related to it, and continuously feed the most up-to-date location-based data to the mobile application. The mobile application would be capable of displaying the data feeds using AR to overlay the information on the paper map. As proven with the Stamen Design products and Avenza's PDF Maps application, image recognition could be achieved by adding a QR code label to maps. The Layar and Wikitudes apps demonstrated that data augmentation could be achieved using AR and the end-users' camera-equipped smartphones. Real-time information could be pushed to the end-user through NPS' geoRSS feeds and social media feeds of the park visitor community.

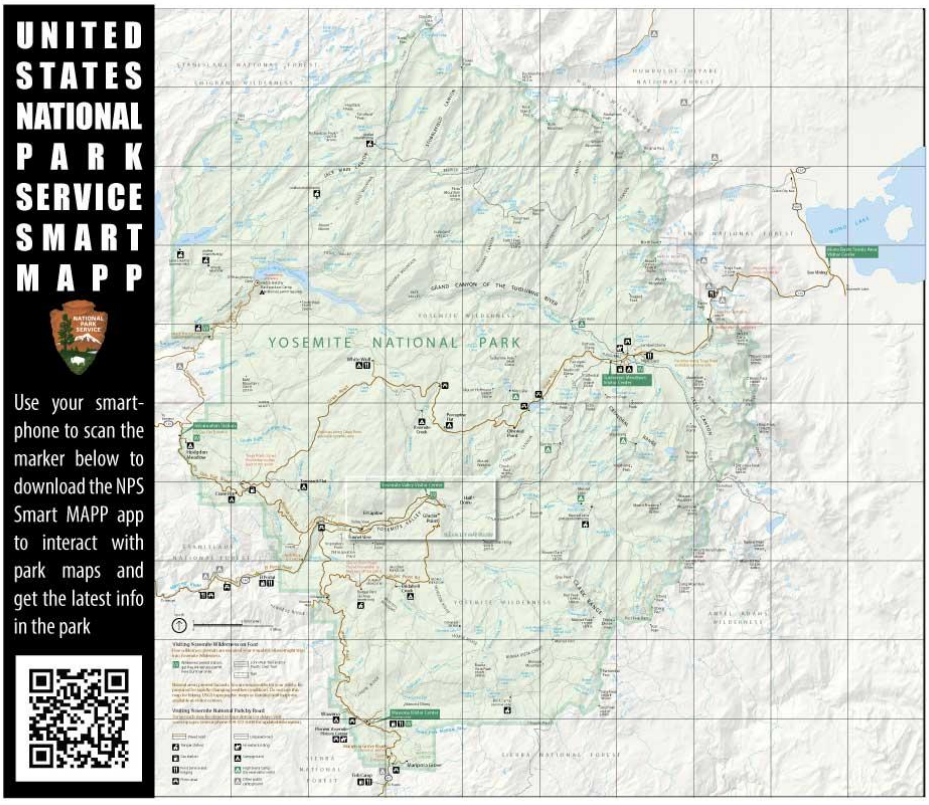
Proposed Methodology

The materials, end-user, and technology assessments yielded important requirements necessary for a successful product. These requirements were translated into a user interface (UI) design and user experience that were simulated in a conceptual video entitled, "Augmenting Yosemite's Paper Maps" (www.**youtube**.com/watch?v=D2iaceDNGlM).

For the conceptual video I started by sketching a storyboard of the user experience. Mock up UI screens were designed with green screen background to allow a multi-media designer to create a visual effect to simulate AR. Scenes were shot at a local park and editing was coordinated with the multi-media design. The final video was used at the end of the NACIS presentation in Portland to help the audience visualize the final concept in action.

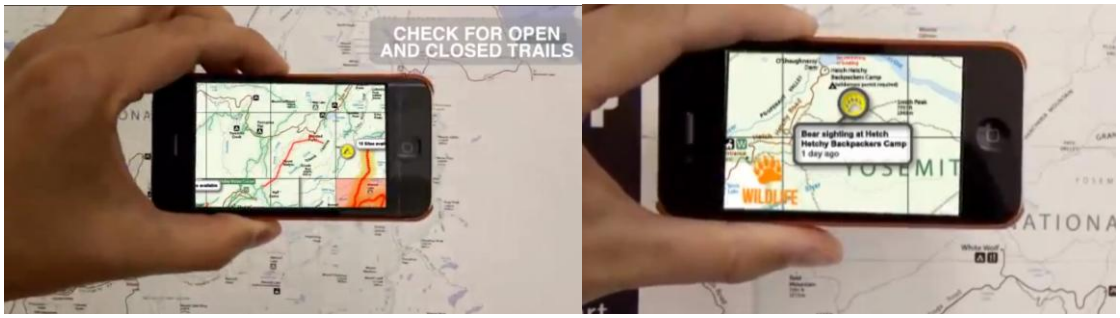
(Figure 1) Illustrated storyboard of the user experience of a fictional smartphone application that creates a combined navigation experience using Augmented Reality on a smartphone to read an official park paper map.

Figure 1 above Illustrates the end-to-end user experience beginning when the visitors to the National Park would find a QR code printed on park maps, including kiosks, brochures, and trail maps (Figure 2). Scanning the QR code with a smartphone or tablet would download the NPS Smart MAPP application.



(Figure 2) The map above is an example of adding a QR code tag to the existing Yosemite Park map.

The user could then select from the app menu to choose various augmented information to view overlaid on the paper map. Examples of augmented information include which trails are open during a particular season or current wildlife sightings (Figure 3).



(Figure 3) Screenshots from the animated simulation video produced for this project illustrate how current thematic data, not included on the original paper map, could be geographically augmented using a smartphone application. The images above show the capability of viewing trail access data, published daily by the NPS to learn which trails are open or closed (left). The second image (right) shows current wildlife sighting information near a popular campsite.

The National Park service could also publish critical alerts: areas closed due to fire danger, or post a current list of available campsites in the park (Figure 4). The user can make his selection, and while holding the mobile device over the paper map, the end-user would be able to find the precise location pertaining to the selected information.

(Figure 4) The screenshots above show health alert information, notifying park visitors of an area closed due to hantavirus (left), zones closed to the public due to active wildfires (middle), and a quick glance at available campsites throughout the park (right). Current information is sent to the app on the end-user's smartphone from a backend NPS GIS using GeoRSS feeds.

Conclusion

In conclusion, this study successfully illustrated that there are opportunities to create a collaborative, combined navigation experience using smartphone applications that interactively augment the information found on paper maps. The combined experience is beneficial to the park, the app developers, paper map makers, and most importantly the end-user. In the final presentation to attendees at the NACIS annual meeting, I ended by asking the audience to consider the same question that had lead me to this study, "How can traditional maps and digital

apps be used together?" By encouraging these professionals to work with this question in mind, I hope to see more solutions that allow the use of digital tools to read and interact with paper maps in the future.

Associated Documents:

2012 NACIS presentation:

http://prezi.com/mng6s6w3euym/apm-richard-tinnell/?auth_key=6d58a9505eeb3f037108b1cc5d7a19d3cc34b476&kw=view-mng6s6w3euym&rc=ref-4623300

Presentation Video:

http://www.youtube.com/watch?v=D2iaceDNGlM

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