# Visual and Spatial Data Integration in Mobile Application Design

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**Abstract.** Mobile application design is a strong motivator for student-centered computing. By including visual and spatial data in a mobile application, students can develop a 3-D implementation which can provide the mobile app users with a virtual experience. The development of a mobile app for a historical burial ground provides an example of how to integrate database information with visual and spatial data to achieve s virtual experience. The case study presented here, using both Android and iOS devices, includes three parts. Initially, an existing database was converted for mobile application access. This was followed by design integration in support of the desired mobile app features. Finally, the inclusion of an image gallery, with visual and spatial elements, integrated with the mobile application, resulted in a compelling mobile application, providing a virtual replica of an actual visit to the historical site.

**Keywords:** Mobile application development, Android, iOS, visual data, spatial data.

## 1 Introduction

As part of a student-centered design project, a mobile application ('app') for a historical burial ground was developed by a team of undergraduate computer science students. The mobile app includes a database of deceased people interred in the burial ground of the First Presbyterian Church (FPC) of Elizabeth, New Jersey, which is integrated with visual and spatial data to create a virtual experience emulating a physical visit to this historical burial ground.

The idea for the mobile application was initially motivated by the Reverend Higgs, the religious leader in charge of the FPC. The church is home to a historical cemetery that contains many local people as well as several well-known individuals who were important in the history of New Jersey, one of fifty states in the United States. The cemetery at the church is very old and includes gravestones dating back to the 1700s. The land itself was used to establish The College of New Jersey, which later became Princeton University [1]. Buried in this land are important characters from American history such as James Caldwell and several hundred members who served in the

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American Revolution, as well as slaves and commoners. The church and graveyard receive many visitors every year who are interested in the history of the church and the lives of those whom are buried there.

Reverend Higgs, an enthusiastic advocate of technology, requested a mobile application that would begin by introducing the church with a small description. The primary reason for the app comes from the cemetery itself. The mobile application was envisioned as having a search function that would allow anyone with the app to be able to search the cemetery using any search criteria they desired, for example: name, age, or date of birth. The application would provide information on all the deceased in the cemetery who matched the search criteria. Anyone using the app could then select a person and the app provides all the information on that person's gravestone including where in the cemetery the burial plot and headstone can be found. The gravestone information within the application is useful because of the physical age of many of the gravestones has results in some headstone inscriptions no longer being legible.

In addition to the search function, the app provides a map of the graveyard which can be zoomed in and out using pinch gestures, as well as a section with more information about the cemetery, including contact information and a photo gallery. This paper describes the steps to organize, design and develop this app.

## 2 Organizing Development Groups

The development project was managed and executed by students. The team encompassed a range of programmer expertise. A common method for developing applications is to break up the work that is required among the team of developers, with a team leader [2]. The first task of the team leader was to bring all the developers up to the same level. While all members of the team had prior Java programming experience, there wasn't anyone experienced with the Google Android or Apple iOS APIs.


**Fig. 1.** Platforms Selected for Development

The Android development environment was provided by the Eclipse Integrated Development Environment (IDE), which was then linked to the Android Software Development Kit (SDK) with an Eclipse plug-in. The Apple iOS development was carried out in the Xcode 4 IDE environment using the Objective-C programming language. In both development environments, the work was divided evenly based on the skills and personal preferences of each team member.

The iOS team had to learn Objective-C and the Xcode IDE, which they did by watching the Stanford iOS video lectures on iTunesU [3] and reading books on iOS development [4]. The team leader created a schedule for watching the video lectures so that everyone in the group would be on the same level. The video lectures also included challenges that the viewer should try to solve with hands-on coding. After a few video lectures, the students were familiarized with the IDE and ready to start the development of the app.

The Android team used a similar approach by reading a book on Android development [5]. The team leader created a schedule for reading the book chapters in order to keep everyone at the same level. The book provided practice applications to provide a hands-on learning experience. After reading the first eight chapters, the team was ready to begin the implementation of the app.

Learning new libraries and a new programming language takes time. For that reason, the project would take more than one semester to be completed, so the milestones were set within a two semester time frame. Each member of the group would be responsible for keeping a blog with progress information. This helped the students maintain focus. Also, it was useful for documenting the project.

Additionally, milestones were used to make sure everyone worked towards the same goal. The initial goal was to have a "skeleton" of the application - the base layout with all of the functionality required to navigate the app, but without content - running on the iOS simulator within a month. For the second milestone, the skeleton would be filled with content and include a functioning map that scrolls and zooms in and out. The third milestone was to implement the search functionality retrieving data from the database. Finally, the fourth milestone was to submit the application to the Apple store, a goal which was expected by the end of the first semester.

## 3 Designing the App

With a student-centered approach, the team began with a site visit. By physically visiting the site, the students learned the actual physical layout of the burial ground as it existed in the community, and began thinking about how they could replicate this experience for users of the mobile app. During the site visit, photographs were taken, and notes were made regarding engravings on the tombstones.

After brainstorming ideas and sketching the app, the application design that emerged included four primary functions: a home screen, a search page, a map of the cemetery and more information page. To access each of these activities a tab bar was required at the bottom of the application. An initial splash screen was also implemented to provide a perceived short loading time for the app as well a small amount

of information about the church while the database is loaded in the background. The home page design selected was a simple image slide show of the cemetery accompanied by a quote from one of epitaphs in the tombstones. The slideshow provided the first visual image of the graveyard and served to familiarize the user with the environment in the cemetery.

Applications can be categorized in two groups: web-based and native client [6]. Initially, the team considered developing a web-based app using HTML5. Facebook and Verizon are examples of apps that chose to use HTML5. In this case, it is easier to update the content server-side and all users will see the changes instantly. However, these apps perform poorly compared to native apps. Users also tend to respond negatively to this format [7]. Generally, native code will run better and the perceived value of the product will be higher, which is why the team chose to develop native iOS and Android apps. If they were to create an HTML5 portal, it would not packaged as an app; instead it would be using a universal URL [8].

## 4 Development Phases

The mobile application development identified included three parts. First, an existing database had to be converted and organized to support the mobile application access. This was required to pull the database information into the phone effectively and give the user access to it.


**Fig. 2.** iOS and Android home screen with tab bar navigation

Secondly, the iOS team had to start development ahead of the Android team because the client requested priority for the iOS app. A tab-bar application was developed with four main tabs (Fig. 2). These included the “home”, “search”, “map” and “more” tabs. The home tab is the entrance to the app and the search tab is what connects the user to those interred in the burial ground. The next tab was “map” (Fig. 3), which displays a map of the entire burial ground in which the user can use pinch gestures to zoom in and out of areas.

**Fig. 3.** The map

The “more” tab is a sub-menu that links to three different options: the first option is “plan your visit”. The second option is an image gallery (Fig. 4), and the third is “contact”, which provides the user with contact information. The inclusion of an image gallery, with actual photos from the historical burial ground, adds visual data [9, 10]. The spatial data is provided by the map of the entire area. The inclusion of visual and spatial design elements with database integration make a compelling mobile application, providing a close replica of the experience one would get by actually visiting the historical site.

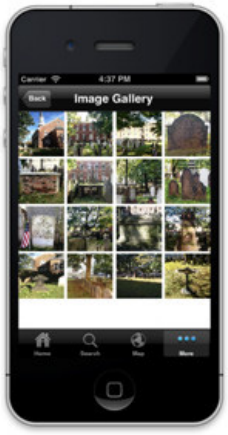


**Fig. 4.** The image gallery

Third, the Android team had to use the iOS app design as a reference to make the app work the same way in both iOS and Android devices (Fig. 2). This presented a set of difficulties because of the differences in developing for the two platforms. It was useful to read other developers perspective on developing for both platforms [11].

## 5 Mobile Application Deployment

### 5.1 The Google Play Store

After developing an application, it was time to publish it to the Google Play store. Before that can be done, a publisher account and a Google merchant account must be created. There is a $25 one-time registration fee for the publisher account and no fee for the Google Merchant account. After these accounts are established, there were still a few important details to complete before uploading the application to the market. A full checklist of what should be done before publishing an application can be found on the Android developer website [12].

The first several points on the checklist are there to ensure an understanding of the publishing process and the policies and agreements. It also specifies an understanding of the billing process and pricing of the application. The next section of the checklist involves checking the application itself for certain criteria. At the time, the Google Play store did not allow applications bigger than 50MB.

Another important quality of an app for Android devices is that the application itself must be ready for the various devices and screen sizes. An app could look quite different on a larger screen than on a smaller one. This was an error that the Android team encountered during this mobile application development; images being displayed were not filling the screen on larger phones as they were on smaller phones.

Before an app can be published, it must be signed and given its own private key to use for future updates. Eclipse makes the signing process of an 'apk' simple. Private keys must be valid until the date specified by the Android market. Properly signing and compiling the 'apk' can be done by using the Export action in Eclipse. Export gives the option to create a new key for new applications or using an existing one for updating older applications. Once exported, signed, and compiled, the app is ready for the app store. After the app is sent to the store, the final item on the checklist is to support users after launch.

### 5.2 The Apple App Store

Publishing an app on Apple's app store requires an Apple developer account, which one can register for free at the Apple Dev Center website. However, Apple also requires developers to join the iOS Developer Program, which costs $99.00 per year for individual accounts. There is a good tutorial on how to create the developer account [13].

Apple requires every app run by iOS to have a signed Apple Certificate, which is done by creating a profile in the iOS Provisioning Portal and using Xcode to sign the app. There are two types of profiles: the *developer profile* allows the developer to

test the app on his own device, but the app cannot be distributed, while the *distribution profile* is used to sign the app before publishing it to the app store.

The app must then be submitted to the iTunes Connect portal, where all of the app store configurations should be filled in. This includes the app name, description, icon, price and screen shots. After submission, a few weeks may be needed for Apple to review the app for approval.

## 6 User Experience

The "FPC Cemetery" app intends to create a near 3-D virtual experience of physically visiting the historical burial grounds. It does so by providing visual and spatial data in the form of a map of the graveyard, as well as images of the individual tombstones and an image gallery of the cemetery. However, the app actually offers more than the experience of a typical visit to the burial grounds. It offers the ability to search (Fig. 5) the database by name or using other queries, such as age at death and whether or not the interred was a veteran.

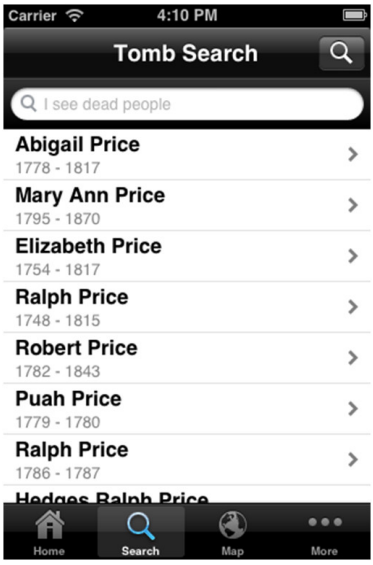


**Fig. 5.** The search tab

Furthermore, the search feature is integrated with the map, so each record in the search has a detailed section (Fig. 6) including personal information of the deceased, an image of the tombstone, the epitaph—which is no longer legible in some of the tombs, cause of death, and location of the tombstone in the map. The app is capable of creating a memorable user experience for the curious person who does not plan to physically visit the site. The mobile app is also a great tool to guide those who decide to visit the cemetery in person, as detailed information and the complete cemetery map (Fig. 3) are available as the actual physical environment is navigated.

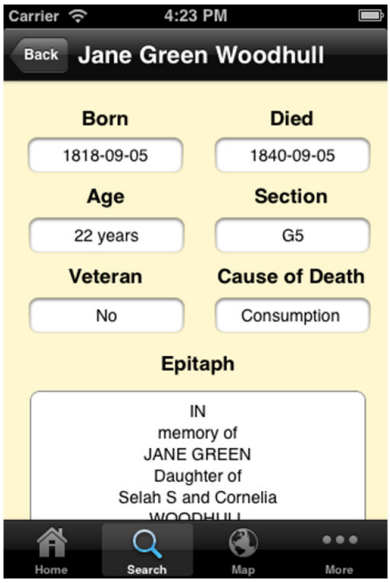


**Fig. 6.** Tombstone details

## 7 Conclusion

This paper has described the approach taken by a team of undergraduate students to organize, design and develop a mobile application for iOS and Android handheld devices. It has explained in detail the steps taken by a group with no prior knowledge for the development of a working prototype and the successful deployment of the FPCCemetery app in both the Andriod and Apple iOS marketplaces. The design of the mobile app interface was a collaborative effort and the resulting product provides a user experience comparable to being in the burial ground. However, the information available from the app is superior to that which is actually available during a visit to the First Presbyterian Church in Elizabeth, NJ, as the tombstone data is clearly presented in the mobile application and the entire database for the site is searchable by query. Clear, detailed information provided by the app is superior to information available to visitors to the physical FPC site.

The students involved in the project, resulting in the *FPCCemetery* app available in both the Apple and Android stores, are proud of their accomplishment. Starting very little knowledge of mobile application design, by consensus the team developed an outstanding mobile application, operable on two platforms, which provides a virtual 3-D rendering of a visit to a historical burial ground. This experience is now available to visitors who live far from the area, who are interested in seeing where their ancestors or predecessors are interred, as well as historians who want to investigate death patterns related to age at death and year of death.

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