Teaching and Designing for Augmented Reality

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This paper discusses ways emerging interactive technologies are adopted by designers and extended into areas of design, education, entertainment, and commerce. It looks, in detail, at various project development stages and methodologies used to engage design focused students into, often complex, technological issues. The discussion is contextualized through a number of case studies of mobile and marker-based augmented reality (AR) applications developed by students. These applications include an app for a fashion based social event that allows participants to preview recent collection additions, an info-navigational app for the High Line elevated urban park in New York City, a marker-based maze game, and an interior decorating interface to visualize various furnishing scenarios. While a number of case studies will be discussed from a developer perspective, the primary focus is on the concept and content development, interface design, and user participation.

Keywords: *Augmented Reality, AR, Gamification, Mobile Culture*

INTRODUCTION

Let's pretend you're on your way to Manhattan to buy some new clothes. Maybe you're looking to impress someone on a date. Maybe you need an outfit to ace that interview. Maybe you're looking to change your style and try something new. Whatever the case may be, you know New York fashion will not disappoint.

You arrive on 54th Street on Fifth Avenue early in the afternoon. There's a ton of different stores in that five-block radius. There's high-end fashion retail and some typical name-brand stores. Some stores aren't in your price range, but you might be interested in what they have to offer. You're not sure where to shop first. Decisions, decisions...Luckily, there's an app for that! (students: Philip Caleja, Nick Haby, & Daniel Schittone)

The above excerpt from one of the scenarios formulated by students as part of an augmented reality (AR) project proposal explored ways mobile AR applications can enhance the fashion retail experience by taking advantage of location-aware services and electronic social networks. These applications also address other, less tangible needs, such as the sense of social happening and the excitement associated with emerging technologies.

This paper looks into ways that emerging interactive technologies are being adopted by designers and extended into the areas of tourism, education, entertainment, and commerce. It discusses in detail the project development stages and methodologies used to engage design-focused students into often-complex technological issues. The discussion is contextualized through a number of case studies

of mobile and marker-based AR applications developed by students. These applications include an app for fashion-based social events that allows participants to preview recent collection additions, an infonavigational app for the High Line elevated urban park in New York City, a marker-based maze game, and an interior decorating interface to visualize various furnishing scenarios.

While a number of case studies are discussed from a developer perspective touching on technical intricacies, the primary focus is on content development, interface design, and user interaction considerations. The paper also discusses pedagogy, concept formation, and broader social and spatial narratives.

AUGMENTED REALITY ENVIRONMENTS

Traditionally, AR environments employed two distinct types of data overlay. Marker-based environments employed distinct markers and, more recently, images (image targets) to locate virtual data within the physical world. A second approach associated with mobile AR involved GPS, digital compass, and accelerometer sensors to position users and the virtual content around them.

AR-based applications provide an opportunity reconnect and better realign virtual and physical worlds through location awareness, enhanced data overlays, and user-focused content. Unlike more static forms of digital media, augmented reality, with its interactive and context-aware functionalities, engages users in more direct and meaningful ways. This is evident not only in academia but also, and perhaps primarily, in commerce and advertising. The interactive print approach popularized by Layar or AR Lego models [1] , associated with mainstream toy products are successful because they extend the level of consumer engagement. They provide additional information and enticement (enticement) for consumers. The same lessons of consumer engagement are directly applicable to design education and design services.

While AR technology is routinely employed in the form of data overlays providing supplementary information for physical objects that are visible with the unaided eye, it is also increasingly used to visualize less tangible structures and concepts such as historical events, cultural phenomena, and scientific processes. This can be seen in a number of research projects and mobile apps that help users to learn history and facilitate explorations of urban environments. (Niedmermair, Ferschin, 2011) TimeWarp (Herbst, et al, 2008) a mobile edutainment application designed as an AR game situated in Cologne, Germany, focuses on virtual reconstruction of historic buildings by superimposing virtual imagery over currently existing structures. The application not only shows no-longer-existing buildings as they originally appeared but also visualizes design changes that occurred over time to still-present structures. Along the same lines, the Immersive Experience of Cultural Heritage project (Kim et al, 2009) uses an AR tour approach to provide tourists with a more realistic experience by placing virtual characters within historical structures. Visitors to the heritage sites of Sajeongjeon and Gangnyeongjeon in Korea can use their mobile devices to access additional facts associated with the showcased physical content. While a similar approach is routinely used by many museums, this particular project does not rely on AR markers such as QR codes. It implements visual camera tracking of the rectangular display space to position its virtual actors without a need for visually intrusive markers.

Figure 1
Augmented Reality (AR) environment as social and design activism and urban games.

Virtual environment allow for explorations of inaccessible or not-yet-materialized designs. They can be precursors of future physical urban spaces and potent drives in their realization. This is the case with AR environments (fig.1) developed by Tremont Underground Theater Space (TUTS) initiative [2]. This initiative is using AR gaming media not only to popularize ideas of the adaptive reuse of the abandoned public infrastructure but also to build social constituency and connect with general public (fig.2) The shifting focus from virtual-reality (VR) environments toward mixed-reality and AR frameworks indicates the reexamination of earlier visions of separated physical and digital worlds. The emerging picture fuses both dimensions into a single continuum.

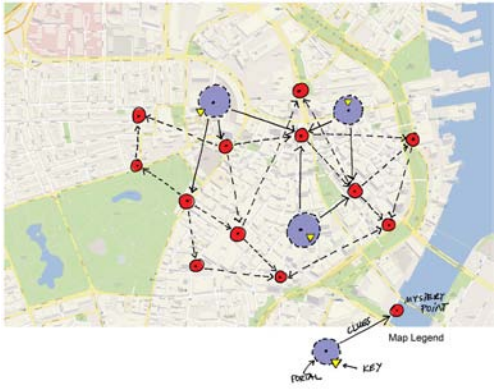


Figure 2
Mystery Spaces, a map with POIs arranged in the form of the game play.

The newfound physical context adopted by AR games encourages players to push the boundaries of social conventions and accepted public behavior.

Unlike more passive forms of entertainment such as reality TV or even active-yet-confined console-based games, the AR framework incorporates physical activities and social interaction as well as encouraging exploration, learning, and discovery. Furthermore, as activities integrate digital media culture within the built environment-cities-these games provide an insight into our physical-digital selves and better understanding of ourselves and our communities.

CASE STUDIES

FashNYC

The FashNYC application helps its users make smarter shopping choices while informing them about the current fashion scene. Through the app, users have access to online videos from each store's current collection, watch interviews with designers, and access garment information including sizes, colors, materials, prices, and availability. The app is geared toward those interested primarily in high-end fashion designers. FashNYC brings awareness to the fashion industry, connects with seasonal events, creates an exciting new shopping experience, and establishes a presence in today's heightened mobile application culture.

The app was developed for the Layar AR browser using PHP programming and MySQL as a database. The student team focused not only on creation of individual assets and associated Web pages (fig.3) but also on the overall packaging, user experience (fig.4), and final layout for the navigational map (fig.5). Since the seamless connectivity to various social networks and fashion-based websites was key here, the app user interface became a critical part of the overall effort.

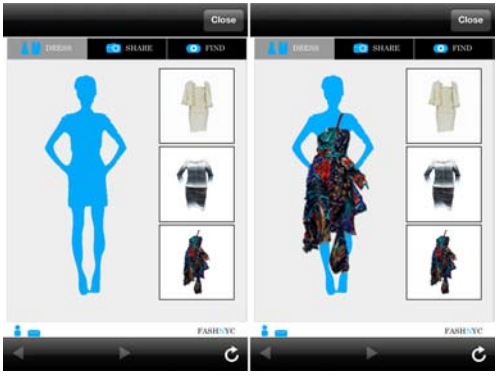
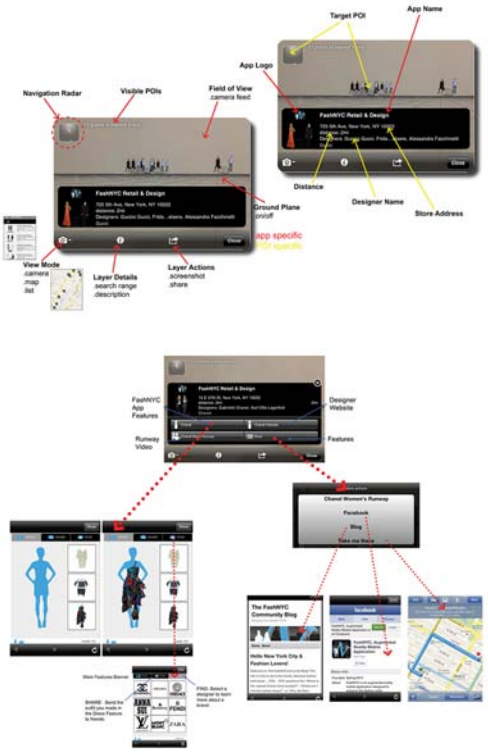


Figure 3
Virtual changing room with FashNYC

While the student team developed a fully functional prototype [3], they also proposed the next level of functionality that went beyond the scope of the class and student technical competencies.



This was an important part of the overall design strategy, where each team was asked to develop the project concept initially and later rework it into a more formalized business proposal with future development stages indicated. One of the proposed features that could be implemented with Layar's interactive graphics was garment (image) recognition. The proposed app functionality was expressed in the following statement.

Let's say you're looking for a new blue suit. You see one you like in the window of Versace. To be quite frank, you can't afford it, but you really like the color and the style. You can take a picture of the suit and have the application search for it. As the application searches for it, you take the time to watch a video of the Fall/Winter 2013 runway show where the suit was first featured. You notice you like the way it looks when on the runway, but the blue one that was shown looks even better. Once the suit has been found in the search, you can try to find similar garments in nearby stores. You're in luck! That application located a similar blue tight-fitting suit in Zara across the street for half the price! Bam! Success. (students: Philip Caleja, Nick Haby, & Daniel Schittone)

Figure 4
Mobile interface for FashNYC

As with any new app or a product relying on social interconnectivity and input, the key issue is to develop a critical mass of active users who would propagate its virtual life. This is a major challenge facing many new media products including an AR community like the one proposed by students. The strategy to address this impediment and help with the future commercialization of the app was to tie it to a particular event that is highly localized with a defined time frame. The student team proposed to connect it to the Fashion's Night Out (FNO) event or the New York Fashion Week. While this was not implemented yet, it provides a feasible strategy for launching an AR app product that is highly contextualized with its theme, location, and timing. This is also an approach used by other mobile AR games such as Comfort of Strangers [4] that rely on a critical mass of participants for their success.

Figure 5
App navigation map

Highline Tour

Highline Tour [5] is a navigational and informational mobile AR app geared toward visitors to the High Line, an urban park in New York City (fig.6).

It provides users with historical and current information as well as plans for future developments. Its location-aware functionality allows for sorting and positioning data in relationship to the urban context. It shows year-around activities with imagery of various plants and foliage reflecting seasonal changes occurring in the park. Users of the app can look at a particular section of a project and freely navigate

Figure 6
Highline navigational AR app

through historic photographs and future proposed designs (fig.7). The Highline app utilizes a Layar AR browser that is available for most mobile platforms. After initial time spent on understanding Layar SDK environment, students focused on gathering geolocation data for individual points of interest (POIs) (fig.8) and setting up online databases.

Since this particular section of the course was made up almost exclusively of architecture and design students, teaching faculty had to provide initial help with basic PHP programming and MySQL database setup. As part of the development process, students participated in hands-on workshops organized by teaching faculty and on some occasions received a skeletal prototype of an app. This helped to stage the progress of the project in such a way that at any level of its development, students had a fully functional prototype ready for testing with various numbers of features and assets. The focus of the student design team was on gathering relevant information, imagery, and outside references. The second stage involved population of the database, interface design, and development of Web page links with additional information.

Since many of the assets were Web pages related to the app content, students had to consider designs that were both desktop and mobile browser friendly. This quickly became a challenge on its own, considering the diversity of mobile devices (phones and tablets), their screen resolutions, and horizontal/vertical layouts. Once all the assets were in place, the design team focused on overall packaging, user experience, and interface design.

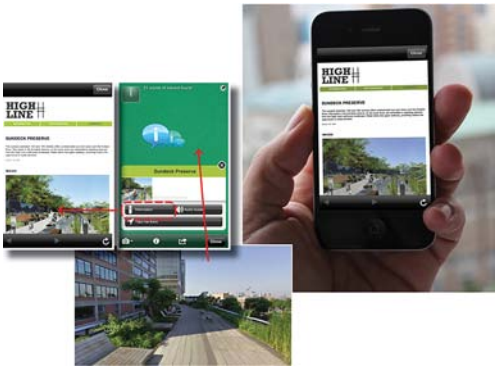


Figure 7
The diversity of assets developed by students

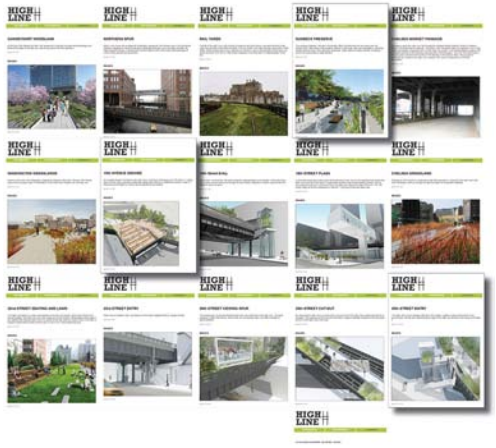


Figure 8
Points of Interest (POIs) for Highline app

Augmented Interiors

The goal of the project was to enhance communication between interior designers and their clients, and to empower consumers to experience the impact a particular design or set of furniture may have on their home. Traditional home decorating is done by imagining what a space would look like with the new furniture or other design features without having a true sense of scale or color gamut. Most commonly, customers would measure the space in a house and see if a new piece of furniture would fit within. Let's consider another scenario.

You're looking through a furniture catalog and find a piece that you like. But how would it fit into your living room? Now you can find out without leaving your couch, or wherever you are. Take the marker attached in the catalog, place it on the desired location, download the AR app, and look through the display of your mobile device camera. The piece of furniture you're considering is there for you to see in the context of your own living room.

The marker-based AR application associates each marker with a piece of furniture, material color, or design features. The combination of markers allows for a high number of variations of possible designs. This app would allow ordinary people to take design into their own hands and see exactly how a new furnishing would look like in the context of their home before they buy it. The approach does not require a digital rendering of the entire room. Instead, it overlays a product in real time over the image of the existing space. The applicability of AR in this project is appropriate; it achieves its desired effect with very few resources, could be easily commercialized, and has the potential of reaching a broad consumer population.

This AR application was developed with the Processing platform utilizing the ARToolKit library, which provided a relatively streamlined production process with good online support. The actual prototype (fig.9) was developed for a regular PC laptop, not a mobile device.

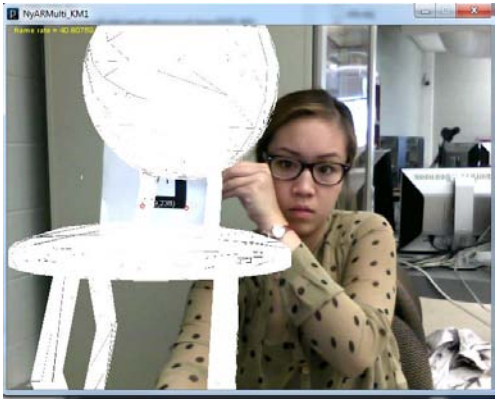


Figure 9
A student working with a marker-based AR application

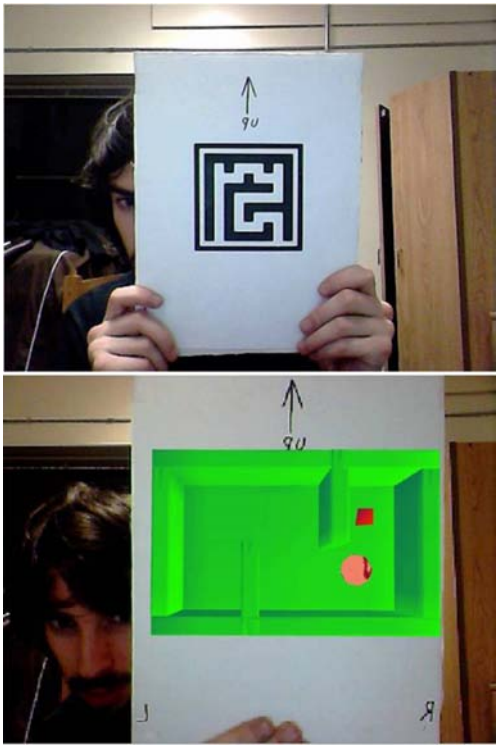


Figure 10
A student interacting with the Maze Game

The major limitation of this platform was a low resolution of AR markers-16 by 16 pixels-allowing for a small number of possible marker variations. This provided a major limitation to the size of the project and the number of assets. Furthermore, even with mid-size projects, some markers were easily mistaken when they looked too similar to each other.

The Maze Game

This marker-based AR game involves navigation of a virtual ball through a virtual maze by physically moving around and tilting the AR marker (fig.10). Movements and adjustments of the marker in the physical world are translated to the virtual space and interpreted with physics-based interaction (gravity and collisions).

While this is a relatively straightforward design, it involved a wide range of problems to be resolved and thus multiple software toolkits. Four main toolkits that contribute to this game's functionality. FLARtoolkit (Flash/ActionScript port of ARToolkit) deals with camera and marker detection. Papervision3D (open-source real-time 3D engine for Flash) deals with the construction and placement of maze walls. JiglibFlash (open-source ActionScript 3D physics engine) provides the collision detection between the ball, the floor, and the maze walls as well as gravity to propel ball movement. Finally, FlashDevelop (open-source code editor for ActionScript 3) compiles all the layers of code and runs the game application. The maze walls are built and placed based on X, Y, and Z coordinates, and then the gravity is directed inward from the Z axis. The floor is the plane with collision detection, preventing the virtual ball from falling down.

Another variation of this game, proposed but not realized, could utilize a mobile device instead of a computer. It would use a stationary marker with the device functioning as a display and a virtual maze. In this case, the device's accelerometer, compass, and tilt sensors would provide the rotation and slop information. This is one of the earlier projects developed for the course before the Vuforia and Unity3D platforms were introduced. Presently, the latter would be the platform of choice from the physics engine, easiness of development environment, and mobile output perspectives. Additionally, the Unity3D game engine would provide a more effective and streamlined environment for graphic user interface (GUI) development, particularly in tracking game scores and enhancing user interactions.

CLASS OBSERVATIONS AND LESSONS LEARNED

AR technology is entering a new stage where it is no longer the domain of technology-oriented individuals with heavy involvement of computer programming and other software tools. Products such as Vuforia, Qualcomm's plugin for the Unity3D Game Engine, delivers a highly functional tool that can be easily integrated into academic teaching and professional practice. The choice of a game engine like Unity3D further makes the commercialization of AR technology easier and more imminent. The ability to integrate physics and other modules already existing in game engines simplifies the development process and reduces the need for technology savviness from the creative team. This does not mean that the development is completely effortless as far as coding is considered-scripting is always required for effective game engine implementations-but it significantly eases the learning curve, leading to democratization of digital creative tools. This transition from technology heavily involving tools to designer-oriented technology was visible in class projects with over time, shifting from Processing and Flash-based development environments (Interior Decoration and 3D Maze projects) to Vuforia and Unity3D. This directly facilitates the content and the user becoming the primary drivers for the future of AR. This also suggests that the climate is ready for design schools to embrace AR technology as a new creative and information visualization medium. Through the AR projects and courses discussed above, students are becoming aware of new modes of visual and data-based thinking. Concepts such as location and

context awareness form an important framework for dealing with the over-supply of information and navigating the current, almost ubiquitous data jungle.

While teaching AR-based courses, early lectures and discussion are usually heavily involved with the mechanics of AR technology, which often overwhelm students. However, this initial technology shock quickly evaporates, with projects' focus shifting toward design, user experience, and content. Projects connect with other disciplines and uses that respond to a broad range of social and cultural needs. Students perceive AR technology, even more than other modes of computer graphics, as highly transparent, without a strong technological footprint. Thus, this technology naturally transitions them to explore diverse content-based topics. There was very little "technology for the sake of technology" attitude among students, who naturally gravitated toward the multitude of ways to connect AR technology with design, cultural, or social needs.

Furthermore, many of the team projects were developed by the multidisciplinary teams with students from various programs across the campus, including digital design, computer science, and information technologies, but also architecture, interior design, product design, and media communications. Some of the most successful teams were in fact a random combination of competent and passionate strangers who just met during the first class when prospective semester projects were discussed and teams were formed. The fact that students brought to the team their own distinct competencies and were able to realize their expertise provided a successful base for their team projects.

CONCLUSIONS

AR-based applications increasing occupy an important place in branding/marketing, tourism, education, and many other parts of life. AR has brought the virtual and the physical world closer and made them highly interconnected and interdependent through location awareness, enhanced data overlays, and user-focused content. It also finds its applications in a diverse range of disciplines and ...

A number of the AR applications discussed here exemplify an idea of "learning anytime, anywhere," which builds on Weiser's proposition for the role of computation in the 21st century (Wesser, 1991). This new role synergizes key characteristics of AR environments that include location awareness of data sets, always-connected networks, and the ability to superimpose images of the physical world with interactive digital graphics. It allows for passive as well as active interaction with information and virtual content. Users are able not only to visually experience static information but also to interact with data in more dynamic and speculative ways by posing "what if..." questions. These speculative investigations create an environment of increased user engagement with the benefits of experiential learning.

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