

Igpaw: Intramuros — Design of an Augmented Reality Game for Philippine History

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Abstract: We present work on a tablet- and smartphone-based Augmented Reality game application for learning Philippine History. This paper highlights the design of the game application with regards to its educational content, game mechanics, and user interface, discussing how these elements combine to enjoin players to learn about Philippine history while visiting the actual historical locations situated in Intramuros, Manila.

Keywords: Augmented Reality, Philippine History, Educational Game Design

1. Introduction

Augmented Reality (AR) refers to the superimposition of interactive digital information on real settings in 3D space to provide supplementary situated knowledge to the user (Azuma, 1997). AR has the potential for application in a number of contexts including medical visualization, manufacturing and repair, entertainment, and education.

In this paper, we describe work that attempts to use AR for both education and entertainment in the form of a smartphone- and tablet-based AR game for Philippine history, *Igpaw: Intramuros*. The game is set in the historical site of Intramuros, Manila, and aims to introduce players to Philippine history.

We begin this paper with a brief survey of the ways AR is used in education. We then discuss the constraints surrounding the design of *Igpaw*. We then move on to describing *Igpaw*'s design given the said constraints, specifically discussing which types of educational content are featured in the game, how the game mechanics are designed in order to present this content to the user in an enjoyable manner, and how the game's user interface (UI) is designed to accommodate the game's mechanics, accompanied with a preliminary evaluation of this UI based on a beta prototype of the game. The paper ends with lessons learned and ways forward.

2. AR in Education

In the 1990s and early 2000s, mobile wireless AR was implemented using cumbersome head-mounted displays, with processors carried in backpacks as the user moves in various spaces (Vlahakis et al., 2001). In recent years, however, increases in processing power and miniaturization (Löchtefeld, Krüger, & Rohs, 2011), the pervasiveness of Internet access (Ferreira & Boavida, 2011), and the availability of easy-to-use toolkits (Gu & Duh, 2011) have made it possible to deploy AR applications on tablets and mobile phones. Indeed, researchers now regard AR as a game-changing application in education because it can be used for visual and highly interactive learning, is an active technology that can interact with students, is situated and immersive, and can therefore foster greater transfer of learning (Johnson, Smith, Willis, Levine, & Haywood, 2011).

Many history-oriented AR applications take the form of prototypes, demonstrations, or serious games (Anderson et al., 2010). When used as a prototype or demonstration, AR helps students visualize ancient historical sites. Some examples are virtual cultural heritage reconstruction of a temple in ancient Asuka of Japan (Taketomi, Sato, & Yokoya, 2011); MARCH,

an application with expert drawing overlays of prehistoric cave engraving in the French Pyrenees (Choudary, Charvillat, Grigoras, & Gurdjos, 2009); and The House of Olbrich, a cloud-based AR game for an Art Nouveau building in Germany (Keil et al., 2011).

Serious games refer to complex, highly interactive applications that are designed not only to be purely entertaining but also to carry an instructional message as well (Anderson et al., 2010). Many history-based AR games follow a narrative or storytelling approach usually with an element of fantasy to wrap the historical content. TimeWarp (Herbst, Braun, McCall, & Broll, 2008), uses elves who were lost in time to narrate history around Cologne, Germany. Explore! (Ardito & Lanzilotti, 2008) employs a virtual gift system whenever the player answers correct on every one of 10 missions in an archeological scavenger hunt game. A Greek horse becomes the narrative vehicle of the Acropolis Museum, as it tells of its important contributions to different events (Pujol et al., 2013). The story weaves the horse's story to draw the museum patron's attention to the different artifacts on display.

Igpaw: Intramuros is a serious game that uses an adventure game format to introduce players to historical figures, places, and events. The premise of the game is that a malevolent being has displaced historic figures from the past. The player embarks on various quests in order to restore these characters to their correct time periods, visiting several key historic locations within Intramuros and learning about Philippine history in the process.

3. Constraints

The design of *Igpaw* is subject to many constraints and limitations, from curriculum considerations to their delivery, as well as location issues that affect the usability of the game. This section discusses some of these constraints.

3.1 Curricular and Pedagogical Constraints

The Philippines is an archipelago in Southeast Asia with 7,107 islands. It was a colony of Spain from the 16th to 19th century. In 1898, following the Spanish-American war, the Philippines became a colony of the United States. The country fell to the Japanese in 1944, during World War II, but was liberated in 1945, and declared independence in 1946. During the Spanish era, the capital city of Manila was contained in a walled area called Intramuros, which literally means "inside the walls". For protection, the city contained Fort Santiago, a military complex that housed, among other things, a prison. Among the fort's inmates was Philippine national hero José Rizal. Rizal is most famous for his novels *Noli Me Tangere* and *El Filibusterismo*, which described the conditions of the colony under Spanish rule (Central Intelligence Agency (United States), 2002; Guerrero, 1963).

We intend *Igpaw* to provide supplementary content for Filipino students and local and international tourists with an interest in Filipino history. Filipino students are required to take Philippine history during the 5th and 6th grade (Philippines Department of Education, 2014). The scope of the 5th grade is from the beginnings of the Philippines up to the end of the Spanish colonial period (1800s) while the scope of 6th grade history spans from the 1800s to the present day. Because the curricular scope is so wide, the game designers have to select time periods that are interesting and significant.

Igpaw is not intended to replace classroom instruction. Indeed, it aims to be a non-formal means of education, i.e., learning that occurs in a non-traditional setting; the means of learning (the game design) is controlled by other people; but learners determine what education (if any) they ultimately derive from the experience (Perez-Sanagustin et al., 2014). Follow an adventure game format, players embark on quests to complete predetermined missions that are pulled together by a loose story arc. The adventure game format is suitable for this project's purposes because of adventure games' cited potential to impart knowledge, skills and attitudes to students (Cavallari, Heldberg, & Harper, 1992) and to improve their motivation to learn (Torrente, del Blanco, Marchiori, Moreno-Ger, & Fernandez-Manjon, 2010). *Igpaw's* story makes use of a minimal

number of fictitious characters and objects while still presenting historical information. The historical information is key to solving each mission. Missions may be accomplished in any order, but all missions must be completed for the main story arc to be resolved. This format is intended to be motivating and engaging, to make the learning of history fun and exciting, but whether the players will find it motivating and engaging is, at this point, undetermined.

3.2 Geographical and Usability Constraints

Because *Igpaw* requires players to walk around, looking for game-related sites, the geographic scope of the game has to be limited. Furthermore, it should be noted that Manila was the second most destroyed city during World War II (Jose, 2010). This means that many historical buildings no longer exist. Therefore, game designers have to select outdoor and indoor sites that are still standing or at least have historical pegs on which the developers can build a scenario. On a related note, some historical places require entrance fees. Because these fees may be an impediment to game adoption and completion, sites with such fees are to be avoided if possible.

Partly related to geographic constraints are usability constraints and considerations. As discussed in Herbst et al. (Herbst et al., 2008), these constraints include the balancing of users' attention between real and virtual objects, the simplification of the interaction scheme, and the use of environmental features to overcome technical problems. Foremost among these concerns are the choice of appropriate paths and user safety. Game paths must be interesting and relevant. They must also take into account vehicular and pedestrian traffic, as well as other factors that might compromise the well-being of the players.

3.3 Technological Constraints

Since *Igpaw* is a tablet- and smartphone-based AR application, the level of visual fidelity that can be provided is limited to the capabilities of the target devices. Both Google's Android and Apple's iOS operating systems were targeted to maximize audience reach. In order to achieve a good level of visual fidelity for the game while maintaining cross-platform compatibility across these two mobile OSes, a common game framework called the MAGIS framework (Mobile AR Games for Instructional Storytelling) was developed by the team for *Igpaw* and future games. MAGIS is based on top of the Unity game engine and uses Qualcomm's Vuforia for the computer-vision-based tracking component, as well as a device-sensor-based tracking solution developed in-house that uses accelerometer, compass, gyroscope and GPS sensor data to improve tracking. This combination of vision-based and sensor-based tracking allows for the creation of full 360-degree AR scenes around the viewpoint of the player. An extensive discussion of the MAGIS framework will be the subject of a future paper.

Since the player is expected to finish the entire game in one day (morning and afternoon), battery life is also a major consideration, since players are not expected to be able to recharge their devices during the same day. This consideration influenced the decision to limit the number of AR locations that will be featured within the game.

4. Design Decisions and Implementation

In this section, we document the design of *Igpaw*, subject to the limitations and constraints discussed in the previous section. The options that were available for important design points are enumerated, and the chosen options are provided with justification. We discuss the design considerations for *Igpaw*'s development: from an overview of the selection process of locations and scenarios based on learning objectives, followed by the construction of game mechanics appropriate for an educational AR game, and finally, to the creation of a user interface to efficiently accommodate the aforementioned game mechanics.

4.1 Scope of Contents

History subjects in the elementary and high school level tend to emphasize the recall of historical information, usually following a narrative (Bage, 2012). For the purposes of *Igpaw*, a variety of historical narratives were constructed and interweaved around a number of sites in Intramuros. It is the team's hope that players will be able to recall historical events, persons and objects associated with key sites in Intramuros, as well as develop a deeper appreciation of Intramuros in general after playing the game.

The temporal and geographic constraints discussed in the previous section prevent the development of a historical narrative that follows a strictly chronological order, as this might require players to backtrack to places that s/he has already visited in order to complete the game. Thus, *Igpaw* was designed to present historical sites in a geographically linear manner (rather than the temporal linearity imposed by a strict chronology of events). *Igpaw* is thus divided into three main modules, each focusing on a different location of Intramuros (see Figure 1):

- The first module (in blue) navigates through the longest side of the walled city in the west, and deals with the foreign relations of different nationalities, such as invasions, infiltrations, and trade.
- The second module (in yellow) is centered on the plaza area where most of the power of the city is concentrated. The player is introduced to structures and forces that shaped colonial Intramuros: from the Catholic Church (represented by the Manila Cathedral), to the Spanish government (via Plaza de Roma and Palacio del Gobernador).
- The final module (in red) takes place within cobblestone road area near San Agustin Church and Ateneo Municipal de Manila, and explores the roles of religion and education in the Philippine historical context.

A player that follows the modules in sequence will be able to complete the game with minimal detours, as depicted in Figure 1 (although the player may complete the three modules in any order, to accommodate players who might start at different positions in Intramuros).



Figure 1. Intramuros area map with corresponding avatars per module. Map image © Google.

Since geographic linearity was prioritized over temporal linearity, this has the side effect of simultaneously presenting events/characters/objects that historically appeared in different time periods. This issue is resolved by employing a game narrative that, while deliberately mixing these entities of different time periods, uses in-game dialogue that mentions (either directly or indirectly) the time period of each entity in question. Examples within the game dialogue include:

- Pope John Paul II appearing in the same game scene (Manila Cathedral) with Archbishop Gabriel Reyes. The former mentions the 1995 World Youth Day while the latter mentions that he served as Manila's first Filipino Archbishop starting in 1949.
- An 18th century flintlock pistol present throughout the first module. When the pistol is presented to different characters, they react differently, e.g., Gen. Douglas MacArthur

(1880-1964) describes it as outdated, while Gov. General Basco y Vargas (1733-1805) describes it as advanced.

Some players will be traveling and playing the game alone (i.e., without the presence of a teacher to guide the experience); therefore, some form of virtual mediation must be created in-game in lieu of real-world mediation. An effective example of virtual mediation involves the use of *avatars* to engage students (Carmen Juan & Beatrice, 2011). For the purposes of this game, three such avatar characters were created, one for each module. The three avatars are, in module order: (1) a *daligmata*, a supernatural creature from the Western Visayas region, (2) Crispin, a young character in José Rizal's novel *Noli Me Tangere*, and (3) a decapitated priest with a wardrobe pattern used by the Franciscan friars of the 19th century (see Figure 1).

4.2 Translating Learning Objectives to Game Mechanics

As earlier mentioned, *Igpaw* follows an adventure game format. Adventure games typically operate with an overarching narrative, the unfolding of which serves as a motivation for players to finish the game; if written correctly, historical narratives themselves can serve as adventure game narratives. Adventure games also typically encourage players to explore the game world thoroughly and often in order to solve puzzles; this focus on exploration translates well to an AR game format, where each key geographical feature can be turned into an AR marker that the player needs to find and interact with in order to progress through the game.

The following subsections present the game mechanics. The first subsection focuses on how the individual scenes in the game were designed based on historical information and geographical features. The second subsection elucidates the writing process involved for composing the in-game narrative and how the game engages the player to interact with the world. Finally, the third subsection focuses on the interface options that allow the player to interact with the world and accomplish the learning objectives.

4.2.1. AR Scene Design

Each scene in the game is situated in real-world areas in Intramuros that possess historical significance; key geographical features are selected for use as AR markers. The selection of geographical features is a result of different criteria and constraints in the environment:

- Places must have no entrance fees and must also be safe from vehicle traffic or theft, since the players need to use and concentrate on their phones when playing.
- The developers only included markers from the Intramuros Administration or the National Historical Commission which can be found outdoors, since these markers are permanent and provide great contrast. Otherwise, features that change shadows during daytime (e.g. church embellishments) or are not permanent (e.g. ruins that are prone to erosion) were not considered. (See Figure 2.)



Figure 2. Candidate fiducial markers from (a) National Historical Commission and (b) Intramuros Administration.

4.2.2. *Dialogue Construction and Revision*

The in-game dialogue serves to move the game’s narrative forward. In order to keep players engaged, scene interactions must affect the way the characters behave and react. Thus, every time the player accomplishes a minor objective in the scene, the dialogue for a specific character changes (these are tracked by the game by setting internal *flags*) and the player is encouraged to interact more with that character or other entities on the scene.

While writing the game dialogue, the team extensively used the concept of *motivators*. A motivator refers to a mechanism that elicits intended behavior or responses from players (Jian & MacKie-Mason, 2012). For example, one scene requires that a Spanish dictionary be given to an officer-in-training who is struggling with the language. The characters and objects reveal information to clue in the player about what s/he needs to do (e.g., when talking to the officer-in-training, he will mention that he is “probably going to fail the Spanish language component of [his] three-month course”). Apart from this, the designated character guide of each module will usually remind the player of the current objectives and how to accomplish them (e.g., the *daligmata* in the said scene will mention that dictionaries “are always helpful for people learning the language”).

4.2.3. *Interactions as Game Mechanics*

Igpaw adopts standard adventure-game mechanics such as starting conversations, returning objects to owners, and using objects for a purpose. Players can use, talk to, or examine the current virtual entity on screen, as well as combine the said entity with any of the items that the player has acquired. To streamline the game design for usability, the types of interactions possible for each game entity is minimized and made as context-sensitive as possible: “talking” can only be done with virtual guides and characters, while “using” can only be done with virtual inanimate objects.

To establish the scene objectives, the virtual guide for the module introduces the location, and then encourages the player to look around for objects to interact with. While most virtual items that can be picked up by the player are designed such that their use is self-evident, they can also be presented to the virtual guides, who will, in turn, provide hints for these items’ intended use, thereby encouraging players to pick up and present every item they encounter. For example, in one scene, there is a pre-war pistol that bears enough resemblance to a modern revolver such that players will immediately be aware that it is a weapon, and the *daligmata* virtual guide, when presented with this pistol, will remind the player that s/he may need to eliminate a certain character in order to proceed.

Once the goal of a particular scene has been accomplished, the virtual characters will also provide hints about where to find the next location. The game includes a tutorial mode so that players may familiarize themselves with the types of interactions that will accomplish the scene objectives.

4.3 *User Interface*

This subsection discusses how the user interface is developed around the adventure-game-style mechanics that were designed for this game. We first discuss the unique interaction model developed for this application, followed by a description of the game’s flow and the results of a preliminary evaluation of the interface with test subjects.

4.3.1 *Orient-and-Select Interaction Model*

To support our AR game’s mechanics, a user interface is designed to take advantage of the device camera as a supplementary input device. The “point-and-click” nature of graphical adventure games from the 1990s translates well to mobile AR applications by using a first-person-perspective interface that we shall call “orient-and-select”—a player may interact with virtual objects simply

by orienting the camera to focus on the desired object, then selecting an action, e.g., examine, use, talk, etc., via the touchscreen (see Figure 3).



Figure 3. Orient-and-select gameplay mechanic for character interaction (left) and inventory access (right)

The interaction buttons are radially positioned around the lower left and right corners of the screen in order to minimize hand readjustment from the resting grip position, especially when the player is using a tablet configuration. A reticle also frames the currently-selected virtual object or the face of the virtual character to direct attention and ensure to the player that the currently-displayed interaction buttons apply to the said object.

Instead of having the user swipe through his/her inventory to select an item (as is common with other touchscreen games), the device's pitch orientation (i.e., rotation along the X axis) is used instead. This interaction model is consistent with the model used by the main AR screen and allows the player to keep a firm grip on the device at all times. Additionally, the currently-selected inventory object slowly rotates around its center to allow for close examination.

4.3.2 Game Screens

To facilitate transitions between the AR mode of *Igpaw* and other modes, the game is compartmentalized into use-specific *screens* (see Figure 4). This compartmentalization also helps to minimize the overlap of background processes (e.g., by separating the map screen from the AR screen, the game, at any given time, may enable either the camera or the GPS component of the device, but never at the same time, thus reducing battery consumption).

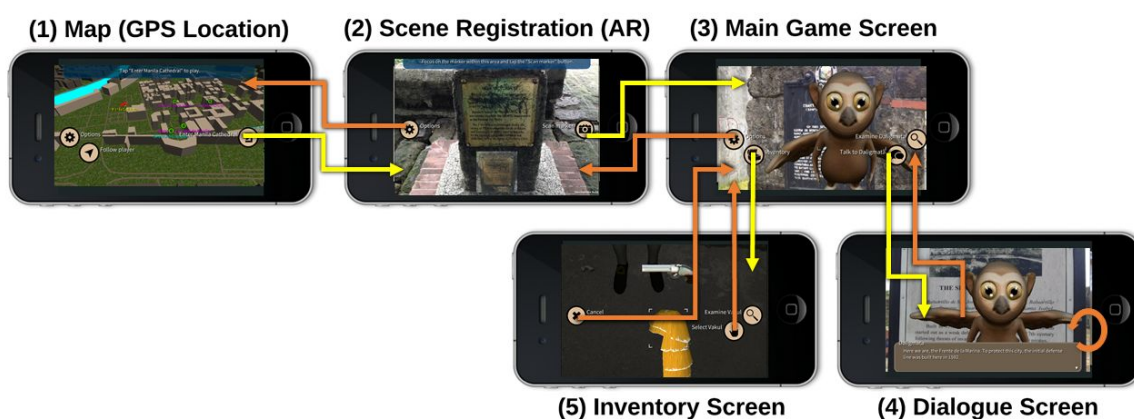


Figure 4. The game's flow visualized in terms of screens.

After some preliminary testing with different device orientations, the team decided to build the interface in landscape orientation only, to allow the interaction buttons, game dialogue and conversations with virtual characters to occupy more space without obscuring the AR view compared to a portrait orientation. Furthermore, holding large devices (such as tablets) upright in order to effectively use its camera will usually require the use of two hands for stability, thus making a landscape orientation more suitable.

4.3.3 Prototype and Testing

A beta prototype using the aforementioned design is built for purpose of gathering observations, and user interface concerns that were uncovered during this test are collected and discussed among the team.

The virtual scenes are constructed in such a way that the virtual objects or characters are placed around the player's location. Preliminary game testing revealed, however, that players did not immediately realize whether a virtual object is existing outside of their devices' field of view (e.g., behind or below them). Hence it became necessary to inform the player of the existence of these objects via the game's narrative (e.g., spoken by the game characters).

Testing also revealed that a minority of users try to "touch" the virtual entities as they appear on the device screen, notwithstanding the presence of the 2D interaction buttons. Furthermore, even though the AR scene was only limited to one fixed position and only allowed for rotational freedom, some players still walked around the area to find the desired objects. The team is currently investigating solutions where the game can exhibit special behavior to prevent these types of player behavior. Aside from the virtual guides' dialogue, GUI overlays are also under development in order to give visual cues for the player to look around for virtual entities while in the AR view.

An extensive beta testing period was conducted prior to the release of the game. This period included, along with black-box/white-box testing of the individual features of the game, *usability tests* involving participants from the target audience of high school/college students, in order to uncover user experience issues. Also, the final release of the game implements *activity logging* to collect important data about how the game is played by unattended players. The information extracted from the logged data can provide useful evaluation parameters concerning time, location, and tasks performed by the user. Raw time logging captures the duration of gameplay on particular scenes or entire modules. GPS locations can also be traced along with time to get an indication of users lingering or hurrying within a scene. Certain "milestones" in game progress (e.g., retrieving an important item, defeating a boss character, etc.) are also logged along with their timestamps. Relating and synthesizing these observations may give an indication of the game's difficulty, immersiveness, and playability. The results of the usability tests and the analysis of user logs will be subject of future publications.

5. Conclusion

This paper describes the design of an AR game for Philippine history. Related work in educational AR games justify the feasibility of this application for educating students about the historical site of Intramuros, and the project constraints and limitations guided the design of this smartphone- and tablet-based application as a narrative-heavy adventure game. In particular, the design process involved (1) identifying the learning objectives relevant to the histories of Intramuros, (2) creating suitable game mechanics to target said objectives, and (3) constructing an optimized user interface for the players to navigate easily throughout the game.

Igpaw: Intramuros has been released on 30 July 2015 on the Google Play Store, with the iOS release pending approval from the Apple App Store, and is a nominee for Qualcomm Vuforia's 2015 Unity Developer's Choice Awards. Future work will involve the development of additional modules featuring sites outside of Intramuros (possibly encompassing multiple game "sequels"), as well as improvements to the core MAGIS framework on which *Igpaw* is based.

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