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Igpaw: Loyola — Design of a Campus-Wide Augmented Reality Game Using MAGIS

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Abstract: We present *Igpaw: Loyola*, a new location-based mobile AR (augmented reality) adventure game designed to be played within the campus grounds of the Ateneo de Manila University. *Igpaw: Loyola* improves upon its predecessor, *Igpaw: Intramuros*, by upgrading gameplay mechanics to accommodate lengthier learning modules, improving the usability of both interactive (AR) and navigation (non-AR) portions of the game, and enhancing the game authoring process with the help of an improved version of the MAGIS (Mobile Augmented-Reality Game-Engine for Instructional Support) framework. A preliminary user evaluation is also presented.

Keywords: Augmented Reality, Educational Game Design, Usability

1. Introduction

Augmented Reality refers to the real-time superimposition of virtual objects (or content) in a view of the real world (Azuma, 1997). Location-based AR expands on this concept by using the user's real location to provide content specific to the user's area (Reitmayr & Schmalstieg, 2003). Location-based AR opens many potential applications in education. One such application is in teaching and learning history while physically visiting historical sites such as prehistoric caves (e.g., Choudary, Charvillat, Grigoras, & Gurdjos, 2009), outdoor museums (e.g., Spierling, Winzer, & Massarczyk, 2017), and entire historical city districts (e.g., Rodrigo, Caluya, Diy, & Vidal, 2015).

Several reviews discuss how AR can boost the educational experience: AR increases student motivation (Billinghurst & Duenser, 2012; Bower, Howe, McCredie, Robinson, & Grover, 2014; Nincarean, Alia, Halim, & Rahman, 2013) and achievement (Bower et al., 2014; Jerry & Aaron, 2010), and positive attitudes towards education (Bower et al., 2014; Jerry & Aaron, 2010). It also creates a rich ecosystem for student-centered approaches such as constructivist learning, situated learning, inquiry based learning, and game-based learning (Bower et al., 2014).

Developing an educational AR game requires finding the middle ground between content, pedagogy, and usability. Poor design compromises the game's effectiveness as an educational medium, its usability, and its overall enjoyability (Rodrigo, Vidal, Caluya, Agapito, & Diy, 2016). Studies have shown that players of educational AR games experience cognitive overload (Yuen, Yaoyuneyong, & Johnson, 2011), fatigue (Rodrigo et al., 2016), exposure to adverse weather conditions (Rodrigo et al., 2016), and risks to personal safety (Rodrigo et al., 2016; Yuen et al., 2011). Classroom management and adherence to a lesson plan can also be a challenge (Yuen et al., 2011).

Faced with the challenge of developing content-rich historical games, this paper discusses the design of a new location-based AR game, entitled *Igpaw: Loyola*. In this paper, we present game design decisions that address or mitigate the above-mentioned encumbrances while aspiring to hold the attention of the user in terms of gameplay length, breadth of content, and enjoyability. *Igpaw: Loyola* is the spiritual sequel to a previously-released game, *Igpaw: Intramuros* (Rodrigo et al., 2015); thus, the improvements that we have built into *Igpaw: Loyola* (henceforth abbreviated as *Loyola*) will be presented in comparison with the earlier game (henceforth abbreviated as

Intramuros). These are categorized into two sections, Gameplay Design and Game Authoring Improvements. A section on the game's usability testing is also presented, followed by some concluding remarks.

2. Gameplay Design

Igpaw: Loyola is a "serious game", a computer game that is not limited to providing entertainment but is also meant to be used for learning and education (Anderson et al., 2010). *Loyola* is the successor of *Igpaw: Intramuros* (Rodrigo et al., 2015). While *Intramuros* is played within the historical walled city of Intramuros in Manila, Philippines, *Loyola* is played within the campus grounds of the Ateneo de Manila University, located in Quezon City, Philippines.

The choice of location serves several conscious design decisions. *Intramuros* focused on Philippine history and was therefore set in a well-known tourist location in the Philippines. This has the advantage of accessibility, but safety is compromised due to the high incidence of petty crimes and accidents. Also, casual tourists usually visit Intramuros only once, which forced the game to be short enough to be completed by a tourist in one visit (1-2 hours). Tourists usually cannot visit the same points of interest (POIs) multiple times, resulting in the game having a very linear progression. Some nonlinearity is introduced by dividing the game into three non-overlapping parts (called "modules"), but this is more to accommodate players entering the city using different entrances, and the story had to be simplified so that story events in one module do not interfere with the events in another module.

On the other hand, *Loyola* is essentially a virtual tour guide for visitors and prospective or current local and international students of Ateneo de Manila University, a school founded by the Society of Jesus. While this audience is significantly smaller compared to *Intramuros*, the game can readily receive an influx of new users every school year due to student admissions. The game's subject matter includes some elements of Philippine history and mythology, as in the previous game, but *Loyola*'s main focus is to provide information on Ateneo's culture, values and tradition, as well as introducing players to various personages of Ateneo, such as Fr. Horacio de la Costa (the first Provincial Superior of the Society of Jesus in the Philippines), and St. Ignatius of Loyola (the founder of the Society of Jesus). Safety risks are minimized because entry to the campus is regulated (although visitors may obtain permission to tour the campus with no fee). Also, the campus is replete with covered walkways and benches, increasing players' personal comfort compared to *Intramuros*. The game's tighter play area also enables *Loyola* to feature a handful of non-linear story branches and to significantly increase play time from *Intramuros*'s 1-2 hours to around 3-5 hours (non-stop), with more content and places to visit. The one-visit-per-POI restriction has also been lifted—players may revisit several locations to accomplish new game objectives, which adds gameplay variety.

2.1 AR Scene Design

The basic Augmented Reality (AR) scene design of *Loyola* follows closely that of *Intramuros*. The player is accompanied by a virtual guide or avatar (Carmen Juan & Beatrice, 2011) that orients the player about gameplay basics and subsequently direct the player to visit the Points of Interest (POIs) within the Ateneo campus. The very first AR scene, as in the previous game, serves as a tutorial and does not require a fiducial marker to start, while each subsequent AR scene happens in a POI that the player must travel to, and contains a fiducial marker that the player must scan using their device.

Unfortunately, unlike in *Intramuros* where most interesting POIs are marked with official plaques and signages from the National Historical Commission and/or the Intramuros Administration, the POIs within the Ateneo campus do not offer the same fiducial marker consistency. Some markers that were initially thought to be permanent were taken down during the game's development. New markers needed to be commissioned to replace older or missing markers. Finally, some markers are too reflective (or the lighting significantly changes throughout the day), so some photo processing was done to allow recognition by ordinary mobile cameras (see Figure 1 for examples).

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Figure 1. Problematic markers, before and after processing to remove unnecessary feature points.

While new mobile AR technology offers initialization of AR scenes completely without fiducial markers, such as the planar-surface recognition offered in ARCore (Google, 2017) and ARKit (Apple, 2017), these technologies are mismatched with the *Igpaw* series' gameplay style, which requires 360-degree viewing around the player's vantage point and may not always have visible horizontal planar surfaces. However, feature tracking provided by Vuforia (PTC, 2016) provides moderately stable AR views while being upward-compatible with ARCore and ARKit, and MAGIS's inertial-measurement-unit (IMU)-based tracking algorithms (Vidal, Ty, Caluya, & Rodrigo, 2018) are used as a downward-compatible fallback for lower-end hardware.

2.2 Narrative Design and User Interface

Intramuros previously relied on a time-traveling plot to explain why historical characters from different points in time appear in the game at the same time—a malevolent force displaced the characters from their respective time points. *Loyola* uses a different plot to bring about the same intention; players use their mobile devices to enter an alternate dimension where personages from the past now thrive. This alternate dimension is also home to Philippine mythological creatures, some friendly and some non-friendly, and references to Ateneo campus lore. (See Figure 2.)

Figure 2. Characters and creatures in *Igpaw: Loyola*, from left to right: Fr. William Schmitt (in agent uniform), a balatiti, a garuda, and Rondo (the resident cat of Faura building).

As with *Intramuros*, the gameplay of *Loyola* uses an adventure game format, a popular and well-studied form of narrative exposition in games (Neitzel, 2005). Players can interact with virtual objects by focusing their camera on a virtual object, then tapping on a verb icon. Selecting the correct chain of verbs moves the story forward, changing the environment and/or the characters. For example, a player can engage in combat using verbs like "shoot" and "swing" (see Figure 3).

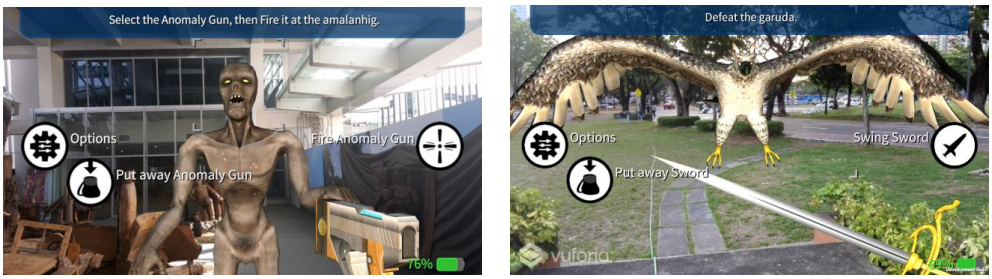

Figure 3. Inflicting damage to in-game enemies with the anomaly gun and the Sword of Loyola.

2.3 Location Sequencing and Navigation

Since *Loyola* now allows players to travel back and forth between POIs and select between POIs for different story branches (unlike in *Intramuros*), the map guidance system is redesigned for *Loyola* to show only the active POIs on the map to reduce confusion, automatically zooming in or out to visualize walking distances to each POI (see Figure 4). The shortest path between the player's current location and his/her selected destination are now automatically computed, using information on the walkable areas of the campus collected during design-time (discussed in a later subsection).

Figure 4. Map guidance showing three POI choices (story branches) from the player's position.

3. Game Authoring Improvements

Igpaw: Loyola, like its predecessor, is developed using MAGIS, the Mobile Augmented-Reality Game Engine for Instructional Support framework (Vidal et al., 2018). MAGIS's AR and mapping subsystems were significantly upgraded for the development of *Loyola*, as discussed below.

3.1 AR Game Logic Subsystem and Script Authoring Tool

MAGIS uses its own scripting language to define the interactive functionality of AR scene objects ("game logic"). For *Loyola*, this scripting language is upgraded to support integer flags. *Flags* are variables that control the overall state of the game and determines which game objects and actions are available for the user to perform interactions with. These flags are strictly Boolean true/false values in *Intramuros*, but support for incrementing and decrementing integer-valued flags, as well as evaluation using comparison operators (such as less-than <, greater-than >, equal ==, etc.) is added due to the increased complexity of *Loyola*'s game scripts.

A more significant change is the construction of a dedicated authoring tool (AT), intended to simplify scripting and consolidate further modifications to the scripting language. Figure 5 depicts the AT's user interface. The AT follows a hierarchy of elements to keep the script organized. The highest elements in the hierarchy are the Objects found in each scene (e.g. Anomaly Gun, Little Pepe, etc.). Each Object has at least one Interaction element (or verb). The most commonly used Interactions are readily available on the dropdowns, which are: Auto, Examine, Talk to, Use, Pick up, Activate, Use, Give, and Show. Authors can also name their own custom Interactions. Each Interaction has at least one Condition Set element. These Condition Set elements hold the Conditions, either bool or int, required to trigger interactions, as well as the list of commands that will be executed when the entire Condition Set holds true (with support for AND and OR operators).

Figure 5. The MAGIS Authoring Tool (AT).

3.2 Mapping Subsystem and Offline Mapping Tool

Intramuros implemented its mapping functionality via the MapZen vector tile service (Mapzen, 2016), which unfortunately was shut down during the development of *Loyola*. Also, the raw OpenStreetMap data (Openstreetmap Contributors, 2012) for the Ateneo de Manila University area was inaccurate with regards to the placement of pedestrian paths. Thus, an offline mapping tool was created that automatically downloads the map tiles from OpenStreetMap for the entire playing area, then uses these tiles as a guide to lay out the pedestrian paths as sequences of segments defined by waypoints (with some waypoints marking the positions of POIs/fiducial markers). This tool is deployed to a mobile device and is used to accumulate raw GPS positions while a developer navigates their way within the campus, with real-time path editing. The paths may also be manually edited on a PC for refinement. The downloaded map tile data can be further stylized by an artist and bundled in the game (so players do not need an internet connection), and the final, accurate walkable paths are overlaid on top (see Figure 4).

4. Usability Evaluation

Igpaw: Loyola's usability evaluation is divided into two phases. The first phase, described here, involved more than 15 participants and is used for soliciting suggestions for improvement and to uncover bugs in an early version of the game. The second phase is detailed in a subsequent paper.

For this first testing phase, each tester is accompanied by a facilitator who briefly introduces the game then asks him/her to figure the game out by themselves, while observing their every action and reaction. The tester is asked to provide feedback and suggestions in an open-ended manner at the end of the test, with each response substantiated by affective feedback observed by the facilitator.

In summary, most testers described their experience as fun and enjoyable, that the interactable objects were interesting to observe through augmented reality, that the story progression was smooth, and that their interactions trigger events that were satisfying to watch. On the other hand, testers also found the game tiring (as was expected due to the walking involved), and that their concentration is broken when bugs appear. They disliked some aspects of the user interface (particularly, choosing items from the inventory), and they feel frustrated whenever they are unable to scan the marker correctly. Notably, some testers remarked that the POIs seem to be irrelevant to what is happening in the AR scene. This is later resolved by updating the game dialogue to make the connection to the POIs more direct (e.g., "Did you know that Dela Costa Hall is named after...").

Some testers liked the combat aspect of the game, but critiqued that there were few combat options available, and that simply pressing a button to attack does not feel engaging enough. Other testers felt that the game needed to have mechanics for when the player is walking from one POI to another outside of AR mode, such as item/weapon collection or random battles. While these suggestions were noted, the game was too far into development to change the current mechanics.

Out of the 12 marker locations tested, 3 markers failed to consistently register, and were subsequently fixed via the preprocessing that was earlier described in section 2.1. Other minor bugs were also found (such as the virtual guide not appearing after scanning), but most issues were due to user confusion (e.g., visiting the wrong POI). All found bugs were fixed before the final release.

5. Conclusion

This paper describes the design of a new location-based AR game, *Igpaw: Loyola*. The design knowledge accumulated from developing its predecessor, *Igpaw: Intramuros* (Rodrigo et al., 2015, 2016; Vidal et al., 2018) allowed the development team to fashion a more streamlined AR game experience, avoiding design pitfalls related to cognitive overload, weather conditions, and player safety, which impede on the game's usability (Rodrigo et al., 2016; Yuen et al., 2011). The additional challenge of targeting a longer overall playing time prompted the development of enhanced game mechanics and authoring tools. While not all factors have been completely addressed with this design (e.g., player fatigue due to walking, insufficient game mechanics to hold

player engagement), the resulting game promises to be an enjoyable learning experience, according to user feedback. The game is available on the Google Play Store and the Apple App Store.

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