ARnopoly: exploring strengths and weaknesses of AR experience enhancing board games

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Abstract

This project aims to explore and apply the best practices of Augmented Reality (AR) design to the board play. We adapted the Monopoly game, developing an AR version that integrates the traditional game with new elements to take advantage of the virtual world. Our goal is to explore which AR game rules and mechanics can be incorporated into board game design to create a more engaging and effective experience for players. With ARnopoly, we specifically examined the strengths of augmented reality and the weaknesses that need to be addressed to seamlessly integrate the physical board play with the digital experience. ARnopoly was tested involving 7 participants, and from the analysis of their feedback it emerged that the integration of the board play with AR increases the immersion in the game and the overall positive feeling. However, in the long run, since the monopoly-like game is very long-lasting, this positivity is dampened by the constraint of holding the device in hand which causes fatigue in the user.

Keywords

Augmented Reality, Board Game, user experience, game experience

1. Introduction

Recently interest in augmented reality (AR) application has risen, in particular in gaming domain. Advancements in the development of CPU, GPU, and sensors embedded into smartphones at an affordable price fostered the design of new engaging augmented reality (AR) gaming experiences in both research and commercial field. The players experience the physical interaction using tangible interfaces enhanced by virtual elements such as images and sounds that integrate the physical world. This blend of real and virtual elements offers a new way of play, transforming how users engage with with real and virtual play elements.

In research, recently AR board-game applications have been proposed primarily targeting the domain of healthcare and education [1]. The AR board game by [2] supports health education for high school students, it is made by a physical board and question cards on health and these cards are integrated by virtual hints on the correct answer visible with the smartphone. While ARQuest [3] is a collaborative mobile augmented reality game for developing computational thinking skills of primary school students. This AR game combines a physical board and tangible tokens with animated 3D content to engage children in the play. Finally, the authors of [4]

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personalized the Monopoly game with Macau representation on the board to spread Macau culture fostering tourism.

These have been the first studies to deepen the integration of physical and virtual elements for a serious purpose. However, in all these approaches the design of the integration of physical and virtual world is strictly tied to the aim of the serious game and educational experience.

Only later, thanks to [5, 6] a common taxonomy on AR board game design has been developed. It clusters eight domains, each one on a policy of interaction design feedback and its integration in the physical play. *(i) Timing*, as countdown or time rounds, since digital devices can easily keep track of play time and inform the user. *(ii) Randomizing*, as randomization of items generated on board, since digital devices allow for a full randomization of game elements such as dices or in case of chance cards. *(iii) Housekeeping*, how the virtual application interacts with the board, since the generation of virtual elements on the physical board should foster the navigation of the game board at each play turn, *(iv) Informing*, as the flow of information to the player, since digital applications allow to keep track of scores of the players and other data that the player can visualize at any moment, *(v) Storytelling*, as digital effects and customization of characters, since digital applications allow to generate customized virtual content on the board. *(vi) Remembering*, since applications can record player's actions and progresses. *(vii) Calculating*, since digital devices allow to automate calculations that in traditional board games are manually held by players, *(viii) Teaching* since digital applications allow the implementation of interactive tutorials.

Based on this taxonomy we adapted the Monopoly game in an augmented reality version called ARnopoly. We integrated the traditional rules of Monopoly with innovative new rules to fully take advantage of the virtual graphics and feedback. Our aim is to explore which AR game rules and mechanics can be integrated in boar-game design to make a game effective and engaging for players. In particular with ARnopoly we explored what are the strengths of the augmented reality experience and instead what are the weaknesses that will have to be addressed to successfully integrate the physical board game with the digital experience.

2. Materials and Methods

ARnopoly is an at-home AR board game adaptation of Monopoly that integrates the physical board with an Augmented Reality application on the smartphone. The game is local-multiplayer and all the players play with a personal smartphone in the same room. The AR app was developed using Unity3D game engine and it is compatible with Android and iOS. Each player will hold her own smartphone to play with the game by framing the physical board to visualize the virtual elements.

2.1. Board and AR tracking management

As first step we designed the **board**. Since the game is inspired by Monopoly, we opted for the traditional Monopoly board with a huge marker stamped in the center. All the players have to frame the marker to start the play. The presence of the marker allows to identify the position of each smartphone with respect to the board and to generate a shared virtual space among all the players. This approach allows each player to visualize the virtual contents, during the

game, from a different point of view based on their physical position in the real space. The **AR generation** is composed by three phases: (i) the marker registration, in which all the players frame the marker and register their device for the play; (ii) the tracking phase, that is deputed to convert the smartphone position in real world in camera coordinates (and vice versa); and the (iii) display & interaction phases that is the generation of the virtual content on the smartphone's screen, based on the coordinates calculated at the previous phase. The (ii) and (iii) steps continuously update over time to maintain consistency of the point of view of the player with the smartphone. Finally since the game is a local multiplayer, the information is shared in real time in a local net (in which the first player is considered the host) allowing the real-time updated of the virtual elements on screed of the actions performed by other players.

2.2. Custom Rules & Design

As second step game rules were designed to fully take advantage of the AR experience. In particular Monopoly is made by multiple pieces that are physically represented as stylized version of real world such as houses and hotels that the player can build on the terrains that she buys. In ARnopoly the player will visualize the virtual building on the physical table, this will allow a more realistic perception of the land that each player is gaining during the play and the achievements following *Informing and Housekeeping principles*. All the buildings are virtually generated on the lands and all the elements on each land are interactive and animated to improve the engagement of players in the virtual experience. In ARnopoly the houses are represented as a single 3D structure that can level up from level 1 to 5, level 1 corresponds to a a single house, level 4 to a huge building, and level 5 corresponds to the conversion in a hotel.

Not only houses and hotels are available, following *Storytelling principle* in ARnopoly we introduced new game mechanics of **Super-Buildings and Artifacts** to fully take advantage of AR technology, allowing the player to make choices and apply her personal strategy. Super Buildings comprehend new virtual animated elements which enable new penalties/gains for the players. Artifacts give temporary super powers to the players. Both these mechanics are implemented thanks to the automatization of complex calculus through technology, following the *Calculus principle*.

A **Super-Building** can be built with limitations (and with higher costs for the player): a player can build a Super Building only if she owns all the lands of the same color and can build only one type of Super Building on the lands set. Also super buildings increase their level from 1 to 5 and are represented with a 3D enhanced aesthetic version (for example the fountain at level 1 is simple, while at level 5 has a statue on it). The *Community Chest* and *Chance* cards have been modified, and new ones have been added to interact with the new game elements. Houses and Super-Buildings are digitally shown on the board. Super Buildings are the following. The **Park** allows the builder to have a constant income: when a player lands on a park nothing happens, however at the end of each player's turn each park has a 5% chance to add money to the owner of the park. The **Casino** is a building for gambling. When a player lands on a cell with a casino she pays the owner an entrance fee. Once payed: a huge virtual Casino wheel appears in the center of the board (over the ARnopoly text) on all the players' screens. The wheel is divided in green and red segments. If the wheel stops on a green one, the player wins the amount of money, otherwise she will have to pay that amount to the bank. If the player who

Figure 1: Game screen on the smartphone with the physical board, the houses build and the UI buttons informing the player on money, on lands possessed and on possibilities of trade/mortgage lands.

ends up in the casino is the owner, she won't have to pay the entrance fee, and has probability of winning higher than other players. When an opponent ends on the **Fountain**, all players will have to make a collection to pay the owner that increases her money. The **Storehouse** gives a fixed profit. If a player lands on her storehouse, she can decide whether to withdraw or deposit money. The player must consider that the money deposited will not be accessible until she lands again in one of her storehouses. The money in the storehouses works as an investment: it increases by a percentage every time the owner passes Go. This *return rate* varies according to the average level of storehouses owned, up to a maximum of 10%.

Artifacts replace the Free Parking cell in the traditional Monopoly. On this cell are represented two 3D stalls and when the player reaches it she can buy some helps, that will work for a a limited round time. Artifacts design follows *Calculus and Storytelling*. The available Artifacts are: the **Sprinter** that increases the money collected at the Go cell with 50$ more; the **Graybeard** that allows the player to pass the turn without rolling the dices; the **Economist** that allow the player to pay the 85% of the total cost of a land to buy it; the **Rogue** that enables the player to steal 3% of the money of another player or to exit free from prison if needed; and finally the Builder that enables to pay 85% of the cost of a structure to build it.

2.3. Game Interface

To ensure *Informing, Remembering and Calculating principles*, the player can obtain various information and interact in multiple ways with the game. The user interface has been designed to inform at every round all the players on what is happening and on their current status (money and properties of lands and buildings).

Figure 1 shows the interface. The tree rounded buttons of the left from top to bottom represent the Trade, the Mortgage and the Buildings management. The player can visualize the card of each land after clicking on each one of the buttons, since information on the land is fundamental to continue with the Trade/Mortgage or Building. These buttons are enabled on screen only during the player's turn. On the right the name of the players are shown with the money earned by each of them, in addition small icons near the name indicate if currently a player possesses an active Artifact. Players' names are covered with a red line if they lost the game and went bankruptcy. To ensure *Informing principle*, the players can view on their screens a label near each land with the color of the pawn of the player that bought it, as shown in Figure 2.

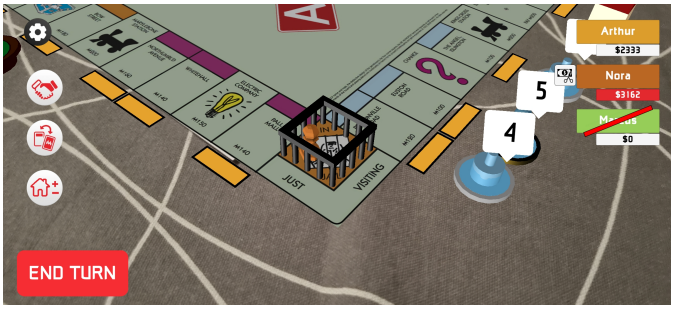


Figure 2: Player is locked in prison. In this image reader can notice the labels that are visible near each land that indicate the proprietary of it

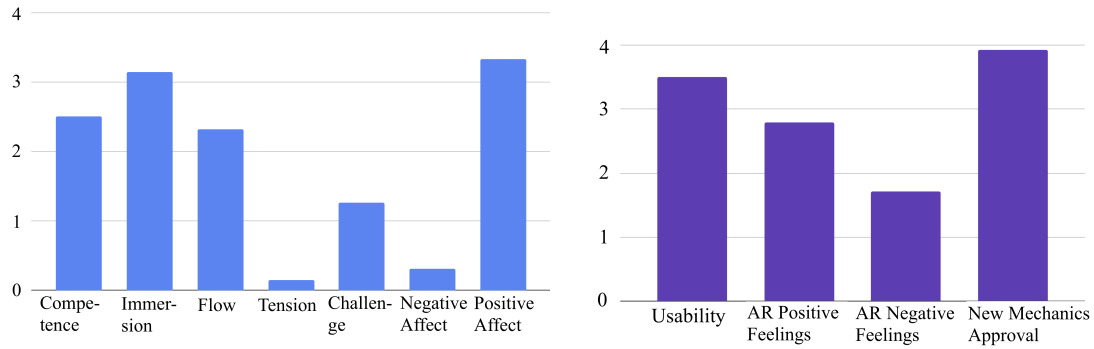
Following the *Randomizing and Informing* principles, only the board was made physical, the players' paws, the Chance and Community-Chest **cards**, and the **dices** are shown digitally on top of the board. When the player picks up a card it is shown in the center of all the players screen to inform them on the card picked. If the player goes to the prison the pawn is moved inside a 3D jail represented on the corresponding cell, once it is the turn of the imprisoned player a popup appears and she can decide to pay or to launch the dices to do a double and exit.

All the 3D elements are shown near the land with an icon on top indicating the current level of each building (in addition to the 3D different shape of the building depending on the level). In addition to the graphics also audio feedback have been implemented, for example the fountains have spatial audio of water sound, the casino has the sound of the rolling wheel, etc.

Finally, for *Timing principle* each player is informed when it is her turn, and at the bottom left of the screen is enabled a red button that allows to roll the dices (or to pass the turn to the next player if Artifact is active). The dices animation, as well as other animations, is shown in real time on all the devices.

3. Results

The final version of the game has been tested by 7 volunteers, 3 males and 4 females (mean age 32.0, SD 14.65) in order to evaluate the game under various aspects by seeing it in action. All the players were experienced in using traditional mobile applications but had not played with AR applications in the past; they occasionally played with board games. All the volunteers played once with ARnopoly in groups of four and three and expressed their opinion. Each player installed the ARnopoly application on her Android smartphone and played by holding the smartphone during the whole game. The players applied their strategies through the interface shown on the mobile phone that enabled the virtual interaction with the board, including the new game mechanics of Super Buildings and Artifacts. To evaluate the gaming experience and collect their opinions, we followed the ***Game Experience Questionnaire*** modified version to access digital experience of games by [7]. The users gave scores to the Questionnaires from 0 to 4, with (0) corresponding to not at all, (1) slightly,(2) moderately,(3) fairly, (4) extremely agree. Specifically, we made use of the *Core GEQ Module* and in addition we posed to users one ad hoc questionnaire to evaluate AR aspects of the project. The first module (*Core GEQ Module*)



(a) GEQ (from left to right): Competence, Immersion, Flow, Tension, Challenge, Neg. Aff., Pos. Aff.

(b) AR (from left to right): Usability, AR Positive Feel., AR Negative Feel., Mechanics Approval

Figure 3: Average of answers given to Game Experience GEQ (a) and AR Experience (b) questionnaires

includes seven categories: **Competence**, as accomplishment, euphoria, and pride as in game experiences, and pride also as post game experience; **Sensory and Imaginative Immersion**, as the immersion the game can create using the player's senses and imagination; **Flow**, as concentration, being absorbed; **Tension**, as nervousness; **Challenge**, as difficulty perceived in the game; **Negative Affect**, as shame, anger, irritation, disappointment, ignorance as in game experiences and guilt as post game experience; **Positive Affect**, as enjoyment, pleasure, relaxation in game experiences, and energized as post game experience.

From what we can observe from Figure 3a, the game has reached a modest *Competence*, *Flow* and *Challenge*, while the *Tension* and *Negative Affect* are really low (less than 1). These data are closely related to the type of game, since in Monopoly-like games these aspects are minimal. While the *Sensory and Imaginative Immersion* and *Positive Affect* received a rather positive rating (greater than 3). This is due to the addition of the 3D graphics and digital feedback to the traditional play, as reported by users. AR elements fostered positive sensations and immersion, due to the animations appearing during the play as well as audio feedback. However, further improvements should be done in the to the design of a full AR experience, by taking advantage of the physical interaction. In particular the game design can be improved with the addition of physical pieces in the board to foster physical interaction between players, not necessarily adding physical cards that should be framed at every round, but adding more appropriated physical pieces such as stylized fountains, casino, houses and even other types of obstacles that will become engaging animated 3D content once framed with the smartphone.

The second questionnaire focuses specifically on the perception of the AR experience. The testers were asked to score: Usability; AR Positive Feelings; AR Negative Feelings; New Game Mechanics Approval. From the Figure 3b, it can be seen that the testers appreciated the presence of the new game mechanics. Furthermore, it seems the graphical interfaces and the methods of interaction with the map have been satisfactory, leading to good usability. In general also the AR experience was positively evaluated, and the AR Positive Feelings outweighed the negative ones. However, from the answers on Negative Feelings it emerges that many players have found tiring to hold the smartphone for a long time, due to the physical weight of the device. In future

developments, the addition of new rules to the game mechanics should be considered with the aim of fastening the game session reducing the load on the players, since AR experience requires the user to keep the smartphone in the hands.

4. Conclusions

ARnopoly demonstrates that integrating AR into traditional board games can enhance player immersion and enjoyment. However, updates should be performed to ARnopoly rules before performing a more in depth usability study. Our testing revealed a key challenge: while AR elements initially increase engagement, the need for prolonged device use in games like Monopoly can lead to player fatigue, reducing the positive impact. The play time should be reduced by integrating new rules, for example updating the Artifacts by increasing penalties and/or gains to fasten a win/loose event keeping the engagement of a strategic play. Also the physical interaction should be improved in ARnopoly, e.g., exploiting a physical board made of parts to compose, or physical cards each one associated to a virtual interacting element/animation, as recently suggested by [8, 9]. Moreover, as highlighted by the participants to this study the presence of physical pawns that interact with virtual objects may further improve immersion in the AR experience. Future studies on ARnopoly should take into account the use of cards and physical paws in the virtual play.

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