

ARe mobile mixed reality games pervasive?

Evaluating mobile mixed reality games in the market for pervasiveness

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Abstract

Smartphones have allowed Mixed Reality (MR) and Augmented Reality (AR) to become accessible to consumers, rather than staying academic exercises. Recently a survey of academic, pervasive, MR games has been made [8]. The study presented in this paper looks at mobile MR games available to consumers to see if they are pervasive and how this influences popularity judged by the amount of players. 56% of the games found are pervasive, but only 32% use AR and only 16% are pervasive AR games. No correlation exists between being pervasive or AR and the popularity of the game.

Categories and Subject Descriptors H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; K.8.0 [Personal Computing]: General—Games

Keywords augmented reality, mixed reality, games, consumers, pervasiveness

1. Introduction

The terms Augmented Reality (AR) and Mixed Reality (MR) are often used interchangeably. This is not entirely correct, as AR is but one end of the MR continuum (see figure 1). AR overlays contextually relevant information on top of a view of the world via a computer [3], while part of MR is also Augmented Virtuality, in which the main part of the experience is virtual and only enhanced by real elements. [7]

AR games for mobile phones typically use the magic lens principle [1] which displays the live feed of the built-in camera and enhances it by overlaying 2D or 3D graphics depending on the current real world position and orientation of the user (potentially gathered from GPS, orientation sensors, gyroscopes or image analysis of the camera data). Location-based games also fall into the realm of MR. Unlike AR, however, they usually display additional information on a map view of the environment.

These two methods are, in current examples, mutually exclusive in the sense that they do not occur at the same time. There are

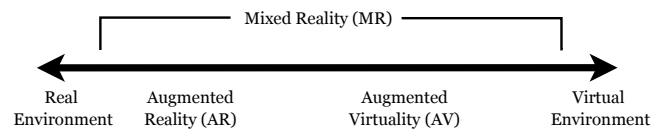


Figure 1. Simplified diagram of the mixed reality continuum. From [7]

examples though of games that make use of both modes, but never at the same time. Examples of this will be given in section 3.

The information displayed can be useful, e.g. for a tour through a city [2], or as part of a game. [6] Mobile games in such a context are called mobile mixed reality games (MMRGs).

Most games adhere to certain social, temporal and spatial boundaries [11] which create the archetypical “magic circle” of play. [5] When one or more of these boundaries is blurred, a game is called a pervasive game. These games may be MR as well, but do not necessarily have to be so. In the game Killer, players try to “assassinate” other players during a certain period of time that can easily stretch over days or weeks and thus pervades into their real life routines (temporal expansion). Players are generally not aware who the other players are, except for their target (social expansion). Everywhere the players travel automatically becomes part of the game which creates a physically borderless game area. Also, the players can make use of any real world object to help them in their task (spatial expansion) Using computers to get information about your target is allowed, but that does not make it MR. For that to be the case, the computer would have to generate part of the gameworld. [9]

Although many research projects into pervasive MMRGs have been conducted, e.g. TimeWarp [4] and Epidemic Menace [6], these have never become available to consumers. Now, with the ever growing proliferation and capacities of smartphones, MMRGs are entering the consumer market. This makes it interesting to analyze if these kinds of games actually benefit from being pervasive.

2. Method

Scope

In order to limit the amount of games to be evaluated the following criteria were used. First, the game has to run on Android phones as this was the technology available to the author. Secondly, the games had to be truly mobile, i.e. you have to move through the real world to play the game. [12] This criterion is taken somewhat liberally, if games allow the player to play without moving but the experience is enhanced by moving, they are still included.

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Finding games

The games were found by searching the Android Marketplace and Google using the terms “augmented reality”, “AR” and “mixed reality” with and without “game” added, as well as the term “location based game”. Google also yielded results for non-Android devices which were inspected for the availability of Android versions. If they were not found, the result was discarded.

To stay up to date, several google alerts were created informing the authors of new results for the aforementioned keywords. These were treated the same way as the results from the original search.

Analyzing the games

Each game is scored on each of the boundaries, spatial, temporal and social. These can be expanded to make it a pervasive game on a three point scale. The values of the scale are “not expanded” (0), “expansion is possible, but not mandatory” (1) and “expanded”(2). This was chosen, rather than a binary rating because some games do not require users to cross any boundary but doing so may make it easier. In a game like Tidy City for example, the player has to solve riddles to find certain places. One could cross the social boundary and ask someone in the street for help in the hope they have local knowledge, but it is in no way necessary to do so. This takes into account that people always interpret the rules in their own way.

Games that are rated as expanded on at least one of the three aspects of pervasive games, are considered to be pervasive.

A game is considered spatially expanded when real world elements are used in the game, even if only conceptually, in a way that is not blatantly obvious.

If the player status can be affected by others, even when not playing a game is temporally expanded. This is also the case when a player can be dragged into the game by other external cues.

Social expansion is the case when players are unaware of who else is in the game and this is relevant for the game or when players interact with non-players.

In contrast with pervasive games that are not mediated with mobile devices, the player can always choose to turn off their device or the game thus preventing true temporal expansion. Some games try to circumvent this somewhat by sending players an email when something relevant happens. For the sake of analysis, it was assumed that players are very dedicated and thus never shut down their device and keep the game running at least in the background.

3. Survey of the market

What now follows are the games that are included in the study together with a short description. Due to limited space, no screenshots are included. When no social activity is mentioned in the description, it is impossible within the game. Unless otherwise specified, the games can be found in the Android Marketplace by using their names.

In **Android hunt** the player fights with other players that are in the vicinity. Attacking is done by selecting the avatar of another player and then selecting the preferred attack. Winning is rewarded by points that let the player access better gear and skills. A single player mode is also available.

AR Bots (<http://goo.gl/32XW4>) sees the world being invaded by evil robots you need to destroy with your own robots. The game shows the virtual robots through a magic lens and is purely single player. The playingfield is determined by the location of the player.

ConquAR¹ is another MR version of a board game: Risk. Users have to conquer cities and places by traveling there and attacking

the local armies by selecting them via either a magic lens display, a map or a list.

DJ Rivals is an MMORPG in which the player takes on the role of a DJ that has to defeat the commercial music industry drones as well as other players. The main gameworld is virtual, only the names of companies in the surroundings are used as labels for locations in game. Beating other players is asynchronous, i.e. the computer plays the opponents part.

GPS Draw allows the player to make drawings by walking around, tracing the players steps either on a map or canvas.

Home invasion lets the player invade the neighborhood in which he currently is, as a flying saucer that has to collect dots that are spread out along the streets in the neighborhood while tanks are trying to stop him from doing so.

Mister X is an MR version of the board game², in which a team of up to five detectives has to catch a spy who is on the run before the time runs out. All players get a map of the area showing the current location of the detectives and the last known location of the spy, which is updated at a set interval. All players get tools to help them or hinder the others. The detectives can call each other from the game if they enter their phonenumbers. When setting up a game, the game master sets a radius in which to look for people who are currently looking to join a game. Everybody can be included, even people who are not familiar with each other.

Mobeo pits players against each other, either in a public game accessible to everyone or in games only available to a limited set people, e.g. friends. Players target each other with throwable weapons like flaming cabbages or traps like a banana peel. To deploy a trap, a player has to be at the location where he wants to deploy the trap. Players can also interact with each other via the game.

In **Nuclear** the player has to locate and diffuse a nuclear bomb. The game interface consists of a Geiger counter to determine the proximity of the bomb and an electromagnetic pulse to disable the bomb.

Instead of escaping zombies, in **Outbreak, Zombie Apocalypse** the player either has to kill as many zombies as possible or infect as many healthy people as possible, depending which of the two they are. The game is based on a map display and in order to travel to new locations, the player has to physically move there.

Parallel Kingdom is a Massively Multiplayer Online Role Playing Game (MMORPG) with the game world overlaid on top of a map of the real world. The player can travel to new game locations by traveling in the real world or via several game mechanics, some of which require interaction with other players. It is also possible to chat in game with other players.

Phone Bomber allows players to place virtual bombs on a map to blow up other players who are physically in the blast radius. If one succeeds in blowing someone up, one gains experience and acquires better gear.

In **PhotoFari** players have to take pictures that match a certain pattern. Every correct picture opens up a new, more complex pattern. The player is assisted in finding an image that contains the

¹ Runs on Layar

² also known as Scotland Yard though

correct pattern, by an overlay of the pattern on the camera input (a magic lens display).

In the game **Portal Hunt** (<http://goo.gl/9J23g>) players have to hunt down portals that are floating around the vicinity, alone or in teams. These portals become visible through a magic lens display.

ScavengAR Hunt¹ is a digital take on the real life pastime scavenger hunt. Instead of collecting tangible objects, players look for digital objects and collect them. In doing so, they gain points and rise on the leader board. The virtual content is presented via either a map, a magic lens or a list.

SVNGR is a scavenger hunt game in which players complete tasks at certain locations to qualify for both virtual and real rewards. Tasks can be e.g. checking in, i.e. notifying ones friends via a social network that one is at a certain location, a set amount of times, answering a question or posting a message about the location to a social network. Reality is mixed using a map and by awarding real rewards for virtual actions.

In **Seek 'n Spell** players walk around in a set radius for a set time, collecting letters which are displayed on a map to form words. Their length determines the awarded points.

In **SpecTrek** ghosts are roaming the neighborhood and you have to catch them. The device is used both as a magic lens and a map. When you are close enough you can see the ghosts through the magic lens and catch them, otherwise you will need to use the map to locate the ghosts. The more ghosts you catch, the more experience points you get and the further away you can see and catch ghosts. It is also possible to find items, though these are not marked on the map. Players are rewarded with awards, a logbook of their records and an overview of the calories they have used. Results can be shared via Twitter, but this is not mandatory.

Tidy City (<http://goo.gl/t9NAT>) lets people collect riddles that can be both textual and/or visual, which they have to subsequently to solve by bringing them to the correct location. When a riddle is solved points are granted, if one tries to solve it in the wrong place points are deducted. Per mission a highscore list is available. The information is displayed on a map.

Tourality can be played alone or in competition between individual players or teams. The goal is to be the first at certain points in the game. This is rewarded with "gold" that can be used to buy powerups. Players can see the location of the points and each other on a map.

In **Treasure Hunters AR** players bury and look for virtual treasure chests. The longer it stays hidden the more valuable it becomes. The goal is to acquire as much gold as possible.

The goal of **VuHunt** is to conquer as many castles as possible from other players and prevent others from capturing yours. Attacking a castle is done by completing a task which can be answering a question, writing a story, making a picture or video of a certain object. The greater the distance to the castle under attack, the more costly it is to attack.

The goal for the player in **Woomba Mania**¹ is to catch as many of the right sort of Woombas, a sort of fluffy creatures that float around you, as they can. There are also bad Woomba's though that deduct points. The player can see the Woomba's through a magic

lens display, a list or a map.

YouCatch is basically a mixed reality version of the game Killer [9] that runs on the **Joyity** platform. Players have to hunt each other down and virtually catch them with the aid of their phones.

In **Zombie, Run!** the player has to get from his current location to a new location of his choosing without getting caught by (virtual) zombies. The game gives the player a map on which the current location of the zombies is displayed. It is possible to play the game with multiple players.

4. Results and Discussion

The results of the analysis of the games can be found in table 1. Some games are available for other platforms too, so the number of installs in the Android market is a minimum amount.

A general observation is that there are different and interesting game concepts in the MMR spectrum available, but few of the ones offering or even relying on social aspects have reached critical mass and so hinder the players.

AR games are difficult to do well, as tracking and occlusion are known problems [12], this is reflected in the relatively low number of AR games found (8 or 32%) of which 3 are built on the same framework (Layar). More games, 14 (56%), are pervasive but only 4 (16%) are both pervasive and AR.

After removing the games for which no information on number of players was available and converting ranges to their average, the correlation between number of players and pervasiveness or AR was tested using R. Pearson's product moment was used to calculate the point-biserial correlation and its significance was tested using a two sided t-test. There is no significant correlation between number of players and AR, $r_{pb} = -.15, p = .49$, or pervasiveness and number of players, $r_{pb} = .01, p = .95$.

Pervasive games are arguably more demanding to a player. They involve traveling to achieve game goals, require regular attention and force the player to socially interact with outsiders.

AR may fail to attract consumers for a number of reasons. First of all, there aren't many AR games to be found and the ones that exist are hardly marketed. This means a consumer has to actively look for this type of game, rather than being able to suddenly find them. Furthermore, technical limitations may reduce the players satisfaction which makes them less likely to actively search for similar games. These limitations are e.g. the inaccuracy of GPS and the high end hardware that is required. Finally, AR has a high novelty value which can wear off quickly, especially when the aforementioned limitations come in to play.

5. Conclusion

Where most of the games in [8] require specialized hardware, games in this study need generic (Android) smartphones. This allows the public to play, though pervasiveness nor being AR seem to have an impact on the popularity of MMRGs.

This paper has only looked at the effect that being AR or pervasive had on the popularity of games that fall under the category Mobile Mixed Reality. For future research, it may be interesting to compare popularity between MMRGs and regular, non Mixed Reality Games on mobile phones. Furthermore, including other platforms like the iPhone may yield different results.

Although many games meet the definition of a pervasive game, none of them are as extensive as the games mentioned in [10]. Those games are generally set up way more massively, encompassing larger areas and some times even actors. A possible explanation

Game	Pervasiveness			Map or Lens	# players
	Spatial	Social	Temporal		
Android Hunt	0	2	2	Map	10k-50k ^b
AR Bots	0	0	0	Lens	119 ^c
ConquAR	0	0	2	Both	16k ^c
DJ Rivals	0	0	0	Other	500k-1M ^b
GPS Draw	0	0	0	Map	3k-15k ^b
Home Invasion	0	0	0	Map	10k-50k ^b
Mister X	2	1	0	Map	10k-50k ^b
Mobeo	2	2	2	Map	1k-5k ^b
Nuclear	0	1	0	Other	1k-5k ^b
Outbreak, Zombie Apocalypse	0	0	2	Map	50k-250k ^b
Parallel Kingdom	2	0	2	Map	500k-1M ^b
Phone Bomber	0	2	2	Map	10k-50k ^b
PhotoFari	2	0	2	Lens	5k-10k ^b
Portal Hunt	0	0	0	Lens	N/A
ScavengAR Hunt	0	1	0	Both	39,964 ^a
SCVNGR	2	2	0	Map	500k-1M ^b
Seek 'n Spell	0	0	0	Map	1k-5k ^b
SpecTrek	2	0	0	Both	100k-500k ^b
Tidy City	2	1	1	Map	400 ^c
Tourality	0	1	0	Map	5k-10k ^b
Treasure Hunters AR	2	0	2	Both	1k-5k ^b
VuHunt	2	0	2	Map	10k-50k ^b
Woomba Mania	0	0	0	Both	N/A
Youcatch	2	2	2	Map	N/A
Zombie, Run!	1	0	0	Map	500k-1M ^b

a. Based on highscore list; b. Based on installs in the Android Marketplace; c. According to the developer.

Table 1. Table showing the scores for games on different dimensions. Names in **bold** mean they are pervasive.

is that those games have been played for many years and thus have had the time to mature, while the technology for mobile mixed reality is only now coming into the hands of the average consumer. Another explanation is that the pervasive games mentioned in [10] are more like event based games. This means a lot of time and effort has been put into organizing them for a one time run, whereas the ideal for MMRGs on the market is that anyone can pick them up at any time and just play them.

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