**Applied Game Technologies Report**

**Name:** Euan Watt

**Student ID:** 1200755

**Module:** AG1003A Applied Game Technologies

**Module Tutor:** Grant Clarke

**Word Count**: 3819

Table of Contents

[Introduction 2](#_Toc449450144)

[Chosen Technology 2](#_Toc449450145)

[Developed Prototype 3](#_Toc449450146)

[User Guide 3](#_Toc449450147)

[Prototype 4](#_Toc449450148)

[Inspiration 4](#_Toc449450149)

[How is AR Used Appropriately? 4](#_Toc449450150)

[Limitations 5](#_Toc449450151)

[Application Design 5](#_Toc449450152)

[Problems and Solutions 6](#_Toc449450153)

[Critical Evaluation 6](#_Toc449450154)

[Assets 7](#_Toc449450155)

[Augmented Reality Innovation 7](#_Toc449450156)

[Marker-less AR 7](#_Toc449450157)

[Alternative Hardware 8](#_Toc449450158)

[Microsoft Holo-lens 8](#_Toc449450159)

[Android/ iOS 8](#_Toc449450160)

[CastAR 9](#_Toc449450161)

[Nintendo 3DS 9](#_Toc449450162)

[Conclusion 9](#_Toc449450163)

[Reference list 10](#_Toc449450164)

# Introduction

Technology in games has come a long way since the industries humble beginnings in the 1940’s (Kent 2001). From arcade machines to simple 8-bit home consoles; the Sinclair ZX Spectrum to monstrously powerful PCs and the Nintendo Power Glove to modern virtual reality (VR). Each passing year sees a slew of new hardware and advances in techniques to get the best out of such hardware. Augmented Reality (AR), the concept of bringing the digital world into reality, was first conceived by Lyman Frank Baum in 1901 (Norman 2016). Since then, it has progressed from an idea on paper to a technology capable of bringing high quality, real-world overlays to mobile devices (Swider 2015), of aiding soldiers in the battlefield (Prigg 2014) and transporting video games physically into the living room (C. Burns. 2015). The developed prototype aims to expand a relatively small, but ever expanding catalogue of AR games by utilising AR and marker technology within the PlayStation Vita. The prototype is a take on the racing genre, where the goal is for the player to construct the track they are to race upon and race against the clock. It utilises all six available markers and can be played anywhere with an available flat surface. AR has a way to go however, with several advancements on the horizon such as marker-less AR (Fetters 2014) and dedicated hardware (Microsoft 2016).

# Chosen Technology

Augmented reality and virtual reality are fundamentally very similar concepts. The ultimate difference however, where virtual reality transports the player into the virtual world they wish to explore, AR brings the digital world into reality.

AR gives a direct or indirect view of the real world through their device (Mashable 2016). Using this, the technology overlays a digital output to augment it in particular ways. It is capable of providing real-time feedback of the surrounding environment, such as geographically relevant information; shop and restaurant details to social media posts posted from tagged locations. Sony has even been able to create a device that can give physical information about an object placed onto the display. The device can also detect drawings and illustrations within books and automatically bring them to life with colour and subtle animations (Statt 2016).

Of course, an extension of many technologies is video games. AR provides an entertaining and novel platform for innovative mechanics and play styles. One of the main genres for AR, particularly when it comes to using markers, is puzzle games. PulzAR (XDev Studio Europe 2012) for the PlayStation Vita utilises the given markers to generate a puzzle on a flat surface. When the game detects a marker, a laser grid with obstacles appears on the table. The player is then tasked to bounce lasers off of mirrors, rendered where the player places the remaining markers, to hit the target and complete the puzzle.

There are also a couple of games that flip AR on its head and allow the player to almost reach out and touch the game they are playing. Both Tearaway (Media Molecule 2013) and ModNation Racers: Road Trip (SIE San Diego Studio 2012) utilise the rear touch pad of the Vita to give the player control over elements within the game. Tearaway has the player defeat enemies by pressing on the back of the console, which renders a finger within the game giving the impression the player has physically reached in to the game (see figure 1). Similarly, ModNation Racers features a track builder which the player can interact with through the rear touch pad. When placing track pieces, the player can manipulate the height of the terrain by simply dragging their finger across the back of the console.



Figure : A human finger interacting with the digital world of TearAway (Media Molecule 2013, Seeto 2013)

AR is so different from traditional video game technologies that it offers certain gameplay mechanics not yet seen in traditional video games. Not only does it mix the real and digital worlds in a graphical sense, but the real world can interact with the digital in new ways. Real objects can be used to disrupt or enhance gameplay by having them incorporated into the digital world. New mind-bending puzzles requiring physical movements to solve and using the player’s physical location and surroundings can provide world-scale gaming environments.

# Developed Prototype

## User Guide

On start-up of the application, the user will be greeted with a view from the rear-facing camera. On-screen, there are various UI elements to be aware of. Firstly, down the left-hand side of the screen is the scoreboard featuring the top 5 best times set by the player. Secondly, at the top of the screen sits the current lap timer. To start a race, the user has to simply accelerate the car (by pressing X) off of its starting position and the timer will start. The race will end by hitting the start position again or by resetting the car – the scoreboard will update automatically. Lastly, in the bottom right hand corner is the speedometer of the car and the frames per second counter.

If, when the application loads, the screen is washed out or is too dark; simply press the triangle button to recalibrate the sensor. This is also useful if the Vita is finding it difficult to pick up the desired markers.

To build a track to race upon, the user must place marker 1 in view of the camera. Then, by placing other markers near and around marker 1, more track pieces will appear on screen. When the other track pieces are close enough to marker 1, these will ‘snap’ to marker 1 and extend the track. Whilst constructing the track, each piece can be rotated (by rotating the marker) to fit the design the user is looking for. Once the user is happy with their creation, may the race begin!

Controls:

X: Accelerate

Square: Decelerate

Circle: Reset vehicle

Triangle: Reset camera

Left Analog Stick: Steer

The car will rotate to a higher degree the more the analogue stick is rotated to the left or right. Thus, the analogue stick should be treated like a real steering wheel within a car.

## Prototype

### Inspiration

The prototype concept was devised whilst considering the current catalogue of games for the PlayStation Vita. Several games utilise features of the Vita to great effect and it was from this that the list was quickly narrowed. ModNation Racers: Road Trip (SIE San Diego Studio 2012), allows the user to create customisable race tracks for them and their friends. Utilising the built-in touch controls both on the front and rear of the console, players can manipulate sections of the track. This concept stood out as each marker could be placed on screen and act as a piece of race track. Using the markers to build the track means that not only can the player design the track they wish to race upon, but also choose the environment in which it resides.

### How is AR Used Appropriately?

In place of a dedicated track builder like that found in ModNation Racers, the prototype relies on the six markers used for AR on the Vita. The main mechanic of the prototype is for the player to place markers in an appropriate fashion in order to construct a track. This is done by first placing marker 1 on screen, followed by the remaining markers until the player is satisfied with their track. As each subsequent marker is placed down, and it is within range of another marker that is either marker 1 or already attached to marker 1, the new track piece will ‘snap’ and extend the track. This fully customisable, modular aspect of the prototype pushes past the ModNation Racers track builder by mixing reality with the digital world. By using augmented reality and the associated markers, the track can be built on virtually any surface; a desk, a table, the floor, on grass, anywhere. Furthermore, the race-car almost becomes a toy for the user to play with. Instead of the user physically using their hand to drive a Hot Wheels or Matchbox car across potentially easily damaged surfaces, the game gives a fun, digital representation to be driven around freely.

### Limitations

There are a number of limitations with the prototype. Firstly, the Vita only supplies and allows for six markers to be used at once. This results in the user having to be somewhat imaginative with their track layouts. Secondly, with the limited scope of the project and artistic talent of the developer, there is little physical customisation of the track pieces themselves. The prototype provides the user with two straight pieces of track and four corners; each of which can be rotated by simply rotating the associated marker. However, the original concept aimed to provide alternative textures, banked corners, humps and bridges and much more. Similarly, an alternative choice of car was planned but acquiring the appropriate models proved extremely difficult. Thirdly, the lack of screen real-estate on the Vita limits the effective ‘canvas’ for the user to play with; providing cause for the lack of markers the Vita supports. Fourthly, the prototype is limited to a ‘time-attack’ style of gameplay. Without an AI opponent, the user must play alone or pass the console among friends. Lastly, the track must feature marker 1. Without it, the player’s car will appear on a marker on screen and will be able to drive, but the racing and track building element of the prototype simply will not exist.

### Application Design

The application is based off of the ar\_app project provided by Grant Clarke for AG1003A Applied Game Technologies. Several classes were added to increase and aid functionality of the prototype. A GameObject class was created to store relevant functions and variables, such as; collision detection, various matrix manipulations as well as storing the mesh or model and local transform matrices. Similarly, an input class was devised to handle any necessary input; utilising a switch case to determine the response based on which button was pressed. Furthermore, the marker tracking code was also wrapped into a class. This allowed for a simple call to reset the camera if needed and an update to be called in the main loop which returns a vector of marker transforms if any have been discovered.

The ARApp class contains the bulk of the project and the main update loop. It is within this class that all rendering is done, models are loaded and meshes created. It also contains the main attraction of the application; the track builder. By calculating the Euclidean distance between markers on screen, the track builder will align each of the track pieces to a grid centred on marker 1. The track can be thought of as a form of puzzle as each additional piece added to the track becomes a new hub for pieces to snap to. Two vectors control which pieces are a part of the track. One vector simply contains the marker ID of each track piece not currently attached to marker 1. The second utilises a struct to provide information on both the marker ID and the x and y positions relative to marker 1.

### Problems and Solutions

Over the course of the project, various issues were encountered. Firstly, it quickly became apparent that there were very specific requirements for loading models into the application. This proved troublesome when searching for models online, but ultimately was no more than a nuisance. Secondly, file reading and writing was attempted using std::fstream and later using Abertay Framework’s File class. Reading a text file from the bin folder was a simple task; but even after adding a write function to the aforementioned File class by following the provided Sony documentation, writing to the file consistently failed. This was overcome by simply reverting to pre-defining the high score table in the initialise function of the ARApp class. Thirdly, in order to determine the chosen orientation of track pieces, numerous attempts were made. The first consideration was to garner the rotation difference between marker 1 and the current marker. Multiplying marker 1’s quaternion by the inverse of the current marker’s quaternion would provide the rotation difference in between the markers, but the conversion into Euler angles would not have been trivial. After some trial and error, the final solution was rather simple; by taking a point in space relative to the current marker, rotating it by the marker’s physical rotation and taking the arc tan of the x and y coordinates, a final rotation around the marker’s z axis was found. Lastly, finding an appropriate way of building a track and keeping the car on said track took some effort. Initially, the prototype was very similar to its final form but neglected to ‘snap’ the different pieces together. This resulted in z-fighting and peculiar interactions with the collision detection. Later, a system was developed to have the car determine which marker it was closest to at any given moment. With this, the car’s base transform would change to the new closest marker, requiring finding the world position of the car and the difference in marker positions, as well as the difference in rotation between the markers in order to translate and rotate the car seamlessly around the new marker. This was soon scrapped in favour of the current system. Where the car’s transform is always based around a single marker and the other track pieces are translated to perfectly align with said marker. This prevents all aforementioned problems in z-fighting, collision detection and complex rotation mathematics woes.

### Critical Evaluation

There are numerous areas where the application could be improved. Firstly, the overall class structure is not ideal. The controller input class requires being initialised with a specific game-object. This severely hampered the ease-of-use nature of classes for various tasks requiring the use of the input class outside of the game-object. There were at least two examples of things needing to be reset within the game that resulted in Boolean pointers and a Boolean getter within the GameObject class in order to work around the poor design. In hindsight, at least one of these could have been moved to the GameObject class and reduced part of the problem. Secondly, due to the lack of appropriate resources for the game, the texture coordinates of the plane class were modified when a corner section was required. By rotating two of the coordinates by 90 degrees, the same texture can be used for both the straight and corner pieces of the track. It results in a stretched texture over half of the object, but it serves its purpose. Lastly, the track builder is not wholly stable at times. Occasionally, the markers, when rotated, will flicker between two rotated states. This can be very distracting for the player and is a little disappointing considering the effort expended in getting it to work. Furthermore, when the application detects a second marker for the first time, it will sometimes freeze for a moment. It is not entirely clear where the freeze occurs, but is presumed to be within the track builder, getting stuck in an iteration loop.

Despite these perceived failings, the developed game is a fun and interesting take on the racing genre for AR. Allowing players to create their own tracks, albeit with limited options, is a platform primed to be expanded upon. With the addition of some varied assets and a more complex collision detection algorithm allowing for more detailed terrain among other things, the track builder could form a very entertaining game for the PlayStation Vita.

## Assets

A few assets were sourced for the developed prototype.

* The car model (3dregenerator 2012)
* The road texture (Chugai 2013)
* The speedometer needle (DSMTuner 2012)
* The speedometer notches (Speedhut 2016)
* The speedometer numbers (Speedhut 2016)

To conserve memory, the speedometer notches and numbers were combined using GIMP. A small logo was also removed from the speedometer numbers.

# Augmented Reality Innovation

The PlayStation Vita is only one of many vessels for the application of AR technology; there are numerous alternative devices and innovations in the works.

## Marker-less AR

In contrast to the Vita’s method of AR, where the application of AR requires markers, marker-less AR is on the rise. No longer are dedicated markers required to bring the virtual world into reality. Geographical apps for smartphones and some dedicated hardware are capable of detecting elements of the user’s surroundings without the aid of markers. Devices such as the Holo-lens (Microsoft 2016), CastAR (Takahashi 2016) and some smart phones are at the forefront of AR development and offer unique experiences. Commercially available apps for smart phones can detect a person’s geographical location and by scanning the local area with their phones, are given real-time feedback about near-by points of interest. It is this form of AR that could take the developed prototype to new levels. By detecting surfaces in a player’s local environment, such as walls and tables, tracks could be built across entire rooms without having to stick markers everywhere – infinitely expanding the games replay-ability.

## Alternative Hardware

Whilst the prototype was developed for the PlayStation Vita, companies are developing alternative and even dedicated AR technology. All of these could be used to play the game in various ways; as discussed above, marker-less AR would allow the game to be played in infinite ways and the 3DS offers a wider market share for the current game to access.

### Microsoft Holo-lens

The Microsoft Holo-lens is a dedicated piece of hardware; similar to the Oculus Rift or HTC Vive, both brand new consumer headsets for VR; in terms of it being wearable technology. When the user puts on the headset, the digital world is projected onto surfaces in their environment. A recent demo at E3 2015, Microsoft wowed audiences by playing Minecraft on a table (Kotaku. 2015). As video games become more ingrained in society and kids learn more and more from playing them as they grow up; being able to take a game like Minecraft and allow them to play it in a similar way to, for example, toys in a sandbox or playing with Lego could not only help stimulate their brains in a new way, but gives parents greater accessibility to their digital creations also. This hardware is particularly interesting as it is capable of detecting items within its environment and projecting scenes directly onto them. A second demo from Microsoft demonstrated a player battling aliens that were bursting out his living room walls (C. Burns. 2015). This room scale gaming environment was attempted before via the Kinect, but restrictive dimension requirements limited its usage; the Holo-lens appears to combat this by centring the game-world around the player in their environment.

### Android/ iOS

In 2014, there were approximately 6.8 billion active mobile phones on the planet (Chen 2014). According to Statista (2016), roughly a third of those will be smartphones by the end of 2017. This makes the smart phone the ideal technology for bringing something novel to world. We have seen it happen countless times with games; Flappy Bird, Angry Birds and Monument Valley; all huge global successes all thanks to the humble smartphone. It is for this reason that AR has a growing market on mobile; spreading past games to promotional material, fun additions to books and geographically relevant information; all on your smartphone by peering through its camera. Later this year, Pokémon Go (Niantic Inc. 2016) aims to finally get everyone using AR by combing an overly popular technology with a similarly popular franchise. The game will have players scan their surroundings in search of Pokémon who will appear on their screen – on a table, in a bush, anywhere; the goal is then to battle, capture and train your Pokémon as you would in a typical Pokémon adventure. Furthermore, the Guinness World Book of Records tried out AR for their 2015 edition book (Feltham 2015). Users were able to scan markers next certain entries and see a representation of the record. For example, scanning the marker next to the world’s tallest man made the man pop out of the page in full scale.

### CastAR

CastAR, similar to the Holo-lens is a dedicated piece of hardware for mixing reality with the digital realm. Originally developed under Valve (French 2013), CastAR has an ambition reaching further than just video games. Tech demos have demonstrated traditional computing on any surface; word processing, task management and browsing the internet; as well as room scale and table top gaming (Takahashi 2016). CastAR is touted as being the device to bring dedicated AR to the mass market, just as Oculus and HTC/ Valve have for VR with the Rift and Vive, respectively.

### Nintendo 3DS

Nintendo embraced the world of 3D with the release of the 3DS. The handheld boasts several novel features; 3D rendering without glasses, a camera capable of taking 3D photographs and much more. With this, Nintendo has included AR capabilities with the use of markers like Sony with the Vita. Alongside the pre-loaded mini-games, several games in the 3DS library utilise the markers to great effect. Nintendogs (Nintendo and Nintendo Entertainment Analysis & Development 2011), for example, allows the player to visualise their virtual pets within the real world; playing on your desk or in the garden. However, Nintendo takes their AR a small step further than Sony. One of their pre-loaded mini-games, Face Raiders (HAL Laboratory 2011), places enemies in the surrounding area directly around the handheld. The player’s task is then to rotate the console to look around the room and shoot down the enemies. The game is simple, but utilises an alternative method of AR.

# Conclusion

In conclusion, augmented reality continues to be a technology in its relative infancy. It is still being treated as something of a novelty on mobiles and handheld games consoles, and dedicated hardware is still out of the reach of consumers. However, with the upcoming release of Pokémon Go (Niantic Inc. 2016) and said hardware, there is a distinct possibility that AR will become a household technology. It could be argued, like with some technology, that until it has been developed to an extent where users can enjoy the benefits of AR without having to openly show off that they are doing so, AR will not take off. Humans have an intrinsic desire to please those around them, even with their appearance. So, until something can be hidden or is seen as fashionable, the general public will not actively seek out a new piece of wearable technology. However, gamers are renowned for embracing new technology. The recent release of the Oculus Rift and HTC Vive has demonstrated this to an unprecedented degree. It is likely that the hardware will exist in some form, such as the CastAR glasses, for some time before the perfect game captures the imagination of gamers worldwide. Perhaps that game will be a fully customisable, modular racing game for the PlayStation Vita.

# Reference list

3dregenerator. 2012. Old Car. [Online 3D Model]. <http://tf3dm.com/3d-model/old-car-80440.html>. [Accessed 22/04/16].

*Microsoft HoloLens demo onstage at BUILD 2015.* 2015. [Online]. Directed by C. Burns. <https://www.youtube.com/watch?v=3AADEqLIALk>: YouTube. [Accessed 25/04/16].

Chen, S. 2014.  *More people around the world have cell phones than ever had land-lines.* [online]. Available from: <http://qz.com/179897/more-people-around-the-world-have-cell-phones-than-ever-had-land-lines/> [Accessed 23/04/16].

D. Chugai. 2013. *Seamless Road Texture.*[Online Image]. Available from: <http://texturelib.com/texture/?path=/Textures/road/road/road_road_0021;> [Accessed 20/04/16].

DSMTuner. 2012. *Ptkct.* [Online Image]. <http://gtaforums.com/topic/518950-a-speedometer-request/> [Accessed 21/04/16].

Feltham, J. 2015.  *Preview: Guinness World Records: See it 3D 2015 for Gear VR.* [online]. Available from: <http://www.vrfocus.com/2015/01/preview-guinness-world-records-see-3d-2015-gear-vr/> [Accessed 25/04/16].

Fetters, Z. 2014.  *What is markerless Augmented Reality? | Augmented Reality Bites.* [online]. Available from: <http://www.marxentlabs.com/what-is-markerless-augmented-reality-dead-reckoning/> [Accessed 25/04/16].

French, M. 2013.  *Valve's 'perfect hiring' hierarchy has 'hidden management' clique like high school.* [online]. Available from: <http://www.develop-online.net/news/valve-s-perfect-hiring-hierarchy-has-hidden-management-clique-like-high-school/0115316> [Accessed 10/22/2015].

HAL Laboratory. 2011. *Face Raiders.* Nintendo.

Kent, S. L. 2001. *The ultimate history of video games: From pong to pokémon and beyond : The story behind the craze that touched our lives and changed the world.* Three Rivers Press.

*Minecraft Hololens demo at E3 2015 (amazing!).* 2015. [Online]. Directed by Kotaku. <https://www.youtube.com/watch?v=xgakdcEzVwg>: YouTube.

Mashable 2016.  *Augmented Reality.* [online]. Available from: <http://mashable.com/category/augmented-reality/> [Accessed 24/04/16].

Media Molecule. 2013. *Tearaway.* Sony Computer Entertainment Europe.

Microsoft 2016.  *The latest on Microsoft HoloLens.* [online]. Available from: <https://www.microsoft.com/microsoft-hololens/en-us> [Accessed 25/14/16].

Niantic Inc. 2016. *Pokémon Go.* The Pokémon Company.

Nintendo and Nintendo Entertainment Analysis & Development 2011. *Nintendogs + Cats.* Nintendo.

Norman, J. 2016.  *L. Frank Baum's "The Master Key" Imagines a Kind of Augmented Reality.* [online]. Available from: <http://www.historyofinformation.com/expanded.php?id=4698> [Accessed 23/04/16].

Prigg, M. 2014.  *Google glass for war: The US military funded smart helmet that can beam information to soldiers on the battlefield.* [online]. Available from: <http://www.dailymail.co.uk/sciencetech/article-2640869/Google-glass-war-US-military-reveals-augmented-reality-soldiers.html> [Accessed 23/04/16].

Seeto, D. A. 2013.  *Tearaway (PS Vita) Hands-On Preview.* [online]. Available from: <http://www.justpushstart.com/2013/10/tearaway-ps-vita-preview/> [Accessed 24/04/16].

SIE San Diego Studio. 2012. *ModNation Racers: Road Trip.* Sony Interactive Entertainment.

Speedhut. 2016. *GR4-SPEEDO-03\_STANDARD-000000.* [Online Image]. <http://speedhut.s3.amazonaws.com/temp/GR4-SPEEDO-03/GR4-SPEEDO-03_STANDARD-000000.png> [Accessed 21/04/16].

Speedhut. 2016. *GR4-SPEEDO-16\_CENTURY-000000.* [Online Image]. <http://speedhut.s3.amazonaws.com/temp/GR4-SPEEDO-16/GR4-SPEEDO-16_CENTURY-000000.png> [Accessed 21/04/16].

Statista 2016.  *Statistics and facts about Smartphones.* [online]. Available from: <http://www.statista.com/topics/840/smartphones/> [Accessed 24/04/16].

Statt, N. 2016.  *Sony's prototype projector turns any tabletop into a touch-sensitive display.* [online]. Available from: <http://www.theverge.com/2016/3/13/11215454/sony-interactive-projector-future-lab-sxsw-2016> [Accessed 25/04/16].

Swider, M. 2015.  *Google Glass Review.* [online]. Available from: <http://www.techradar.com/reviews/gadgets/google-glass-1152283/review> [Accessed 23/04/16].

Takahashi, D. 2016.  *CastAR shows how it will turn your tabletop into an animated gaming world.* [online]. Available from: <http://venturebeat.com/2016/04/11/castars-latest-demos-show-how-it-plans-to-enable-tabletop-mixed-reality-games/> [Accessed 25/14/16].

XDev Studio Europe. 2012. *PulzAR.* SCEE.