GAME DEVELOPMENT FOR AN AUGMENTED REALITY SYSTEM

by

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE OF CONTENTS</td>
<td>2</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>3</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>4</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>5</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>6</td>
</tr>
<tr>
<td>2. INTERACTION</td>
<td>9</td>
</tr>
<tr>
<td>3. ISSUES WITH AUGMENTED REALITY</td>
<td>10</td>
</tr>
<tr>
<td>4. AUGMENTED REALITY GAMES</td>
<td>11</td>
</tr>
<tr>
<td>5. CURRENT AND FUTURE DEVICES</td>
<td>13</td>
</tr>
<tr>
<td>6. META 1 DEVELOPERS KIT</td>
<td>18</td>
</tr>
<tr>
<td>7. PROPOSAL</td>
<td>20</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>20</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>The Touring Machine from Colombia</td>
</tr>
<tr>
<td>2</td>
<td>The Sword of Damocles</td>
</tr>
<tr>
<td>3</td>
<td>Iron Man’s HUD</td>
</tr>
<tr>
<td>4</td>
<td>Terminator looking for clothes that fit</td>
</tr>
<tr>
<td>5</td>
<td>A paddle interacting with a virtual box</td>
</tr>
<tr>
<td>6</td>
<td>Two people playing RV Border Guards</td>
</tr>
<tr>
<td>7</td>
<td>View from AR Hockey system for a user</td>
</tr>
<tr>
<td>8</td>
<td>Pokedex 3D Pro for the Nintendo DS</td>
</tr>
<tr>
<td>9</td>
<td>Ingress for mobile phones</td>
</tr>
<tr>
<td>10</td>
<td>A level in PulzAR for the PS Vita</td>
</tr>
<tr>
<td>11</td>
<td>The Meta 1 developer’s kit</td>
</tr>
<tr>
<td>12</td>
<td>Atheer one</td>
</tr>
<tr>
<td>13</td>
<td>Microsoft’s Hololens</td>
</tr>
<tr>
<td>14</td>
<td>Mini’s Augmented Vision’s view</td>
</tr>
<tr>
<td>15</td>
<td>Screenshot of the package needed to create a Meta application</td>
</tr>
<tr>
<td>16</td>
<td>Screenshot of Unity showing Cube with Meta Body</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1: Comparison of Devices

17
ABSTRACT

Augmented reality is a growing field with applications that will make life easier by giving access to a computer with simple gestures and voice commands. We compared multiple augmented reality systems to determine which one gives the developer the most support, and has a low price point, and high resolution. We discuss how to develop for an application for an augmented reality system and propose an augmented reality game.
1. INTRODUCTION

Augmented reality (AR) is the combination of real and virtual objects in a real environment usually to improve understanding, draw attention to certain areas or objects, or help a user complete a task. AR is different from virtual reality (VR) because AR takes the user’s world and overlays a virtual world and VR puts the user directly in a virtual world. AR gives the user context within the virtual world since they can use the real world objects to determine depth and how they are interacting with the environment, and since the user can directly see their hand. VR can’t give users the same type experience, since you are not seeing your hand interacting with an environment, but instead you are seeing a completely virtual world with a representation of how you are interacting with the world. AR has been used for multiple applications from design, sports, and simulators. AR is a young field even when compared to computer science, since it was only started in 1960, whereas computer science goes back to the 19th century.

AR is not dependent on a particular type of display. There are three main types of displays, which are Head Mounted, Hand-held, or Projection. Head mounted displays (HMD) give the users the ability to move around the environment and interact with objects in the environment because the system is mobile. HMDs tend to have cameras attached that record the real world close to how your eyes are seeing the world. This gives HMDs an edge when determining where the user is looking or which object is being interacted with. Hand-held displays such as phones and tablets allow the user to be mobile, but restricts what the user can see augmented since the display is limited in size. Hand-held AR has the benefit of being a familiar platform and having a screen that can be interacted with in multiple ways, such as tapping, swiping, or choosing from a menu. Hand-held AR may be limited in display size but they make up for this by being highly mobile, readily available, and having a lot of built-in tools, such as an accelerometer and gps location services. Projection is the most limited in terms of mobility, because it requires projectors and cameras to cover the environment, which limits projection augmented reality to indoor environments or well prepared outdoor environments. Projection AR is best for attractions, sporting events or concerts, since they can be set up and then viewed and used by multiple people with minimal effort. For example, in the future the yellow line marking the first down could be projected on the field so even people in the stands could see where the first down is currently.

AR was very limited at first, since displays and computers were bulkier and heavier than today. Early AR systems had to have prepared spaces with fiducial markers to give the system
a coordinate system to determine how to place virtual objects. The first virtual reality and augmented reality was the Sword of Damocles, created by Ivan Sutherland from the University of Utah [16]. The Sword of Damocles is a Head Mounted display which can only be used in a single room and can only create wireframe environments[11]. Researchers have been testing the limits of what they can do with AR. Early mobile AR systems needed to have prepared indoor environments until Columbia University developed the Touring Machine in 1997 [16]. The Touring Machine was the world’s first outdoor AR system [16]. The Touring Machine tells users the names of buildings and departments on Columbia's campus [16]. The military improved upon the Touring Machine with the Battlefield Augmented Reality System which was designed to help soldiers avoid hazards and find goals [16]. Though both of these systems were mobile they still required heavy packs with large batteries and computers, so they were still not viable for commercial or personal users.

Figure 1: Left the Touring Machine from Colombia[12], Figure 2: Right The Sword of Damocles[11]

AR systems have become lighter and can even be the size of a simple pair of sunglasses like Google’s Glass or the Meta Pro. These systems are powerful enough to track users hand movements and read gestures. These systems can read hand movement as input to interact with virtual objects.
AR is slowly becoming accepted and a part of common knowledge, even if people don’t know what AR is by name. Most people will have seen at least one example of AR but probably don’t think of it as AR. AR has invaded all of sports because it makes following the games easier from football displaying the down, how many yards until a first down, the score, and the range of a kicker. Football uses AR to breakdown plays that were run to explain why a play worked or failed or even to show how a player is doing whether good or bad. Racing uses AR to tell racers’ position or which racers they are currently seeing.

AR has also found its place in movies as well. AR is a popular tool in science fiction movies like Terminator, Robocop, Avatar, Iron Man, and Predator. In Robocop, Robocop has targets highlighted and gets turn by turn directions directly in his visior. The terminators use AR to give themselves an edge over the humans that they are hunting down that give the terminators names of people, can determine if clothes will fit, or number of targets. Predators use their AR to hunt their quarry and it gifts them with multiple ways to see the world including thermal and to aim their laser cannon that is perched on their shoulder. The best example of AR in a movie has to be Iron Man, since he is using AR for more than just attacking. Tony Stark, aka Iron Man, is a genius who develops his own tech, so for his mech suit he adds an AR system so he can get relevant information which is accessed by voice or given to him by his artificial intelligence, JARVIS. Tony also designs things in his lab using AR with a direct hand interface with some voice commands. Iron Man shows the people how AR could be used to help them.
AR will become a great tool in the future because it will help people with tasks that could be aided by projecting a person's vision on the real world. AR can be used to help humanity design buildings, vehicles, cities blocks. AR can help people go through their everyday life by giving them access to the internet as they walk. People could use this to skype on the move or look through information. AR HMDs could also replace TVs, desktop computers, laptops, and mobile phones because they would give people a lighter and very mobile. AR HMD could change shade to react to changing light like the transition lenses.

2. INTERACTION:

AR environments can be interacted with using multiple types of interfaces, such as direct hand, paddles, or buttons. Direct hand interfaces have the most intuitive interfaces, since you know how your hands work, so all you have to learn is how the system will read your actions. The major problem with direct hand interfaces is finding the hand and determining the gesture it is making. The most often used way to find the hand’s position and determine its gesture is by finding it through the hues in a camera view and looking for flesh colored areas by looking through the image captured pixel by pixel or regions of pixels. The main difficulty of direct hand interfaces is the hand being confused with other people, objects with similar hues, or the hand is angled oddly at the camera[20]. Examples of AR devices or application having direct hand interfaces would be Meta 1, Atheer one, or RV Border Guards [14]. AR environments can also be interacted with by paddles or any real object with markers on it. The markers allow the system to track where the paddle is and what object the paddle is interacting with at the current time. Paddle interfaces are easy to track because you have to only look for a set pattern in an image instead of trying to parse out a hand. Examples of paddle interfaces can be found in PlayStation move, the Wii, and Kato's memory card game [23]. Though the PlayStation move and the Wii are examples of VR; they provide well-known versions of a paddle interface.
Button interfaces are usually not stand alone interfaces, but they give users a way to toggle things or change settings. Buttons are used to turn the system on or off, to give users a tactile feedback, or to adjust settings that scale such as brightness or volume. Buttons are used on the google glass for example, to navigate the menus.

3. ISSUES WITH AUGMENTED REALITY:

AR systems have to occlude objects to give the virtual objects the illusion of depth and interaction with the real world. Occluding objects is the biggest problem of AR because the system has to decide how much of the virtual object should appear. One approach to solving this problem is to use a probabilistic function that makes virtual objects transparent around the occluded region. For example Jebara created an AR system to help people play billiards that used a probabilistic function to where the top of the pool table is[15]. If a new image is acquired, then each pixel is judge and if it is above a threshold of probability then the pixel was accepted as part of the table[15]. Another problem with AR is latency, because if there is a delay between a user interaction and the system responding, then the user feels a disconnect from the user experience. When a user feels a disconnect, the user can’t interact with an AR if their interactions aren’t being responded to in real time or at least close enough to real time. This makes time to process very important to when dealing with augmented reality.
AR is becoming more viable since the graphics are able to create photorealistic images. In the past, rendering photorealistic images was impossible on any mobile system. A reason it is difficult is because of environmental illumination differences over the world. Also reflective surfaces can blind or obscure the cameras, which can cause the system to lose position if the system is finding location based on visual landmarks. Photorealism can be hindered when there are too many virtual objects because the user can be overwhelmed by too many objects.

Users can become fatigued when using augmented reality systems and that can come about for multiple reasons. If the left and right eye are given the same view, they will experience fatigue because the brain is used to seeing two different images [16]. Seeing the same image in both eyes confuses the brain and works to create a space between the two images it is receiving. This can be fixed by using two cameras so each eye can receive a different image. AR fatigue can also be caused by uncomfortable AR systems. For example the Meta 1 developer kit that we intend use is not comfortable for long periods of time. The Meta 1 is heavy which creates pressure on your nose and ears. It also has multiple straps that can get in the way of the camera or squash your ear.

4. AUGMENTED REALITY GAMES:

Ohshima has created two AR games, RV Border Guards and AR Hockey. RV Border Guards is a first person multiplayer AR game that allows users to shoot at virtual enemies using gesture controlled weapons and shields [16]. AR Hockey allowed users to play air hockey with a virtual puck and actual mallets with fiducial markers [13]. The main problem with AR Hockey was the tracking of the mallets, since the system had to see the mallet to determine where it was and if it was making contact with the puck [13]. Ohshima found that users were less likely to miss the puck when the mallet was real [13]. Ohshima’s research proves that you have to be careful when deciding what to create a virtual object or use physical object.
John Petty of Marxent Labs compiled a list of some of the top AR Games of 2014 which included Pokedex 3D Pro, Ingress, PulzAR [17]. Pokedex 3D Pro for the Nintendo DS brings Pokemon to life if you have a card with a fiducial marker that represents a Pokemon[17]. Pokedex 3D Pro also gives a description at an encyclopedic level of every Pokemon that it has cards for[17]. The game part of Pokedex 3D Pro is testing how well you can identify Pokemon[17]. Ingress is a game that puts you on one of two teams and then asks you to take over the other team’s portals so that your team can conquer the world. The story behind Ingress is that the discovery of the Higgs boson particle lead to a discovery of Exotic Matter[17]. Exotic Matter can control human thought and is coming through portals around the world. In order to take a portal you have to get in range of the portal and start attacking. If you have taken a portal, you need to defend it from other players trying to take your portal. PulzAR is a puzzle game for the PS Vita that uses fiducial markers to place mirrors to guide a laser around obstacles to destroy an inbound asteroid[17]. While all three of these were well executed, they had limitations on them because of the platform they were built for. For example all three have limited views and can only be interacted with through a screen no bigger than 6”x6”. This limits the amount of information that can be show on screen for games on a phone for example Ingress. PulzAR and Pokedex 3D Pro require a steady place to put the fiducial markers that translate into game objects such as a table, PulzAR in particular because the game requires multiple markers to complete levels.
5. CURRENT AND FUTURE DEVICES:

There are multiple augmented reality HMD that are on the market or have been announced. To name a few: Atheer one, Epson Moverio BT-200, Vuzix WRAP 1200DXAR, Hololens, Mini’s Augmented Vision, MetaPro, and the Meta One developer’s kit.

The MetaPro is the commercial version of the Meta One developer’s kit. The MetaPro has a field of view (FOV) of 40 degree and a resolution of 1280 by 720 surround sound,
Whereas the Meta One developer's kit has a field of view (FOV) of 35 degrees and 960 by 540 resolution[2,4]. Both the MetaPro and the developer's kit have a nine-axis motion tracker, an accelerometer that can measure ±16g, a 1.5Ghz core i5 processor, 4GB of RAM, 128GB of memory[2,4]. The Meta One developer's kit has a depth camera with a resolution of 320 x 240, shoots in 30 fps and sees 74 x 58 x 87(H x W x D) degrees[4]. The Meta One developer's kit's color camera has a resolution of 1280 x 720, sees 63.2 x 49.32 x 75.2(H x W x D) degrees at 30 fps[4]. The Meta One developer's kit has two built-in electret microphones which produces Dolby 3D audio[4]. The Meta SDK uses Unity 3D software to create their images[5]. The Meta Pro and Developer's kit use Unity C# or Jscript, a subset of JavaScript, to build native Meta apps[5].

Atheer AR One, the Atheer one and the Atheer developer's kit are essentially the same, much like Meta Pro and developer's kit. Atheer developer's kit has an FOV of 36 degrees while the Atheer one has a FOV of 65[1]. Also the Atheer developer's kit weighs 65g more and has connectivity beyond the smartphone, while the Atheer one can only connect to a smartphone[1]. The Atheer one can display on and use a high definition 26” Android tablet and is floating about 50 centimeters in front of your face[3]. The Atheer developer's kit has a Snapdragon processor and can display on and use a high definition 26” Android tablet, which is floating about 50 centimeters away from your face[3]. Touching the floating tablet has mm accuracy and a low latency[3]. The Atheer one can connect with multiple devices over Bluetooth and wifi,
including keyboards, joysticks, smart watches, or anything that can pair with an Android phone[3]. According to Sleiman Itani, writer at indiegogo.com, Atheer’s SDK/API provides developers with the ability to create more engaging games and more useful applications[3].

Figure 12: Atheer one[3]

Epson’s Moverio BT-200 has no development kit for the Moverio BT-200. The Moverio runs Android 4.0.4, which updates via Wi-Fi[6]. The Moverio has a smaller field of view at 23 degrees, less ram at 1GB, and a slower processor at 1.2Ghz[6]. The Moverio can connect via Bluetooth 3.0, USB 2.0, and IEEE 802.11/b/g/n with Wi-Fi Miracast[6]. The Moverio has 8GB of internal memory which can be expanded by up to 32GB via microSD(HC)[6]. The Moverio can project screens of 80 inches at 5m to 320 inches at 20m[6]. The Moverio has capacitive multi-touch controls which each of the following : Power(lock), Home, Menu, Back, Function(Brightness, 2D/3D), Volume, Reset[6]. The Moverio supports the following file formats: MPEG2, WAV, MP3, AAC, MP4, and Dolby digital plus[6]. The Moverio can output surround sound[6].

The Vuzix WRAP 1200DXAR is one of two made by Vuzix. The WRAP requires a computer with an HDMI compliant port and Windows operating system such as Windows XP, Vista, 7 and 8(32 or 64 bit)[7]. The WRAP is compatible with most Windows based AR authoring software[7]. The WRAP can create a 75 inch virtual screen that seems like it is ten feet, with display resolutions of 1152 x 628, 1280 x 720, 1600 x 900, 1920 x 1080. The WRAP has a FOV of 35 degrees and a resolution of 852 by 480. The WRAP has stereo earphones. The WRAP can adjust the image to account for people’s eyesight[7]. Windows drivers for the WRAP’s stereo AR camera system are included and show up as USB video cameras[7]. The WRAP’s head tracker has a gyro resolution of less than 0.25 degrees/sec and collects 3
magnetometers, 3 accelerometers and 3 gyros[7]. The WRAP has removable noise-isolating stereo earphones which comes in 3 sizes[7].

Microsoft’s Hololens is currently still in development so details are limited, but based on the video teaser that Microsoft released, we can say that the Hololens is a fully functional computer with AR to display[9]. The Hololens can project interactive surfaces on the real world and remember what applications you want to have in what places such as a calendar or grocery list on your refrigerator[9]. Users can also watch Netflix on a projected TV screen and the user can change the size of the projected TV screen by pinching the corner and moving your hand either away from the TV to make it larger, or towards the TV to make it smaller[9]. Microsoft also showed how the Hololens could be used for designing things such as motorcycles or models[9]. Microsoft’s announcement video shows a women working with the model of a motorcycle on her desk and then overlayed her model upon the unfinished motorcycle. The Hololens gives the ability to walk someone through repairs such as fixing a sink[9]. Microsoft’s announcement video shows an old man with a tablet show a woman how to take apart the pipes under a sink.
Mini’s Augmented Vision looks to help drivers navigate, see their current speed as well as the current speed limit[10]. Mini’s Augmented Vision will highlight points of interest while you are driving[10]. Mini’s Augmented Vision will tell the user that they have received a text and then it will read the message aloud[10]. The real power of these One is shown off when it comes to parking, because they will highlight open spaces and display your side view mirrors[10]. The user can see things that are usually blocked by parts of the car thanks to “X-Ray View” but Mini has given no answer as to how they will accomplish this task[10].

Table 1 shows a comparison between the three best options and the Meta Pro over field of view, video display, RAM, and price. The Atheer is not included because they do not give three out of the four fields. The Moverio BT-200 is the worst across the board.

### Table 1: Comparison of Devices

<table>
<thead>
<tr>
<th></th>
<th>Meta Pro</th>
<th>Meta 1 Dev Kit</th>
<th>Moverio BT-200</th>
<th>Wrap 1200DXAR</th>
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<tbody>
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<td>35°</td>
<td>23°</td>
<td>35°</td>
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<tr>
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<td>960 x 540</td>
<td>1920 x 1080</td>
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<tr>
<td>RAM</td>
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</tr>
<tr>
<td>Price</td>
<td>$3000</td>
<td>$667</td>
<td>$699.99</td>
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Based on the information talked about above, the best choice would be The Atheer, but they are not currently accepting any orders from non-enterprise customers, so the second choice would be the Meta 1 Developer’s Kit because the Meta 1 is the cheapest, it is a Developer’s Kit which comes with example programs and runs unity which has multiple tutorials, supports C# as well as Unity JScript, and Meta has private developer forums[5,6]. The third best choice is the Espon’s Moverio BT-200 because it runs on the android platform so it can be updated as android updates, has expandable internal memory and can project screens as big as 320 inches[6]. The Wrap 1200DXAR is the fourth best choice because it is more expensive than both The Meta 1 Developer’s kit and Espon’s Moverio BT-200[7]. Microsoft’s Hololens and Mini’s Augmented Vision were either just announced at the beginning of this process or announced after we had already bought the Meta 1 Developer’s Kit, and both are still unavailable for purchase.

6. META 1 DEVELOPERS KIT:

The Meta 1 runs Unity and C# code, which makes them easy to develop for. In order to start working with the Meta 1, you have to download Unity 5 or 4.6.1 but only the 32 bit version and the Meta SDK, and of course a Meta 1 for testing purposes. When opening a new unity project make sure to check the box “Meta.unitypackage” because that package gives you the tools to make objects intractable with the Meta 1.

![Figure 15: Screenshot of the package needed to create a Meta application[22]](image-url)
Then you need to create a new scene and save it. Next you need to replace the main camera with a MetaWorld object it can be found in the top bar. You can add any object to the scene in order to make it interactive you need to add a MetaBody to the object and then write in the script to determine what happens when the object is interacted with. The Meta 1 supports touch long and short, pinch, grab, swipe, and release.

The Meta 1 track users’ hands by using the Color Camera to find where the hues are of a flesh color and try to pick out where the fingers are. Meta 1 determines where the finger are located by first finding where the center of the flesh colored regions and finding the furthest points from the center. Then the Meta 1 compares the current points to past points or the calibration when you first setup the Meta 1[20].

The Meta 1 tracks a users’ head by using an accelerometer, a gyroscope, and a compass. The accelerometer can interpret 16g of force and The gyroscope can register a change of 2000 degrees per second[4]. The Meta 1, before starting an app, determines where the user is facing so it can determine where the user is turning when looking around the environment. It saves this information so it can determine where you are in reference to your original x, y, and z positions.
7. PROPOSAL:

We propose using the Meta 1 as a platform for a video game that gets gestures from the user to interact with virtual objects, such as a first person shooter where you throw pies at people. In order to do this game, when a user lets go of a pie, the game would have to determine how fast the pie was moving and where it would land. First we must have the orientation of the hand which can be given by a built in meta function, in palm(), to get the orientation of a hand[22]. This allows us to calculate the pie’s velocity when throw in a 2D space instead of a 3D space. We can calculate the distance traveled by the thrown pie by breaking the motion into x and y which can be expressed by the cosine or sine of the angle multiplied by velocity. To move the pie towards its final destination we multiple the x and y velocities by time to determine where the pie will be in relation to its original position. This pie throwing game will allow users to hit and be hit by other people’s pies. A hit is confirmed by comparing the pie’s path and the position of the other Meta. A hit is shown by a pie smearing down the target’s view. To test this we would have to simulate this because we only have one Meta one. To make the game multiplayer we will need to setup a server to host the game. The players will be given the same view by serializing each view and merge each player’s view. If the pie were to land on a person the pie would splat on the person.

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[5]"META 1 DEVELOPER KIT The Meta 1 Developer Kit Brings Superhero Tech to


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