Senior Project

Game Implementation in Real-Time using the Project Tango

By: Samantha Bhuiyan
Senior Advisor: Professor Kurfess
June 16, 2017

Figure 1: Project Tango Device

Table of Contents

ABSTRACT

The goal of this senior project is to spread awareness of augmented reality, which Google defines as "a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view." It's a topic that is rarely known to those outside of a technology related field or one that has vested interest in technology. Games can be ideal tools to help educate the public on any subject matter. The task is to create an augmented reality game using a "learn by doing" method. The game will introduce players to augmented reality, and thus demonstrate how this technology can be combined with the world around them. The Tango, Unity and Vuforia are the tools to be used for development. The game itself will be a coin collecting game that changes dynamically to the world around the player.

List of Figures

List of Tables

Project Overview

Background

Google developed the Tango to enable users to take advantage of the physical world around them. Users can utilize computer vision to allow the device to acquire a location in relation to the world. This project uses the Tango to map the space around the user in an attempt to simulate a game around what users see. The purpose of augmented reality is to integrate the physical world with technology. In this case it combines the world as we see it with a game.

Games can be a fundamental learning tool that helps educate people. The widespread availability of both virtual reality and augmented reality devices like the Tango have helped increase their popularity. A game is what really put augmented reality on the map. Pokémon GO introduced millions to the augmented reality world. People are more aware of augmented reality and its possible applications. The game has proven vital in spreading the awareness of the augmented reality environment.

Intended Users

The main demographic are individuals who are interested in video games, and would like to experience an augmented reality game. These individuals range from all ages – from children to adults – and would be ideal for those who have not yet experienced an augmented reality game in the past. The intended purpose is to spread awareness to the public and to educate them on what augmented reality is, and what it might become in the future. It is attempting to instill excitement into the main demographic.

Difficulty and Relevance

Augmented reality is relatively new and finding documentation and information for research is limited, which required more time and effort in solving any problems that had risen over the course of this project. Trial and error was necessary and coming to an understanding for the technologies that were being used. There was a steep learning curve in properly utilizing the Tango, Unity, and Vuforia for the project to be successful.

Requirements and Features

The preliminary requirements of the project are shown in the link below:
https://docs.google.com/document/d/1usLepZ_fHKLPED4_8JaRw1amQXixSK5D7tAfdFt0tQk/edit?usp=sharing
But during the coding process changes were made because of the difficulty of the task at hand.

Hence, features are changed as follows:

- Research
  - Unity, Vuforia, and the Tango.
- User-friendly UI
  - Limited explanation to game understanding
- Combination with Tango's camera and technology
  - Character
    - Uses image recognition to spawn the character
  - Coins
    - Uses image recognition to spawn coins
  - Image Recognition
    - Images are loaded onto a database and then imported into Unity for camera detection
  - Button Press
    - Uses image recognition to load a button press that animates the character movement
  - Text
    - Text will appear to help describe certain aspect of game
  - Joy Stick
    - Joy stick is available at the bottom left of the screen for the user for character movement
  - System should handle these game objects accordingly
- Assets should be available for game play
  - Images
  - Character
  - Coins
  - Joy Stick
  - Button
- Character will be controlled by the user
  - Movement can occur
    - Image movement
    - Button Press
    - Joy Stick movement
- Game objects
  - Should include
    - Animation
    - Button Event Handler

        - Collision Detection
- Design should be simple
    - Where it gives the user visual understand of augmented reality
- Approach should demonstrate an understand of the technologies used
    - Relying on third party application for the game
- Application should allow user interaction between the Tango and the game itself
    - Users should only be play the game without problem
- Software used should accommodate testing
    - Application should use proper technologies for the project and the language that support those technologies

Evaluation Criteria

To evaluate this project this game implementation in Tango the criteria are shown in the table below.

Criteria	0%	50%	100%
Ability to transfer game onto the Tango	Cannot transfer	N/A	Game is available for play on the Tango
User physical world integrates the game for usage	Not loaded	3D mapping is available but cannot implement game or visa versa	3D mapping is integrate with the game
Images are recognized	No image recognition	N/A	Images are recognized
Character is set up on proper image recognition, and the user can move character with image movement	User cannot move	User can move in certain directions	User can move all directions
Button and text is shown when image is recognized	User can't see button or text	User can see either text or button	User can see both the button and text
Character responds to button press	Character doesn't move on button press	Character moves sometimes	Character does move on button press
Character responds to joystick movement	Character doesn't move to joystick	Character responds to joystick movement	Character does respond to joystick

	movement	sometimes	movement
Character and Coin collision creates coin collection	Character is not able to collect the coins	Character can sometimes detect character and coin collision	Character is able to collect the coins

Table 1: Evaluation Criteria

Technologies Used

Early implementation of the game used two technologies, the Tango and Unity. First, Unity was downloaded and installed, and then was set up to have the Android SDK to allow for Android development. The Tango SDK was then imported. Next I used area learning, which depended on motion tracking that maps out the 3D space around user as the space changes. I started off by testing whether I could differentiate various settings within a room, such as the ceiling or floor. A marker was intended to point outwards from the surface of that location. Figure 2 depicts a still image of a ceiling with different markers pointing out of it. Figure 3 shows a still image of the floor with the same markers point out of it accordingly.

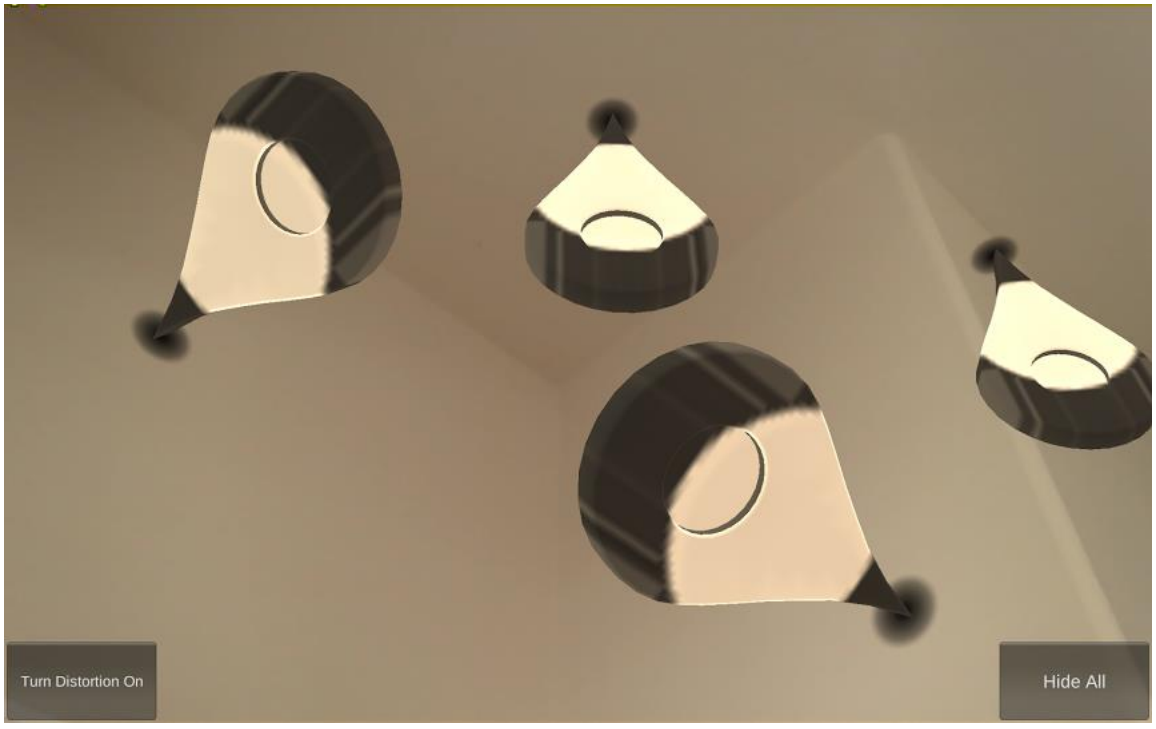

Figure 2: Ceiling with an array of markers

Figure 3: floor with an array of markers point

Area learning helps the device differentiate from top and bottom as well as left and right, which helps understand an edge and a corner. Area learning aims to store a mathematical description of the space as the perspective of the world changes as observed from the camera's movement. A searchable index demonstrates the visual features seen. For example, inside an enclosed box you'll see its ceiling, floor, and its surrounding walls. Somewhere in the Tango that index is stored as a bunch of numbers. The localization is taken into account so it can orientate itself with the area; unfortunately, these points are always changing making it difficult to properly add game objects or colliders to code a coin collection game. The Tango does not store the data because it is performing an area learning action as the camera's perspective changes. With motion tracking and depth perception, it can understand the surrounding environment, which lead to the addition of Vuforia.

Vuforia is an application that supports augmented reality. It takes advantage of computer vision by having image recognition. With an active developer account you can add any image you want to use. I used a standard Vuforia image shown in Figure 4 added it to the database to be used in game. With image recognition some qualities that enables best tracking ability would be the amount of detail the image has, unique patters, and a range of color.

Figure 4: Vuforia stock image used for image recognition

In Unity this image can be recognized. The game is dependent on this image and cannot function without it. Upon recognition a character, coins, button, and joystick appear. These are set up as game objects so that it can do specific tasks when triggered. The character is linked with the coins, button, and joystick. If the character collides with the coins they will disappear. Example code is show in Table 3 below. With the button the character is set to animate itself moving by detecting the button press event and goes back to idle when released. For the joystick the character will move according to the joystick movement.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class collectCoin : MonoBehaviour {
   public GameObject goldCoins;
   private void OnTriggerExit()
   {
      goldCoins.SetActive (false);
   }
}
```

Table 2: Example of code for coin collection

Research

Questions asked prior to starting the project and during the project as shown in Table 2.

What is Augmented Reality?
What is the Tango?
What is Unity?
What is Vuforia?
What are some applications related to my project?

Table 3: Research Questions

- What is Augmented Reality?

Augmented reality can be defined as simply the combination of the viewable world with technology.

- What is the Tango?

The Tango is a device created by Google. It utilizes the 3D world and can map out a room by using a combination of its camera, accelerometer, gyroscope, and infrared sensors. The Tango uses motion tracking so that it can know where a person is and how they are orientated in an environment. For depth, it uses IR sensors to determine the shape of each object in the vicinity of the tablet.

With computer vision, no external sensors are required to help the device detect their current position relative to their surrounding environment. It encompasses navigation, 3D mapping, physical dimensions of the surrounding spaces, recognition of known environments, and augmented reality. There are three key functions carried out by the Tango: motion tracking, depth perception, and area learning.

1. Motion Tracking
   By orientating itself with the environmental features observed, along with data collected from the accelerometer and gyroscope, the device is able to accurately track its own movement.

2. Area Learning
   Data detailing the surrounding environment is stored as a reference and shared with other Tango devices; the data is further enhanced with notes, instructions, and points of interest

3. Depth Perception
   Used to detect and simulate depth between the device's perspective and the surrounding objects

With these, data is generated in what is called “6 degrees of freedom”; the device and the surrounding objects described in Euclidean space along with the collected 3D information (known as the Pitch Yaw Roll). The orientation could be described as: x-axis for forward and back, y-axis for left and right, and z-axis for up and down. Pitch could then be described as the degree of tilting along the y-axis, Yaw could describe the degree of tilting along the z-axis, and Roll could describe the degree of tilting along the x-axis.

- What is Unity?

Unity is a cross-platform game engine that is used for game creation. It allows users to create any 2D or 3D game. Since I plan on creating a game in the 3D space in real time I plan on taking advantage of their 3D API. Unity also provides support for multiple textures and resolution settings, which is ideal for working with the Tango. It also has an intuitive workflow.

- What is Vuforia?

Vuforia is a leading software tool for development in augmented reality. It uses computer vision for image recognition. It can recognize physical objects, images, shapes, text, and more. It’s a growing platform for those interested in using their imagination.

- What are some applications related to my senior project?

For this project Tango has a lot of apps available to its users and ones that sparked my imagination to start this was the MeasureIt App and Jenga. Another application that is realated to my project is Pokemon GO! which is meant for numerous handheld devices.

1. Measureit

Measureit is an application available on the Tango that allows its users to take measurements of the world by simply pointing and clicking. You point at say the start location of what you would want to measure and click, then point it to the next location and click again at a different location to get the difference in distance between the points. On the top left of the Tango it will show you the total length. This feature is unique and caught my interest, and I plan on utilizing it into my game.

2. Jenga

Jenga if you haven’t played it before you take a block at each turn from the tower and the entire time you make sure that each block is balanced and that you avoid having the tower topple over. With the Tango the user can take advantage of the space around them, you can easily walk around the blocks and carefully choose

which block you want to move. This is a 2-player game where users simply touch and hold down the screen in order to move the blocks. The Tango acts like a 3D mouse because it simulates clicking and grabbing the blocks. What's great about playing on the Tango is that there is no clean up!

3. Pokemon GO!

A recent mobile game that introduced augmented reality to a large portion of the public in the summer of 2016 was Pokemon GO! Drawing parallels to the initial hysteria the cartoon brought to America in the 90s, the game made history simply due to the volume of users it attracted at launch. Utilizing the built-in GPS of most mobile devices, the game would simulate the player over a rendition of the surrounding environment – very similar to navigation software simulating a car on the road. Pokemon and poke stops would then be generated around the player to interact with. A poke stop would represent a real physical point-of-interest in the real world to visit and collect in-game items, while Pokemon would be generated for the player to catch via throwing the pokeball items. It succeeded in encouraging players to explore the outside world, showcasing real physical points-of-interests while transposing intractable virtual items and creatures and properly demonstrating core aspects to augmented reality.

System Design & Architecture

The augmented reality game started with the system design shown in Figure 5, where the Tango implements the C# code from Unity which can use the 3D mapping to distinguish locations throughout the area. But with lack of documentation on how to take advantage of the area game implementation proved difficult. For this reason, Figure 6 became the final design choice. Allowing image recognition lead to the spawning of characters, coins, movement joystick, and buttons.

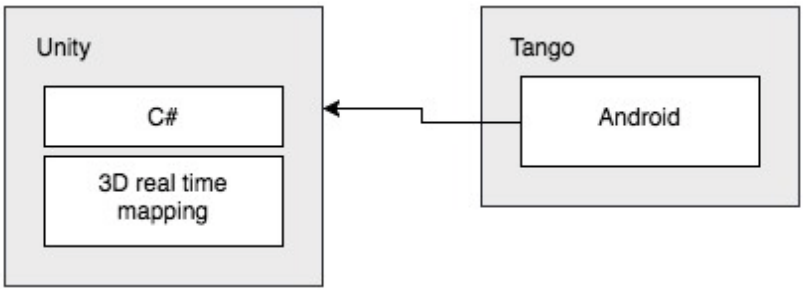

Figure 5: Initial System Design

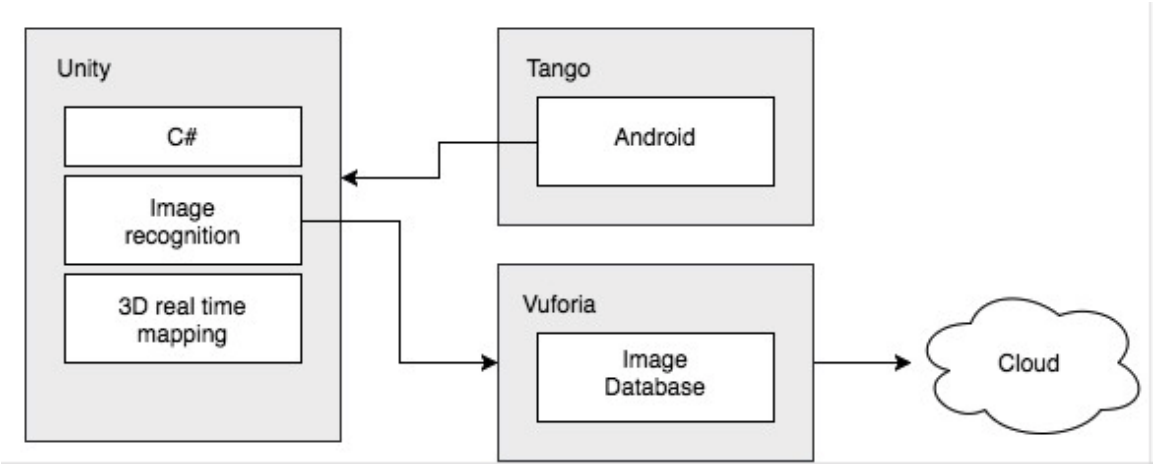

Figure 6: Final System design

Implementation was done by the utilization of Unity, Vurforia, and the Tango. The Unity game engine has built in tools that allow users to develop applications. Unity has an IDE that typically allows the device to simulate how an application will look like before it's transferred to any device chosen. But with the initial system design this simulation was non-existent making testing difficult and prolonging the debugging process.

The IDE was found to be extremely user-friendly by allowing features to be dragged and dropped as well as imputing relevant information for the application. This is where image recognition was entered. On recognition of the image the character, coins, and button would appear. These are assets found on the Unity asset store. The images that appear on certain image recognition photos were added to the game

scene. Besides the IDE personal code can be added for further customization. This is where we give a certain image directions on what task it shall do. For the button it allows moving animation when pressed and an idle animation when released. For the joystick it allows the character to move in any direction. Coins are set to disappear when the character comes into contact.

The Vuforia application provides an online database that can recognize images by using computer vision. This is implemented with the Unity IDE but has to be added on the database personally, and then imported into Unity.

Validation and Evaluation

As mentioned in the evaluation criteria section, the evaluation criteria are as follows: (1) The game is playable on the Tango device. (2) User's physical world is integrated into the game for usage. (3) Images are recognized. (4) Character is set up on proper image recognition, and the user can move character with image movement (5) Button and text is shown when image is recognized. (6) Character responds to button press. (7) Character responds to joystick movement. (8) Character and coin collision creates coin collection.

Through the first wave of testing to create the game, many failures were encountered. Difficulty during testing made it impossible to add proper game dynamics into Unity. Adding markers to the game scene was a success and it was able to understand the users surrounding. Those markers can properly be place perpendicular to surfaces. It failed to take advantage of Unity's IDE where adding items like colliders helped in game creation.

Through research to take more advantages of Unity's IDE a platform called Vuforia seemed the best fit. In game creation having an image be recognized and having the game be create based on that image allowed the game scene to be made. The game scene is shown in Figure 7 below. You can see where the character, coins, and button appear relevant to the image being recognized.

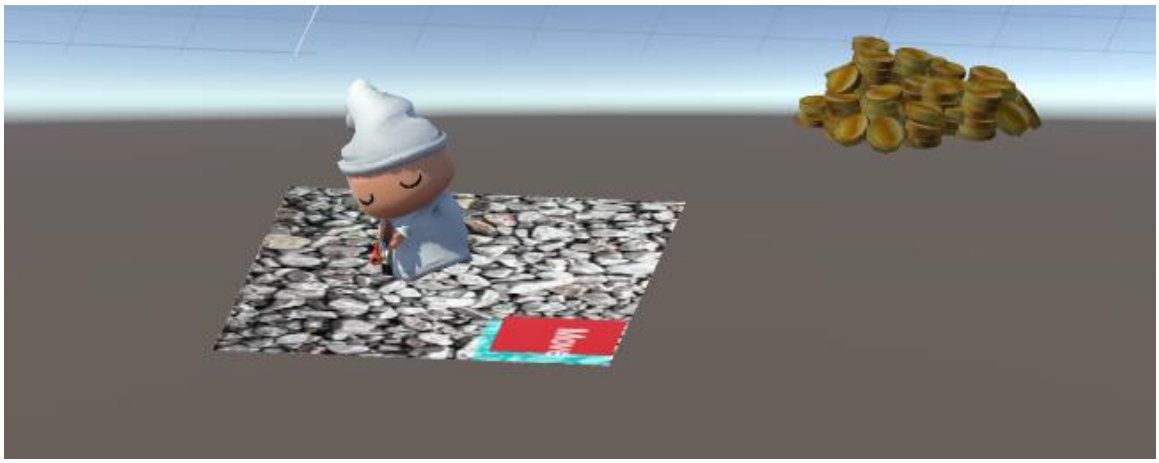

Figure 7: Unity view of game

Usability Study

To evaluate the game based on the evaluation criteria a small user usability study was performed after 6 participants were asked to play the augmented reality game.

After prompting these 6 participants to play the game, they were able to successfully open the game and play it. One realization that is understood is that the game can crash at any given point. But with a simple re-launching of the application the game can be played once more. All of the 6 participants understood that a game is

dependent on the world and on a single image. Again each was able to use the character to move around the world and collect the coin. And to use the button press to make the character to move around. When asked if they have played an augmented reality game previously 2 out of the 6 said no and the rest said yes. This correlates to 33.3% of the participants had no prior exposure to augmented reality and 66.6% had prior experiences with augmented reality. The same goes for whether the participants had an understanding of augmented reality. Finally, after interacting with the application, these participants who had not played and didn't have a complete understanding of augmented reality had gained a basic understanding of the subject.

Conclusions

Findings

The underlying goal of the project was to show how a video game could increase its intractability by marrying augmented reality with the game itself. The Project Tango proved to be an ideal tool to develop an interactive environment. By modeling a character alongside a pre-defined reference point, the Tango and Vuforia were able to successfully generate a 3D world which would dynamically change in respect to the system's perspective of the surrounding environment. This was used to validate the proposed concept.

Although the end result might appear rudimentary with an unengaging gameplay mechanics, many of the core features present in the Tango and Vuforia were implemented and functioned as intended. This serves as proof that the concept is valid, and these tools can be used to create new forms of interactive experiences.

Critiques and Considerations

Although augmented reality is exciting and new, the idea behind it is not. In its current state the technology could still be considered infant, and although one can argue that its future is bright, it is still a new technology requiring much improvement. During application of the project, the device would experience complications recognizing the reference background. In other words augmented reality can be taken to a different level.

A large source of developmental difficulty was rooted in Google's lack of providing abundant documentation. They provide some examples, but it proved to be inadequate and insufficient in efficiently creating the application. The Area Learning feature proved to be extremely vital, and yet a single example was all Google provided, along with minimal API documentation.

Future Work

Moving forward, addressing the rudimentary gameplay in addition to incorporating engaging gameplay mechanics and features would be the future developmental goals. Vuforia had a recent announcement detailing a new platform for the Tango devices aimed at elevating augmented reality interactions to a whole new level. Currently, gameplay was completely triggered by a reference image, meaning the game was dependent on that specific image and could not function without it. However, with the new platform it would be able to graph a scene dynamically while including assets on certain household items. For example a cup can be designated as a spawn point for the character or as an obstacle to move around it.

Citations

"Getting Started With Unity For Tango | Tango Unity SDK | Google Developers". *Google Developers*. N.p., 2016. Web. 1 May 2016. https://developers.google.com/tango/apis/unity/

Isaac, Nick Wingfield and Mike. "Pokémon Go Brings Augmented Reality to a Mass Audience." The New York Times. The New York Times, 11 July 2016. Web. 50 Nov. 2016. https://www.nytimes.com/2016/07/12/technology/pokemon-go-brings-augmented-reality-to-a-mass-audience.html?_r=0

Neagle, Colin. "Why Augmented Reality Is Expected to Be Four times Bigger than Virtual Reality." Network World. Network World, 06 Apr. 2015. Web. 14 Dec. 2016. http://www.networkworld.com/article/2906383/opensource-subnet/why-augmented-reality-is-expected-to-be-4-times-bigger-than-virtual-reality.html

"Simple Augmented Reality | Tango Unity SDK | Google Developers". *Google Developers*. N.p., 2016. Web. 1 Nov. 2016. https://developers.google.com/tango/apis/unity/unity-simple-ar

"Unity - Learn - Overview". *Unity*. N.p., 2016. Web. 6 Aug. 2016. https://unity3d.com/learn

"Unity Tutorial : Motion Tracking With Unity | Tango Unity SDK | Google Developers". *Google Developers*. N.p., 2016. Web. 7 May 2015. https://developers.google.com/tango/apis/unity/unity-prefab-motion-tracking#change_the_build_settings