

Applications of Mixed Reality with Unity and Arduino

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ABSTRACT

In a fast-developing world of augmented reality and virtual reality, where advancement in both AR and VR has been unprecedented. there is a case to be made with mixed reality also. Basically, mixed reality a form of augmented reality where physical interactions can be made with computer generated objects placed in the user's environment using physical input methods. This can have a profound impact on the way augmented reality application are developed and can open a world of endless possibilities for AR applications.

In this paper, a study of mixed reality application development is carried out using Unity as a development environment for mixed reality applications, along with Arduino for the development of different input/output methods used within the experience.

Unity is a game development engine that can be utilized to develop AR/VR/MR applications. The extensive toolkit in Unity enables developers to create applications with 3d models that can be experienced though AR glasses or devices capable of AR. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Using Arduino microcontrollers and a variety of sensors, input and output methods, AR experiences can be made interactable physically.

Keywords: Mixed Reality, Augmented Reality, Virtual Reality, Unity, Arduino.

1. Introduction

In 1994, Mixed reality was defined by Milgram and co. to be a combination of Augmented reality and Augmented virtuality, where the real-world environment was presented with a virtual world. However, this definition only concentrates on the computer graphics part of mixed reality. (Milgram, Takemura, Utsumi, & Kishino, 1994). This definition is incomplete nowadays, as MR has advanced since then to include a variety of human-computer interaction methods. Currently, mixed reality applications make use of environmental, spatial sound, gestures, sensory and physical inputs to create an experience for users. (Cheng, Keyu, & Weiwei, 2020).

Increasing the realism of AR/VR has been a major focus for developers worldwide, immersive experiences are hard to achieve since AR/VR mainly effect human vision and auditory senses only. Incorporating tactical feedback with these experiences can be profound. As such, premium VR systems such as Oculus Quest, Oculus Rift, HTC Vive, PlayStation

VR, etc. all have controllers that introduce tactical feedback in the form of haptics. (Shelstad, Smith, & Chaparro, 2017).

In 2016, Microsoft released HoloLens under the mixed reality field. HoloLens is a head-mounted display that superimposes virtual objects into the real world where they can be interacted with using gestures. (Microsoft Inc., 2021). Here it is evident that the difference between mixed reality and augmented reality is sometimes unclear. (Cheng, Keyu, & Weiwei, 2020).

In this paper, augmented reality is defined as virtual objects placed in a physical environment where these is no or little interaction with the virtual objects. While mixed reality is where virtual objects placed in the physical users' environment can be interacted with using a variety of input methods.

2. Applications of Mixed Reality

There is an infinite number of possible applications for mixed reality. Given the correct set of capabilities, mixed reality can be used in any field for simulation, teaching, practice and much more. In 2004, Bulman

and co. wrote for the paper detailing the use of MR in gaming, workforce management and military operations in urban environments. In his work, Bulman used a combination of hardware to achieve a mixed reality experience. Such as, Tactile Displays, GPS, digital compass and accelerometer, headsets, etc. (Bulman, et al., 2004).

Military Operations in Urban Terrain is a mixed reality application developer for training at the US Army's Research Development and Engineering Command. This application uses all simulation domains, namely live, virtual and constructive, for the purpose of training recruits in extreme and complex representation of combat. On the other hand, MR Sea Creatures is an MR experience to educate children about sea creature and sea fossils. This application is run at the Orlando science center. (Hughes, Stapleton, Hughes, & Smith, 2005).

In a paper entitled "Mixed Reality in Education, Entertainment, and Training", the importance of MR in medicine is highlighted. MR has great capabilities for training and practice in the field of orthopedic surgery. Moreover, using MR surgeons can super impose CT scans and other information during surgery. This naturally means better surgical results and lower recovery time for the patients. (Verhey, Haglin, Verhey, & Hartigan, 2019).

MR can play a big role in scientific education. For example, picturing the quantum realm requires hardware that is expensive and scarce. Thus AR/MR provide an easy method of visualizing such experiments for teaching purposes. (Alkurdi, Augmented Reality Electric Circuit Experiment, 2019).

3. Previous Work

There have been a great number of attempts to develop mixed reality applications. The main purpose of such projects is to provide an easier method of viewing or experiencing complex real-world scenarios.

DUIRA is a mixed reality application used to educate users in ecology. The application makes use of

Arduino microcontrollers and Unity AR marks to show the relationship between plant growth and environmental factors. (Chang, Chen, Lin, & Yu, 2010). A study in 2019 shows that AR/MR can be used to enhance the treatment of children with ASC. The system enhances the facial expressions of people to help children with ASC better understand social expressions. (Ahmed, 2019). Similarly, an AR application was developed in 2020 that helps educate children in astronomy. The system introduces an immersive experience for children into the solar system, where gestures are used as control inputs to view and control planets. (Alkurdi, Educational Augmented Reality Solar System, 2020). Virtuality plays a great role in phobia treatment as well. This technology provides an easy and safe way to administer exposure treatment to patients. A study conducted in 2020 attempts to aid in the treatment of Herpetophobia (Extreme fear of reptiles). (Naif & Ahmed, 2020). Additionally, another paper entitled "VR Mobile Acrophobia Treatment" provides a VR experience for the treatment of Acrophobia (Extreme fear of heights). (Alkurdi, VR Mobile Acrophobia Treatment, 2017)

Moreover, in 2018 an application of a virtual smart house was proposed by Kucera and co. The application relied on Arduino and Microsoft HoloLens to virtually present a house to perspective buys in a manner that they can control the smart house using HoloLens. Arduino microcontroller were connected to the smart devices in the house so that users can experience the house in a more realistic manner. (Kucera, Haffner, & Kozák, 2018). Furthermore, a welding simulation system introduced in 2018 utilizes Arduino and Unity to teach workers welding in a safe and material free environment. The proposed system generates an environment and tracks ultrasonic sensors to simulate welding. The main purpose of the system is to eliminate material use and wastage. (Bharath & Patil, 2018).

4. Implementation

This paper focuses on providing a simple and open-source method of mixed reality application development. Mixed reality applications require input methods and an augmented reality scene. These can be provided using Unity and Arduino. Unity is used to create the scene environment relied on AR capabilities built-in. while, Arduino is used to provide a method of inputs or a detection to the AR scene. See figure 1.

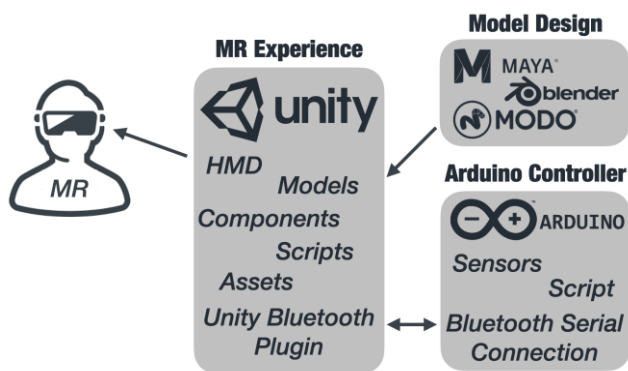


Figure 4.1: System Flow Diagram

4.1 Arduino

Arduino is an open-source platform consists of both hardware referred to as a microcontroller and software or Integrated Development Environment (IDE), that can be used to build digital devices. for instance, build low-cost scientific tools, to prove scientific principles such as physics and chemistry, or to get started with programming and robotics. (Arduino, 2022)



Figure 4.2: Arduino Uno SMD R3

4.1.1 Development

Arduino can be connected to a variety of IDEs, since it is based on open-source programming. Arduino

software code is similar to the C language software code. That being said, to write microcontroller programs, Arduino is considered to be one of the easiest computer programming languages to use. Arduino is predominantly used in designing projects that aim to build Various environmental modules such as Bluetooth, temperature sensor, light sensor, etc. (Arduino, 2022).

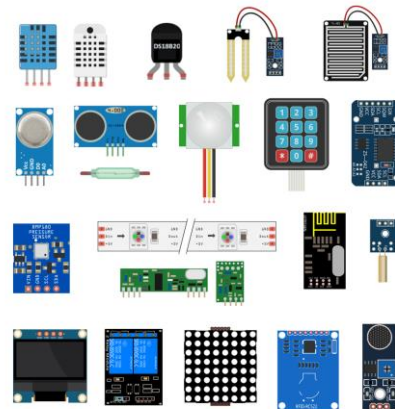


Figure 4.3: Arduino Modules

4.1.2 Connection

As previously mentioned, Arduino has many modules for a range of purposes. Bluetooth module is one of the hardware modules referred to. Regarding software, Arduino has Arduino Bluetooth plugin that support MacOS, iOS, Android, Windows PC and UWP. This Bluetooth module uses nearly the same frequency as (WLAN) with radio frequency at 2.4GHz and a transmission range of 10 meter, which is somewhat shorter than Wi-Fi and ELT (Kajikawa, Minami, Kohno, & Kakuda, 2016). However, it consumes less power since it supports BLE. In case the connection distance reaches more than 10 meters, the quality of transmission decreases. (Hamidi, Effendi, Syarifuddin, Wildan, & Huda, 2021)

4.1.3 Script

The Arduino Bluetooth Plugin can be used to connect Bluetooth module to a selected device name. then a Bluetooth serial is used to check either the serial connection is available or not if available, sending data is done using the sendBT function which sends an array of bytes. (Abou Zaidan, 2022)

```

if (BTSerial.available() > 2)
{
    data_length = 0;
    char pl = BTSerial.read();

    sendBT("SE3", 3);
}

void sendBT(const byte *data, int
{
    byte len[4];
    len[0] = 85; //preamble
    len[1] = 85; //preamble
    len[2] = (1 >> 8) & 0x000000FF;
    len[3] = (1 & 0x000000FF);
    BTSerial.write(len, 4);
    BTSerial.flush();
    BTSerial.write(data, 1);
    BTSerial.flush();
}

```

Figure 4.5: Arduino Bluetooth Plugin Script

4.2 Unity

Unity is a real-time game development software that can be used to develop applications that support 2D and 3D objects. The Unity platform provides capabilities to build AR and VR games or applications. This can be done using the Unity AR Foundation framework with Unity ARKit Plugin or Unity ARCore Plugin for iOS and Android respectively. Hence Unity projects can be built for iOS, Android and several other devices and platforms. (Unity, 2022)

4.2.1 Development

Unity has many powerful components and capabilities to develop mixed reality applications. Primarily simple objects can be design in Unity editor. However, complex and more realistic meshes require the use of additional software such as Autodesk Maya, Blender, Modo, etc. (Unity, 2022). Moreover, Unity has a large assets store with free and paid assets that can be used within a scene. These assets may be models, animations, plugins, etc. (Unity, 2022). Furthermore, Unity is a component-based system. Components can

be attached to objects to perform a specific task, such as emulate physics, rigid body dynamic, colliders, etc. (Unity, 2022).

In this paper, Unity is proposed as a simple and freely available tool to create immersive MR experiences.

4.2.2 Connection

As mention before, Unity has a large assets store that has several plugins for different purposes. One such plugin is the Unity Bluetooth Plugin. This plugin can be used to get access to the device Bluetooth module. As such the device Bluetooth can be used to transmit and receive data from and to the mixed reality scene developed. The Unity Bluetooth Plugin is free and support BLE devices (Bluetooth Low Energy) which is essential for newer devices nowadays.

This plugin can transmit and receive a bitstream with any other capable Bluetooth device using device Bluetooth module.

4.2.3 Script

The Unity Bluetooth Plugin can be used within a script of any object in Unity. The script helps connect device Bluetooth module to a selected device name. then a listener is used to listen to incoming streams while sending data is done using the sendData function which sends an array of bytes.

```

BTHelper = BluetoothHelper.GetInstance("AR-Arduino");
BTHelper.setLengthBasedStream();
BTHelper.OnConnected += OnBluetoothConnected;
BluetoothHelper.BLE = true;

BTHelper.OnDataReceived += () =>
{
    string receivedData;
    receivedData = BTHelper.Read();
    textObject.text = receivedData;
};

public void sendToArduino()
{
    BTHelper.SendData(new byte[] { (byte)'E', 2 });
}

```

Figure 4.6: Unity Bluetooth Plugin Script

5. Conclusion

In conclusion. VR and AR applications have made leap forward in the past decade. This has enabled more complex applications and environments to be developed under the mixed reality title. As mentioned before there are several methods of developing such applications. However, they can be complex or

expensive to accomplish.

This paper shows the potential of mixed reality that can be developed in an easy and freely available environment. Using Unity is simple and free for developers. The intuitive Unity environment along with many capabilities and assets make developing MR simple. In addition, using Arduino microcontrollers is fairly cheap. These microcontrollers can be programmed with a variety of sensors to achieve any form of input to the experience.

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