Neural Nets in AR

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ABSTRACT
This IAPT explores the practical use of Augmented Reality to teach Neural Nets concept to a target audience of secondary school students. By making user of the Oculus VR development toolkit, an AR environment was set to run off the Oculus Quest 2. Full gesture recognition ensured that not even controllers were a hardware requirement to further simplifying the setup process. Adapting some of the lessons from the AI in Education [2] workbook, the basics of a Neural Net was thought in an immersive environment ensuring attention retention from the user. The basics of reinforcement learning were also covered via a rock, paper, scissors game, allowing the user to experience and play against a basic learning algorithm first hand.

Keywords
Augmented Reality; AI in Education; Oculus VR development toolkit; Reinforcement Learning; Neural Nets; Gesture Recognition

1. INTRODUCTION
The main focus of this IAPT was to create an interactive AR platform for the education of students in secondary school about Neural Networks. To achieve this the Oculus VR development kit was utilised to create an AR game on the Oculus Quest 2.

2. INSTALLATION

This section explains how to install the application onto the Oculus Quest 2

1) Make sure you are logged in as an admin in the Oculus Quest 2 with developer access via the Oculus application on mobile (you may need to factory reset the Quest to remove old accounts).
   a. Hold the power and volume down buttons until the bios screen in the Quest 2 is accessed.

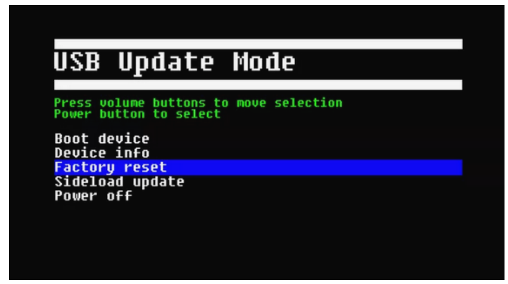

Figure 1: Bios of the Quest 2

   b. Select the Factory reset option.
2) Download the desktop application 'SideQuest'.
3) Connect the Quest to the PC via USB type C.
4) In the headset accept the popup that allows the pc to make changes.
5) The top left circle in 'SideQuest' should be green to show that one is able to upload files to the Quest.
   a. If it is yellow repeat steps 3 and 4.
   b. If it is red make sure that an admin account is being used with developer permissions.

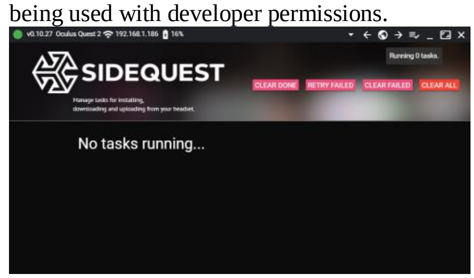

Figure 2: Developer portal in SideQuest with the headset connected

6) Drag and drop the .apk to the 'SideQuest' developer section.

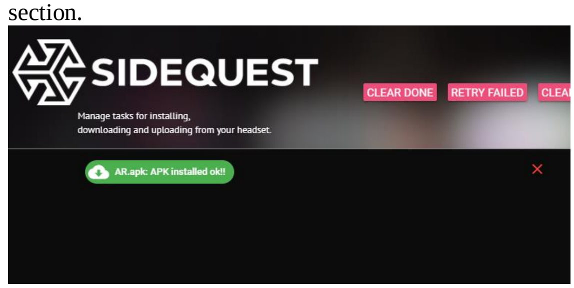

Figure 3: the apk being loaded into the headset

7) Go under "unknown sources" in the Quests library to launch the software.

3. DESIGN OF SOLUTION

3.1 Oculus Quest 2

The Oculus Quest 2 (or Meta Quest 2 due to brand renaming) is the latest device from Reality Labs (formerly known as Oculus from Facebook), with the focus being on lowering the price wall for VR entry. However, it's overall cost effectiveness, coupled with a lack of additional requirements such as a Gaming Pc and a colossal marketing budget, skyrocketed Oculus from 34% market share (Q1 2020) to 75% market share (Q1 2021) [1]. Meta (formerly Facebook) is pushing for the Quest 2 to become the every-persons VR experience.

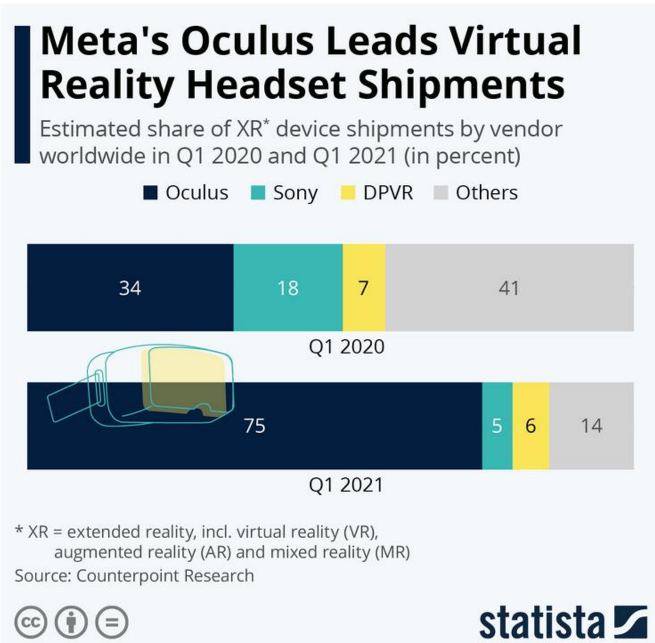

Figure 4: Statistics [1] showing the recent domination of the Quest 2

One feature that the Quest 2 plays a lot to its advantage is its ability to run in both wired and wireless mode, with wireless mode not needing a PC to run. The wireless mode makes use of the Quests onboard power which is akin to that of a modern high-end smartphone. This is to the kits advantage and disadvantage, as although this decreases the hardware requirements it makes most software designed with the main focus being launching on the Quest 2, this is opposed to other VR platforms that allow for cross development among all systems (even ones not by the same company). Due to this the Quest team designed a toolkit tailor made for the Quest 2.

3.2 Augmented Reality in Education

Augmented Reality has come a long way in recent years, although still being relatively new it no longer wows students into a cognitive overload. AR helps students to be more engaged with the topics being covered, stimulate different a lot more senses to better connect with the student, and allows a student to explore the material from a new angle [3]. AR technology used to be hampered due to hardware and software limitations, usually requiring a substantial amount of time to be wasted on troubleshooting [3]. Most people think about people running into walls and hitting lamps when it comes to strapping a headset on, however passing through the surroundings in AR along with Oculus' own 'Guardian', have played a substantial role in decreasing this occurrence.

3.3 OVR Toolkit

The OVR Toolkit (Oculus VR Toolkit) is a Package inside Unity that allows for development specifically for the Oculus platform. The OVR Toolkit allows for one to make full use of the hardware and software on the Quest, for this task the main focus was in utilising the Passthrough capabilities provided by the toolkit.

3.4 OVR Passthrough

OVR Passthrough is one of the main features of the OVR toolkit, competing development kits such as Open XR do not support such AR capabilities. AR, especially on headsets, is quite unexplored, with VR taking most of the limelight many dynamics that it brings remain unexplored. The Passthrough allows for elements in a real user's environment to be passed through the headset as input. On this, the OVR Passthrough allows for easy implementation of hand tacking and gesture recognition.

Figure 5: The background environment along with the user's hand being utilising passthrough to be passed into the application

3.5 References and Citations

Footnotes should be Times New Roman 9-point, and justified to the full width of the column.

Use the "ACM Reference format" for references – that is, a numbered list at the end of the article, ordered alphabetically and formatted accordingly. See examples of some typical reference types, in the new "ACM Reference format", at the end of this document. Within this template, use the style named *references* for the text. Acceptable abbreviations, for journal names, can be found here: http://library.caltech.edu/reference/abbreviations/. Word may try to automatically 'underline' hotlinks in your references, the correct style is NO underlining.

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4. AI TECHNIQUES USED IN SOLUTION

4.1 Hand tracking & Gesture recognition
The OVR Toolkit includes one of the most in depth and easy to use hand and gesture recognition implementations.

Various parameters are taken into consideration when designing a new hand pose. Each finger can be passed certain criteria such as if it is curled (finger joints closed/open), flexion (knuckles closed/open), abduction (area between fingers open or closed) and opposition (if the finger is connected to thumb). So, for example if one wanted to make the 'ok' hand gesture(figure 7) one would need no curling on the middle, ring and pinkie with abduction between each finger and opposition on the index.

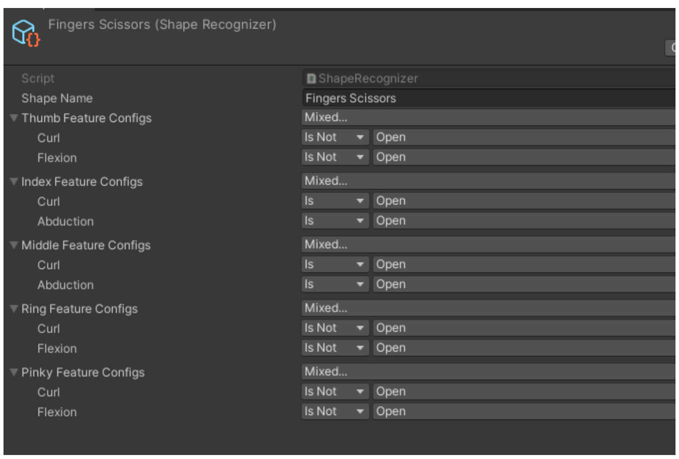

Figure 6: the menu that allows for different poses to be created inside of Unity

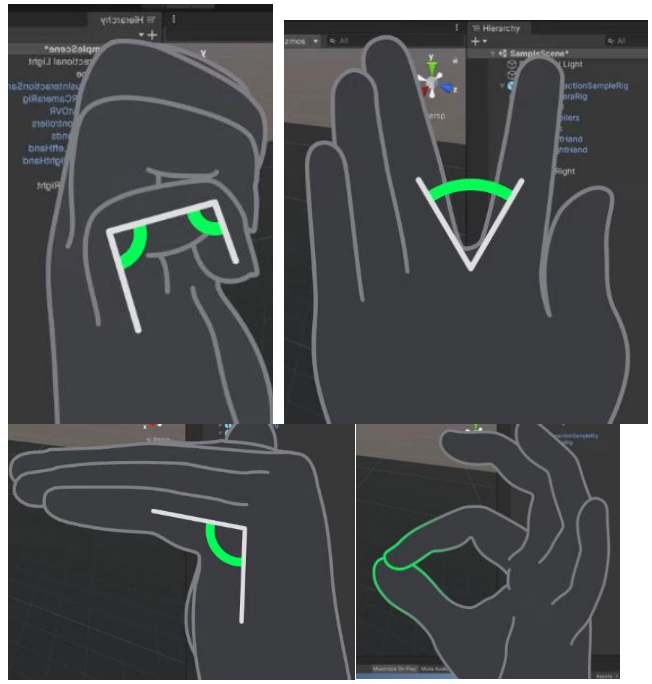

Figure 7: examples showing off curled, flexion, abduction and opposition

One can also specify the rotation of the hand because the difference between an thumbs down and a thumbs up depends on the rotation of the wrist.

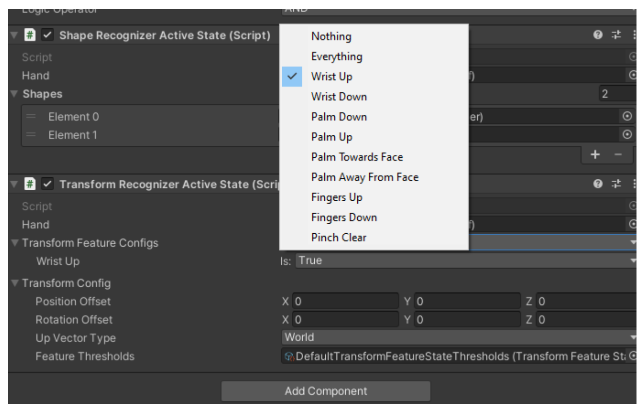

Figure 8: shows how the gesture orientation can define different poses

To reduce some bugs caused by the gesture recognition, it is encouraged that the user leaves their hand and brings out the appropriate gesture before returned their hands to an out of view space. As opposed to leaving their hands in front of their face while cycling through gestures.

5. DESCRIPTION OF THE IMPLEMENTATION

5.1 Hardware
Due to the main aim being using the application in a learning environment having fewer moving parts would be to the benefit of this Practical Task [3]. Ideally the software would only require the headset from where the application would be pre-installed on it, therefore this Practical Task was attempted with an additional

restriction attempted of having as few hardware requirements as possible.

5.2 Intelligent Interfaces

Because the main focus of this Individual Assigned Practical Task is for it to be used by young students, an emphasis was made on the interface between the user and the application. For this reason, sensical hand gestures and big red buttons with adequate in game tutorials demonstrating the interactions, make the software a lot easier to interact with, especially for students who may never have played a video game before.

5.3 Teaching Reinforcement Learning

During this Individual Assigned Practical Task a lot of the education material was adapted from AI in Education [2], one which was able to be adapted in its entirety was 'Rock, Paper … AI?'.

The game consists of learning reinforcement learning by adapting a very simplistic reinforcement learning algorithm. For the first five rounds it initially is set to randomly choose what, it will then make its choices by taking the choice which has had the largest sum of rewards. It takes a reward of 1 when a choice results in a win a -1 when a draw and a -3 when it takes a loss. This is not meant to be a perfect implementation of a Reinforcement Learning algorithm, after all the best algorithm for 'Rock, Paper, Scissors' is to select randomly. The main aim is to teach the concept of reinforcement learning in an easy-to-understand manner which the game more than does.

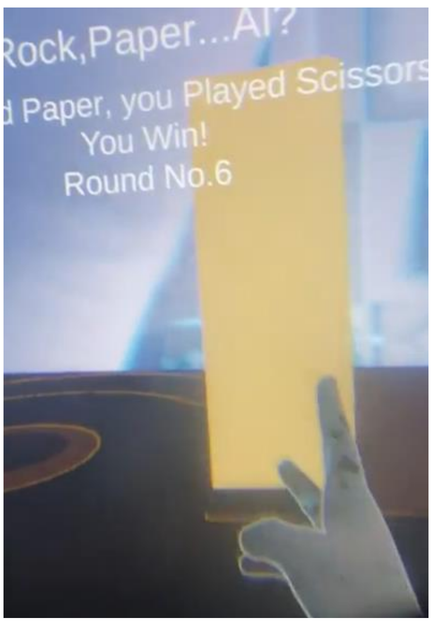

Figure 9: The user, playing scissors, beating the AI who played paper

Utilising hand gesture recognition the game can determine to reasonable success what the player is throwing out. This makes the game very easily accessible from the user side because everyone knows 'Rock, Paper, Scissors'.

5.4 Teaching Neural Nets

For Neural Nets a less hands on approach was taken, being less game and more educatory, for this the explanation part of 'The Paper Neuron' was utilised.

This segment takes the user through an explanatory segment teaching them about the black box nature of Neural nets and how weights are adjusted behind the scenes to achieve an output. The interactable nature of the experience is arguably a better learning environment and may help the student visualise the topic better.

6. ENVIRONMENT

6.1 Main Menu

The main menu is simplistic by design to not overwhelm the user just two buttons that send the user where he wants to go. A decorative in game floor with the rest of the environment being a stylised version of the user' actual environment.

6.2 Rock, Paper … AI?

The game begins with an introductory segment to explain the various mechanics of the game. A good introduction was necessary for the user to understand both the mechanics and the teaching aspect of the game. Hence, this introductory segment teaches the user how the AI learns via reinforcement learning by highlighting game elements that are going to change and showing how the highest-ranking choice is taken. This segment also shows how to use hand gestures, by making the user have to utilise them to get through the introduction.

Behind the user exist two buttons, one to reload the level and one to return to the main menus, the tactile and recognisable nature of buttons are a lot easier for a young user to understand and make use of.

One improvement could have been how certain information was passed onto the user, as the co coon of text may be a bit overwhelming for the user.

6.3 The Paper Neuron

A Large interpretation of a neuron is laid out in front of the user with a textbox and 3D description of what is happening and how the internal weights are calculated and updated. Figuring out how to display the information was a main focus of this segment. With the 3d model changing depending on the situation, the main text box having a dark background to differentiate it from the background.

Having the user go through the steps but using hand gestures (do a thumbs up to proceed), were shown to keep users engaged by having an alternate way to experience the subject [3].

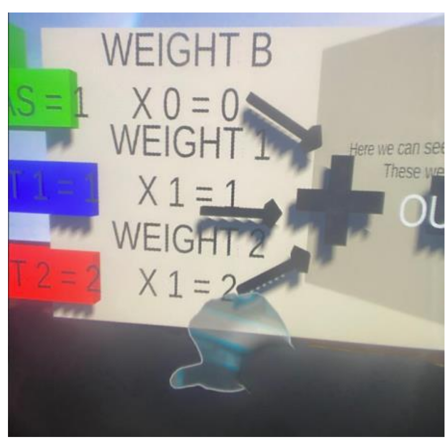

Figure 10: The user, in the process of performing a hand gesture, learning about how neural nets achieve their output by adjusting internal weights.

7. EVALUATION

7.1 Hardware Limitations

Setting up developer mode on the Quest 2 proved especially difficult, as shown in the installation segment of this documentation. Having developed on multiple VR system the Quest 2 proved to be the most nonsensical to setup, as a market leader one would expect developing to be a plug and play endeavour. The Quest 2 required the linking of a Facebook profile, a smartphone app, a factory reset and a desktop application, additionally Facebook wasted no time spamming me with adds for VR applications over all its networks.

Testing on the Quest 2 proved tedious since the software could not be tested directly from Unity, instead requiring the software to be built on the device before being loaded. Building the application every time a small detail is changed was both a resource and time waste.

7.2 Hardware Perks

The Headset is quite light weight and easily adjustable, very few adjustments were needed to achieve a clear picture and the device was well adapted for rapid development. The headset also fit most head types even young teens, compared to other headsets which usually require adapters.

The headset is room independent, not requiring fixed base stations means it can be setup in different environments seamlessly. Its lack of base stations also means that large mirrors do not interfere with its calibration. This makes it ideal for taking it around to schools as a limited setup requirement is a must.

Being the ever-lowering cost of these types of systems, it is not hard to imagine how this hardware may revolutionise our teaching process. A teen may find the intractability and immersion a lot more encompassing then having to read endless pages on a book, especially for those whom may struggle with attention span.

7.3 Software Limitations

Despite the toolkit being a lot more developed that other offering, the lack of cross development support is an unfortunate yet understandable omission.

The passthrough is handled on the hardware side of the Quest and not on the Software side. This made video capture of the application impossible and resulted in videos of the passthrough to be capturable only by filming the lenses of the Quest. Furthermore, this made the environment of the user to be seemingly unscriptable from the developer’s side, this seems more hardware bound than anything. Oculus are one of the first companies with consumer end AR capabilities, however a lot of features indicative of AR are seemingly omitted, hopefully Oculus could invest more into the AR space and allow for additional passthrough features.

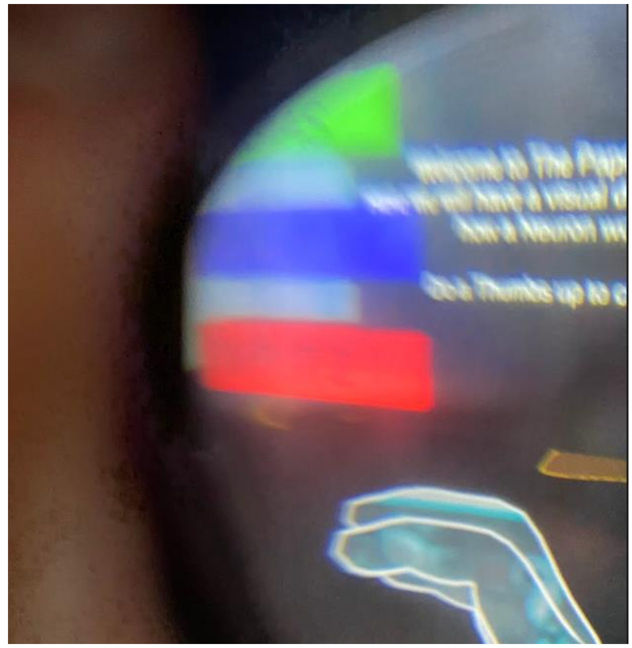

Figure 11: The attempted unsuccessful filming of the Quests lenses, resulting in an unsatisfactory image, being tedious for capture

Noticeably, some hand gestures may be unrecognised by the system, which proved to frustrate some users. Sometimes a gesture may be taken multiple times as input, playing multiple rounds of rock paper scissors at once. This is only to be expected by such an early implementation on less-than-ideal hardware, all in all, the gesture recognition worked decently enough to for the practical task.

Buttons that are implemented throughout the levels are only interactable via finger tips, this served contrary to the limited testing were users attempted to hit the buttons with their palms.

7.4 Software Perks

Apart from the problems mentioned above overall nothing seriously inhibited the development of the Individual Assigned Practical Task. The OVR toolkit sets itself apart as an industry leader in its AR capabilities, with full utilisation of the hardware and this practical.

8. Conclusion

All in all, a working proof of concept was developed with the extra benefit of no additional hardware requirements aside from the VR Headset. The natural hand movements and in-game big red buttons would prove ideal for young teens, offering a unique learning environment.

Therefore, the main aims of this Individual Assigned Practical Task were deemed to be achieved.

9. REFERENCES

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[1] Katharina Bucholz *Meta's Oculus Leads Virtual Reality Headset Shipments* https://www.statista.com/chart/11006/vr-and-ar-headset-shipments/

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[3] Steve Chi-Yin Yuen, Gallayanee Yaoyuneyong, Erik Johnson, *Augmented Reality: An Overview and Five Directions for AR in Education*