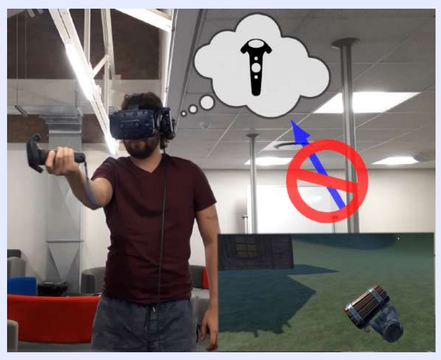
Scaled Haptic Props for VR Games

The Problem

Humans can perceive the shape and weight of a held object using what is known as **dynamic touch.** This does not rely on vision but rather on the **haptic experience** of holding an object. Users can estimate the size and shape of an object by its **feel** and **weight**.



The **haptic experience** provided by current VR controllers does not match the virtual objects they are trying to represent

Interacting with heavy, light, big or small objects all feels identical with current controllers. This creates a divide between the virtual and the real world.

A Solution

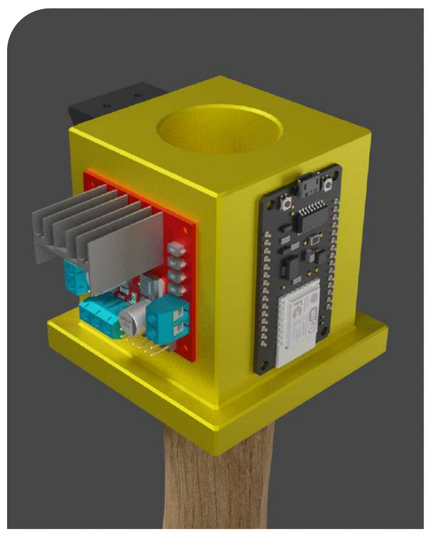
Haptic props are devices that seek to provide more realistic **haptic experiences** by more closely resembling the properties of real world objects. They can do this by providing enhanced **passive or active haptic feedback.**

Passive Haptic Feedback refers to the sensation of shape and texture from a object as well as its weight. The placement of weight further away from the user's hand makes an object feel heavier and longer.

Active Haptic Feedback refers to any vibrational or force-reflecting feedback generated by a object. The use of vibrational feedback can be used to simulate impacts with virtual objects.

We designed, created and evaluated **two haptic props** which are able to create believable **haptic experiences** for two weapons, a quarterstaff and a sword.

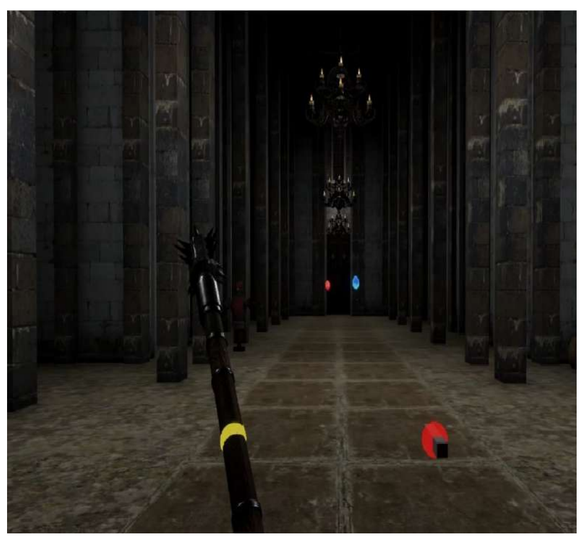
VR Quarterstaff



The **VR Quarterstaff** increases immersion by combining both **active and passive haptics.** It is constructed from a large wooden stick, providing a realistic wooden texture and is fitted with two vibration motors which are connected wirelessly to a VR virtual environment. Haptic pulses from the motors are used to simulate impacts within the game world.

The **haptic shape illusion** is a method for making an object feel larger than it actually is. This is achieved by strategically adding weights to the end of the staff. The **VR Quarterstaff** is 75cm long, but feels more than double the length when used in a VR game. This allows the prop to be used safely in room spaces while still providing a realistic experience.

To test the effectiveness of our **VR Quarterstaff**, a virtual rhythm action game was created. In it, red and blue gems fly towards the player and must be hit with the corresponding side of the staff.



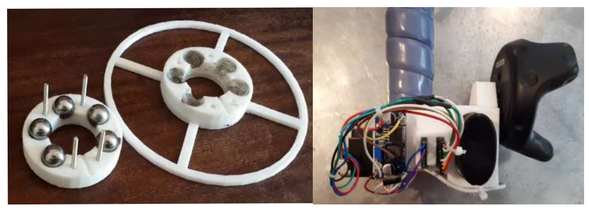
The VR Quarterstaff provided an immersive enjoyable way to wield a two-handed weapon in VR, something that is not possible with standard one handed controllers.

Swifty

While **haptic props** have been proven to increase immersion, each prop can only represent a single object. However, certain props are able to change their weight and feel using internal motors. These provide what is known as **dynamic passive haptic feedback**

Swifty is a wireless dynamic haptic prop that uses a stepper motor to raise and lower a weighted ring. This ring is also attached to a surrounding bellows allowing **Swifty** to change it's centre of mass and air resistance.

Raising the weighted ring moves **Swifty's** centre of mass making the prop feel heavier while expanding the bellows makes the prop feel bigger and longer.



To test the effectiveness of **Swifty**, a virtual food slicing game was created. Player's can swap between a small one handed sword and a large double-handed one by reaching over their shoulder.

Swifty is able to grow or shrink depending on which sword has been just been drawn. Using **Swifty** allows there to be a noticeable difference between the different swords. This creates a greater sense of immersion within the virtual environment.

The Results

Due to COVID-19 we were unable to perform large scale user testing, however we were able to conduct a small scale heuristic evaluation with experienced VR users.

VR Quarterstaff

+ Combination of passive & active feedback led to increased sense of presence
+ Two handed wielding meant users did not get tired, even with added weight
- Electronics need to be housed more securely to allow prop to be freely swung

Swifty

+ Measured to perform just as well as existing dynamic props
+ Evaluators found using the prop extremely believable and realistic
- Limited holding torque of stepper motor meant the ring moves if swung too hard

By using the positive feedback from the evaluations in combination with comparisons to existing haptic props that were tested successfully, we were able to show that both props are more **immersive** and **enjoyable** than standard VR controllers.

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