The VirtuSim Glove: a Haptic Feedback Device for Virtual Simulation

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I. Abstract

The VirtuSim Glove utilizes haptics to simulate a realistic feeling when picking up an object in virtual space. Haptics is the use of the sense of touch to transmit and understand given information. The glove's haptic feedback is achieved through the use of vibration motors, a motor pulley system, and sensors to create a sense of texture, weight, and grip force on the object. The glove communicates with a virtual reality simulator, where a hand and an object are seen on the screen. This project focuses on the vibrational mechanisms that have been tested to create the most realistic result possible when grabbing the object in space. In addition, a model has been proposed to simulate different objects with different vibration levels in order to achieve lifelike sensations for each scenario. The glove is proposed to be a viable option in the entertainment industry with practical applications in video games and ride systems to immerse users more fully into virtual spaces.

II. What is Haptics?

The main concept for this project comes from haptic feedback. Haptic systems use the sense of touch to create a more immersive virtual reality. Commonly found through vibrations in phones or video game consoles, haptic feedback is becoming the new future for the virtual world. Therefore, many companies are trying to figure out how to incorporate its use into their systems. There are multiple ways to accomplish adding touch, including forces, motions, vibrations, and even sound waves. Vibrations are the most common method, with many academic studies proposing different ways to simulate grabbing different objects, using different patterns and combinations of vibrations [1]. The goal is to create the most realistic feeling of picking up an object, without a physical object to hold.

III. Vibration Motor Selection

Choosing the best vibration motor came down to a couple factors: size and power. The main goal was to have all the components fit on one finger. Therefore, the size had to be small enough to fit on a fingertip and slim enough to not interfere with the user's hand when picking up an object in the virtual world. In addition, the power had to be variable to create different vibrations depending on how the object is grabbed. In the end, coin vibration motors were selected, commonly found in phones, due to its desired size and for its enclosed vibration mechanism, which makes for an uncluttered feeling on the tip of the finger. This was connected to an Arduino to test the power; it passed the power requirement, having a range of vibrations from zero to one in increments of 0.1 (see Figure 5).

Figure 1: An example of the coin vibration motor used in this project.

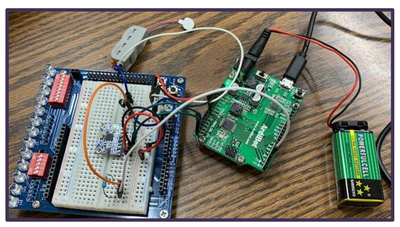
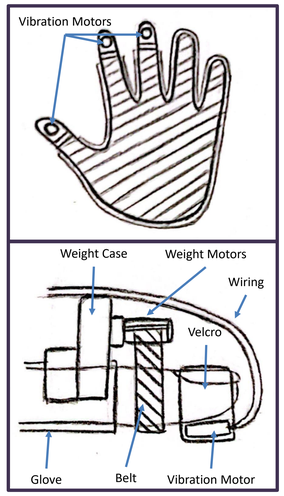
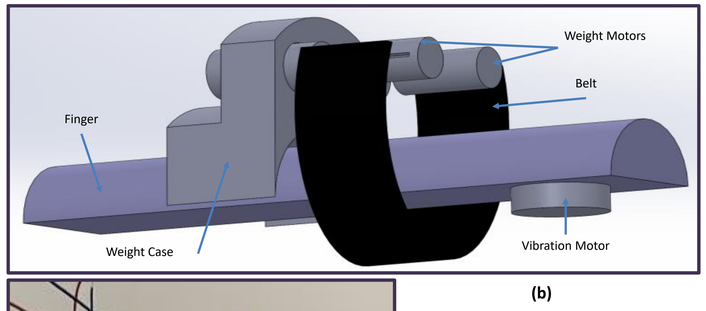


Figure 2: A breadboarded setup of the vibration motor connected to the Arduino to test the range of vibrations.

IV. Full Design





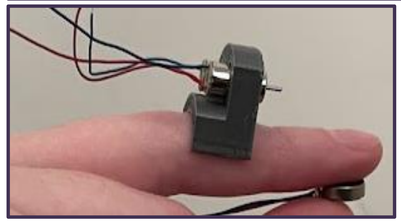


Figure 3: (a) The top sketch shows the palm side of a hand displaying the vibration motors at the fingertips. The bottom sketch shows the design for an individual finger. **(b)** SolidWorks CAD model of the full design of the weight mechanism and vibration motor. **(c)** Realistic location of weight mechanism and vibration motor.

The full design of the glove is shown in Figure 3. The mechanism is placed on three of the fingers as seen in (a): thumb, pointer, and middle. This mechanism simulates grabbing an object with the main three fingers, thus saving on cost and bulkiness of the design by leaving off the last two fingers. The vibration motors are placed on the fingertips, considered the most sensitive part of the finger [2]. The fingertips are usually the first points of contact when grabbing an object in the physical world. Therefore, the fingertips will require the most haptic feedback to create a realistic feeling in virtual reality. Although not discussed in this report, the weight mechanism will also increase the accuracy of picking up an object by simulating weight with a motor-pully system, which is also illustrated in the figures. The SolidWorks model of the design, excluding the glove, is shown in (b) and the actual positioning on a real finger is illustrated in (c).

V. Different Vibration Techniques

The main part of creating a realistic feeling of picking up an object comes from the types of vibrations that occur. When the hand touches a virtual object, the idea is that the vibrations will turn on and simulate the feeling of an object virtually. However, it depends on the object when determining how much vibration occurs. Through research, it was found that low vibrations account for smoother objects, while higher vibrations can create a sense of rougher objects [3]. In addition, how close the fingers get to each other is important. This distance is called the pinch distance [1]. As the pinch distance gets smaller, the user is "squeezing" the object and therefore should feel more pressure. To simulate this, the vibrations would get larger the more the user squeezes the object. The concept of grip force is important to consider when simulating picking up an object. In a future study, two objects, one smooth and one rough, will be simulated in a game engine as seen in Figure 4. Participants will pick up each individual object to feel the different vibrations that result from the perceived texture and the different grip forces that are placed on them. The range of vibration levels (zero to one) that can be utilized when simulating the objects is shown in Figure 5.

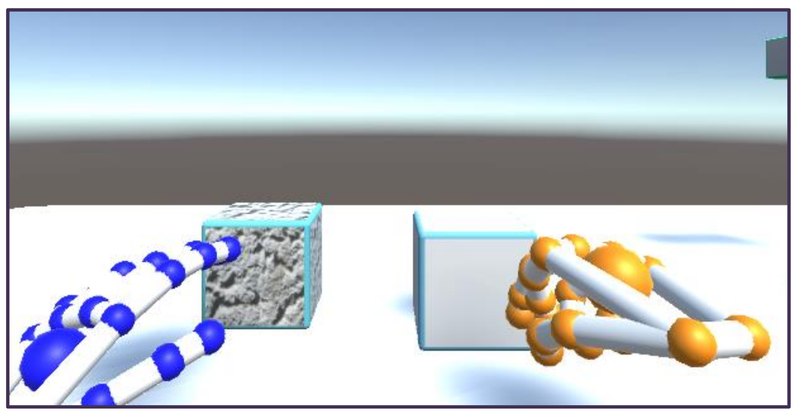


Figure 4 (Above): Displays the virtual reality gaming engine, Unity 3D, in "play" mode. The two blocks have different textures, so when the hands move each individual block, the intensity of vibrations will turn on accordingly.

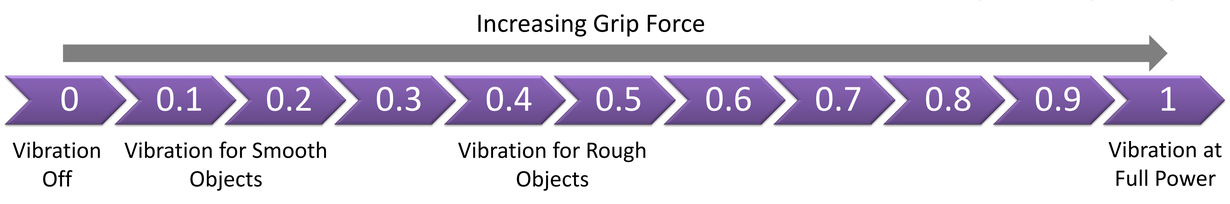


Figure 5 (Left): This is a vibration scale from 0, being no vibration, to 1, being full vibration. Vibrations for smooth items will be in a range from 0.1-0.2 and rougher objects will be from 0.4-0.5. Any larger vibrations will be used for a stronger grip force.

VI. Applications in the Entertainment Industry

The entertainment industry is comprised of-many different companies, including those that work in video games and theme parks. These two can experience many benefits in their industries if they utilize haptics. Video games are already experimenting with haptics, such as consoles that vibrate or body suits that simulate impacts during a game [3]. However, very few companies have created a glove that can be sold to the consumer at a reasonable size and price. In the future, when the glove becomes more streamlined and available, the user's experience will be enhanced with every object they interact with in the game. In addition, this idea can be utilized in theme parks as well. Many parks are leaning towards more virtual screens and experiences to reduce a ride's footprint. A normal ride takes up the space of possibly two or three virtual reality rides. Therefore, if virtual reality attractions become more of the norm, using a glove that creates a more immersive experience for the rider may boost the attractiveness of the ride. The glove could be added to include the feeling of moving an object on the screen. Haptic feedback can also increase the illusion that events not physically there are occurring [4]. For example, haptic feedback can enhance a shooting game attraction where the glove acts as if it is holding the shooter even though there is no physical prop. Attractions, such as this one, could increase the overall satisfaction of the guests and bring something new to the theme park industry.

VII. Next Steps and Conclusion

This report focused on the research findings of the vibration motor, as well as the initial conceptual design. The next steps include constructing the entire glove, creating the code for the system, and administering a study. MATLAB and Arduino have been selected as the programming system and hardware, respectively. They will be connected to Unity 3D to communicate with the Leap Motion sensor. Once the glove is completed, a study will be held. It will consist of participants holding objects of different weights and textures. Through a questionnaire at the end, this study will determine how realistic grabbing an object in virtual reality is with the VirtuSim Glove. The final outcome of this research will be to demonstrate that a glove utilizing haptics can be used to "feel" virtual objects. From the entertainment to the technology industries, haptic feedback is the future of the virtual world.

VIII. References

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