Haptic Wheelchair

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Abstract

Virtual reality aims to provide an immersive experience to a user, with the help of a virtual environment. This immersive experience requires two key components; one for capturing inputs from the real world, and the other for synthesizing real world outputs based on interactions with the virtual environment. However, a user in a real world environment experiences a greater set of feedback from real world inputs which relate directly to auditory, visual, and force feedback. As such, in a virtual environment, a dissociation is introduced between the user's inputs and the feedback from the virtual environment. This dissociation relates to the discomfort the user experiences with real world interaction. Our team has introduced a novel way of receiving synthesized feedback from the virtual environment through the use of a haptic wheelchair.

Keywords: virtual reality, VRNChair, haptic feedback

Concepts: Virtual Reality, Haptic Feedback of the Virtual Environment

1 VRNChair

There is known discomfort with real world user interactions with a virtual environment which stems from lack of familiarity of input devices and comfort biases which are introduced through different age groups interacting with the device, and thus the virtual environment. The VRNChair was designed and built to address these two issues and provide an intuitive method to interacting with the virtual world.

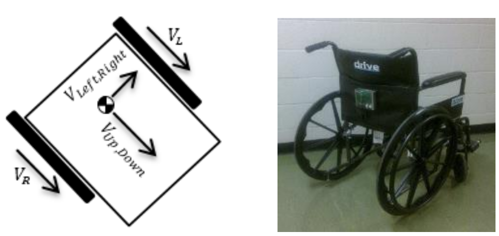

Figure 1: *VRNChair and generated velocity vectors for virtual environment interaction*

Interaction with the virtual environment is performed by the user in the real world. This interaction is physical movement while seated within the wheelchair, or by using the wheelchair as a walker. The user experiences virtual world motion through physical world motion. While the VRNChair reduces the discomfort and disconnect between real and virtual world interactions there still remains a void to be filled thus the introduction of the haptic wheelchair system.

2 Haptic Wheelchair

In order to further reduce the disassociation a user experiences with the virtual environment a method was devised which adds to the VRNChair to provide haptic feedback through synthesized forces experienced in the virtual environment. Haptic feedback to the wheelchair is introduced through a variety of methods in software, electrical and mechanical.

2.1 Haptic and Texture Synthesization

To provide synthesized output of virtual environment interactions these first must be experienced and recorded in the real world. This is achieved by outfitting the VRNChair with an inertial measurement unit (IMU). The VRNChair is then subjected to a variety of real world environment parameters such as surface textures and soft object collisions. Interaction with these parameters is recorded with the IMU and linear acceleration in all three principal axis. This data, combined with the virtual reality game and physics engine allows for the synthetization of a number of environmental forces experienced in the virtual world. These forces include: terrain feedback, wall collision, surface friction, surface texture, and velocity dependent drag introduction.

2.1 Passive Motor Haptic Drive

Often a haptic feedback system is combined with a weighted motor vibrator or driver externally powered to provide feedback. However, with the use of the VRNChair adding external power sources greatly increases the total weight of the system and adds to limits of freedom of movement for the user. To solve this problem a passive motor haptic drive system was introduced. This method uses the back electromotive force (EMF) produced by the motors themselves to assert real world feedback based on the synthesized virtual world forces.

This system utilizes two internal gears, mounted along the rear wheel hubs, which mesh with drive gears attached directly to the motors themselves. This setup allows for the largest possible gear ratio and therefore applied torque on the wheels. This high torque allows the haptic system to simulate collisions and other impulse events without high torque motors, reducing the system's weight. The motors are attached to the VRNChair structure using the original brake mounts and an interface plate. By using the brake

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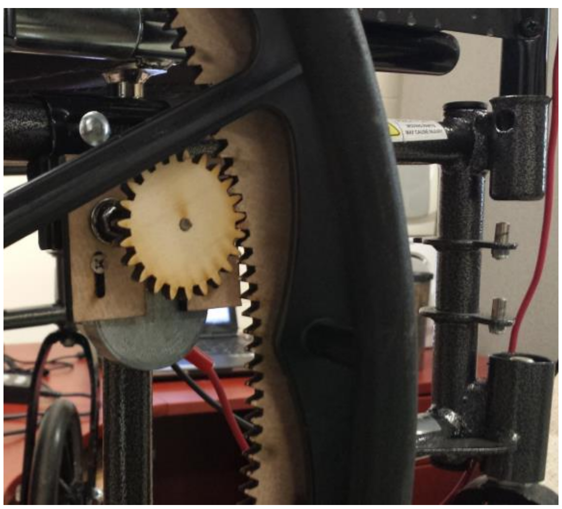
mounts, the system can be more easily attached to any standard wheelchair.

In order to control the motors a USB powered control circuit is used to utilize the back EMF which can allow for smooth rotation of the wheels, stuttering or braking of the wheelchair wheels. With a unique set of commands which are generated from the synthesized virtual environment interactions different feelings of feedback are experienced by the user.

(a)



(b)

Figure 2: *VRNChair Haptic Feedback System*

3 Results

A prototype haptic wheelchair was built to demonstrate the output and real world feedback from the virtual reality game and physics engine. Information about three different surfaces and surface textures were recorded. A smooth surface which had a low amount of surface friction, a grassy terrain which provided moderate resistance to movement, and a pebble terrain which provided moderate resistance and a physical jitter to user movement. With the recorded information, similar environments were built into the virtual reality game. When the user, sitting in the wheelchair moved over the surface in the virtual environment, the passive motor haptic drive was commanded to apply resistance to movement, stuttering, or apply both in varying degrees of force. The immersion level with the virtual environment greatly increased as a result of this.

4 Future Work

Currently, the haptic wheelchair provides only braking properties to real world movement. Using a large capacitor array, real world movement on the wheel can be used to charge the capacitors to provide later forward acceleration of the motors which allows for the addition of negative forces to the system, such as experiencing inclines, or moving on an icy surface.

References

BYAGOWI, AHMAD, DANYAL MOHADDES, AND ZAHRA MOUSSAVI. "Design and Application of a Novel Virtual Reality Navigational Technology (VRNChair)."*Journal of experimental neuroscience* 8 (2014): 7.

WHITE, PAUL J., AHMAD BYAGOWI, AND ZAHRA MOUSSAVI. "Effect of viewing mode on pathfinding in immersive Virtual Reality." *Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE*. IEEE, 2015.

BYAGOWI, AHMAD, AND ZAHRA MOUSSAVI. "Design of a Virtual Reality Navigational (VRN) experiment for assessment of egocentric spatial cognition." *Engineering in Medicine and Biology Society (EMBC), 2012 Annual International Conference of the IEEE*. IEEE, 2012.