Build your Own! Open-Source VR Shoes for Unity3D

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ABSTRACT

Hand-held controllers enable all kinds of interaction in Virtual Reality (VR), such as object manipulation as well as for locomotion. VR shoes allow using the hand exclusively for naturally manual tasks, such as object manipulation, while locomotion could be realized through feet input – just like in the physical world. While hand-held VR controllers became standard input devices for consumer VR products, VR shoes are only barely available, and also research on that input modality remains open questions. We contribute here with open-source VR shoes and describe how to build and implement them as Unity3D input device. We hope to support researchers in VR research and practitioners in VR product design to increase usability and natural interaction in VR.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Interaction devices**.

KEYWORDS

Virtual Reality, Locomotion, Foot Interaction

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Figure 1: VR Shoes used in Unity3D allow for physically walking through virtual environments

1 INTRODUCTION & BACKGROUND

While natural object manipulation is often realized using two hands, feet are used to move around in our physical environment. However, interaction in VR is not yet realized in the same way. Hand-held controllers have became standard input devices for VR head-mounted displays (HMD) to allow for all kinds of interactions, including menu control, object manipulation as well as self-propelled movements through VR, known as locomotion. To support feet input as a more natural input technique for locomotion, VR shoes are currently entering the consumer market. *Cybershoes*[1] is, for example, a kickstarter project for VR shoes being used while sitting, and *Vortrax*[2] are VR shoes consisting of mini treadmills mounted on the sole of the shoe. Moreover, Google patented VR shoes that allow infinite walking in limited space[3].

The use of footwear as a wearable VR input device has furthermore been the subject of various research and studies. Paradiso et al. developed a system to capture detailed, multimodal gesture expressed at the foot and monitored dancer's activity [5]. This system is embodied in a pair of shoes, each measures 16 degrees of freedom (tactile, inertial, positional). Yao et al. investigated a vibrotactile interface applied to shoes to communicate the rhythm and tempo of music for hearing handicapped dancers [8]. El Achkar et al. suggested a solely based wearable system for physical activity recognition [1]. Geißler et al. presented *Sensole*, a tactile interface using the foot especially the plantar as an input channel. Saunders and Vogel investigated *Tap-Kick-Click* is a combination of an insole with force sensors and Kinect to perform foot interaction techniques for a standing desk to control application commands [6]. Junji et al. proposed shoes that guide the user through shoe vibrations while walking [7]. Frey described the concept of *CabBoots* for an alternate tactile interface for pedestrian guidance applications applied to the foot [2]. Matthies et al. studied *ShoeSoleSense*, an insole interface that allows for location-independent, hands-free, foot-level interaction for motion control in a VR installation such as straight-ahead, turn, and jump [3, 4]. In addition, *ShoeSoleSense* provides additional feedback by heating the feet and vibrating in certain areas on the surface of the insole.

[1] https://www.kickstarter.com/projects/cybershoes/cybershoes-step-into-vr
[2] https://www.indiegogo.com/projects/jamie-hyneman-s-virtual-reality-electric-shoes-vr/

[3] http://pdfaiw.uspto.gov/.aiw?PageNum=0&docid=20180326286

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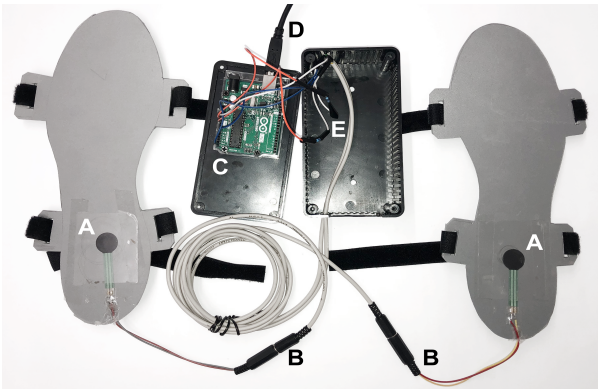

Figure 2: VR Shoes setup: A) Interlink Electronics FSR 402, B) 3.5 mm jack plug, C) Arduino Uno, D) USB connection to PC, E) 10 kOhm Resistor

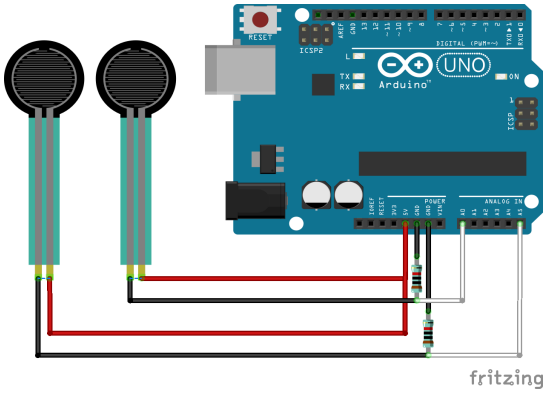

Figure 3: Arduino with pressure sensors for step detection

To ease research and product development in foot interaction for VR, we present here a simple and inexpensive hard- and software. We contribute a *"do it yourself" (DIY)* solution to build and implement VR shoes using Arduino[4] interfaced with Unity3D[5].

2 VR SHOES IMPLEMENTATION

The VR shoes explained here is based hardware using Arduino and software using Unity3D. The hardware consists out of two sandal-like soles, which are fastened with straps on the right and left foot. Force Sensitive Resistors (FSR) of the type *Interlink Electronics FSR 402*[6] are attached to the heel of each sole enable to detect and evaluate the pressure of the feet. A jack soldered to the outputs of each sensor makes it easy to connect and disconnect the soles from the Arduino. The soles are connected to separate analog input pins on an *Arduino Uno* to separately capture and process the input data from each foot as shown in *Figure 3*.

The tight attachment of the soles to the feet constantly causes pressure input. Hence, a threshold of 0,49 V (numeric value 100) was used for each FSR. This corresponds to an approximate mass load of 50 g. If the system detects pressure on both sensors, it assumes that the feet are not lifted and no movement happens. Once one of the FSR sends a pressure signal above the threshold, the system interprets a step event. To avoid unintended continuous movements, the step event is only sent if the status differs from the previous one. In summary, the VR shoes can capture the statuses *no foot touches the ground*, *left foot touches the ground*, *right foot touches the ground* and *both feet touch the ground*. These states are transmitted via a serial protocol to Unity3D.

To demonstrate the VR shoes, a winter landscape scene in the mountains using *Unity 2018.2* and the *Vive* HMD was created. If the status *left* or *right foot touches the ground* is received, the player object in the scene moves forward. The head orientation of the user controls the direction of movement.

The Arduino circuit, the Arduino code, and the Unity project can be downloaded at GitLab (https://gitlab.com/GEVAKUB/diy_vr_shoes), and a read-me file explains step by step how to set up the project.

[4]https://www.arduino.cc/
[5]https://unity3d.com
[6]https://www.interlinkelectronics.com/fsr-402

3 CONCLUSION

Here, we show how to build and implement low-cost VR shoes aiming at supporting research on natural locomotion in VR while keeping hands free for other interaction.

4 ACKNOWLEDGEMENTS

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REFERENCES

[1] Christopher Moufawad el Achkar, Fabien Massé, Arash Arami, and Kamiar Aminian. 2013. Physical Activity Recognition via Minimal In-shoes Force Sensor Configuration. In *Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth '13)*. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), ICST, Brussels, Belgium, Belgium, 256–259. https://doi.org/10.4108/icst.pervasivehealth.2013.252059

[2] Martin Frey. 2007. CabBoots: Shoes with Integrated Guidance System. In *Proceedings of the 1st International Conference on Tangible and Embedded Interaction (TEI '07)*. ACM, New York, NY, USA, 245–246. https://doi.org/10.1145/1226969.1227019

[3] Denys Matthies, Franz Müller, Christoph Anthes, and Dieter Kranzlmüller. 2014. ShoeSoleSense: Demonstrating a Wearable Foot Interface for Locomotion in Virtual Environments. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14)*. ACM, New York, NY, USA, 183–184. https://doi.org/10.1145/2559206.2579519

[4] Denys J. C. Matthies, Franz Müller, Christoph Anthes, and Dieter Kranzlmüller. 2013. ShoeSoleSense: Proof of Concept for a Wearable Foot Interface for Virtual and Real Environments. In *Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technology (VRST '13)*. ACM, New York, NY, USA, 93–96. https://doi.org/10.1145/2503713.2503740

[5] Joseph A. Paradiso, Kai Yuh Hsiao, and Ari Benbasat. 2000. Interfacing to the Foot: Apparatus and Applications. In *CHI '00 Extended Abstracts on Human Factors in Computing Systems (CHI EA '00)*. ACM, New York, NY, USA, 175–176. https://doi.org/10.1145/633292.633389

[6] William Saunders and Daniel Vogel. 2016. Tap-Kick-Click: Foot Interaction for a Standing Desk. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16)*. ACM, New York, NY, USA, 323–333. https://doi.org/10.1145/2901790.2901815

[7] Junji Watanabe, Hideyuki Ando, and Taro Maeda. 2005. Shoe-shaped Interface for Inducing a Walking Cycle. In *Proceedings of the 2005 International Conference on Augmented Tele-existence (ICAT '05)*. ACM, New York, NY, USA, 30–34. https://doi.org/10.1145/1152399.1152406

[8] Lining Yao, Yan Shi, Hengfeng Chi, Xiaoyu Ji, and Fangtian Ying. 2010. Music-touch Shoes: Vibrotactile Interface for Hearing Impaired Dancers. In *Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '10)*. ACM, New York, NY, USA, 275–276. https://doi.org/10.1145/1709886.1709944