TouchVR: a Wearable Haptic Interface for VR Aimed at Delivering Multi-modal Stimuli at the User's Palm

Daria Trinitatova Skolkovo Institute of Science and Technology (Skoltech) Moscow, Russia daria.trinitatova@skoltech.ru Dzmitry Tsetserukou Skolkovo Institute of Science and Technology (Skoltech) Moscow, Russia d.tsetserukou@skoltech.ru

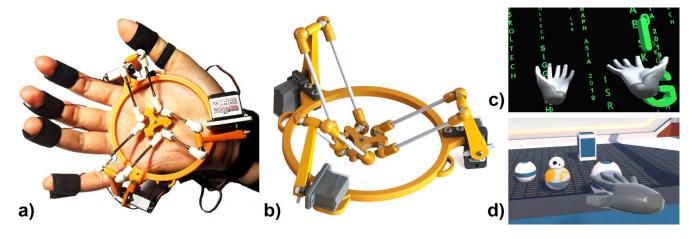


Figure 1: a) Novel wearable haptic interface TouchVR. b) A CAD model of haptic display. c) MatrixTouch application. d) RoboX application.

ABSTRACT

TouchVR is a novel wearable haptic interface which can deliver multimodal tactile stimuli on the palm by DeltaTouch haptic display and vibrotactile feedback on the fingertips by vibration motors for the Virtual Reality (VR) user. DeltaTouch display is capable of generating 3D force vector at the contact point and presenting multimodal tactile sensation of weight, slippage, encounter, softness, and texture. The VR system consists of HTC Vive Pro base stations and head-mounted display (HMD), and Leap Motion controller for tracking the user's hands motion in VR. The MatrixTouch, BallFeel, and RoboX applications have been developed to demonstrate the capabilities of the proposed technology. A novel haptic interface can potentially bring a new level of immersion of the user in VR and make it more interactive and tangible.

CCS CONCEPTS

• Human-centered computing → Haptic devices; Virtual reality; • Computer systems organization → Robotics.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

SA '19 XR, November 17–20, 2019, Brisbane, QLD, Australia
© 2019 Copyright held by the owner/author(s).
ACM ISBN 978-1-4503-6947-3/19/11.
https://doi.org/10.1145/3355355.3361896

KEYWORDS

Haptic Device, Tactile Display, Inverted Delta Robot, Multimodal stimuli, Virtual Reality

ACM Reference Format:

Daria Trinitatova and Dzmitry Tsetserukou. 2019. TouchVR: a Wearable Haptic Interface for VR Aimed at Delivering Multi-modal Stimuli at the User's Palm. In *SIGGRAPH Asia 2019 XR (SA '19 XR), November 17–20, 2019, Brisbane, QLD, Australia.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3355355.3361896

1 INTRODUCTION

Nowadays, many different entertainment applications, games, and simulators that implemented with VR/AR technologies are available in the market. However, the most VR/AR applications have a lack of providing feasible feedback to the user. In order to sense the physical interaction with the virtual environment, it is needed to reproduce tactile senses, which are a crucial component to accomplish the full immersion. Achieving a real touch simulation is a rather hard task which includes a representation of parameters of an object such as shape, hardness, weight, texture, and temperature. Some wearable interfaces for simulating the grasping of rigid objects in a virtual environment have been proposed, such as Wolverine [Choi et al. 2016], and Grabity [Choi et al. 2017]. They can provide the sensation of contact, gripping, gravity, and inertia. A number of haptic interfaces provide both kinesthetic and cutaneous stimuli to the hand [Son and Park 2018], [Hinchet et al. 2018].

We propose a novel wearable haptic interface for providing cutaneous feedback both at the fingertips and on a palm in VR environment (Fig. 1 (a)).

2 SYSTEM DESCRIPTION

A wearable haptic interface provides cutaneous feedback on the palm by DeltaTouch haptic display [Trinitatova and Tsetserukou 2019] and vibrotactile feedback on the fingertips by vibration motors (tablet type, 8x3 mm). DeltaTouch is a wearable haptic display to provide multimodal tactile stimuli at the palm of the user based on the parallel inverted delta structure attached at the hand of the user (Fig. 1 (b)). The DeltaTouch device provides a sense of touch at one point in the palm of the user. The unique feature is that display can generate 3D force vector at the contact point to simulate the direction of applied force and sliding direction with arbitrary pressure. The inverted Delta mechanism is proposed to achieve compact and lightweight structure. The vibration at the contact point is achieved by a vibration motor mounted in the end effector and can be used with vibration motors on the fingertips for simulation of the texture of the object. The display is worn on the user's hand in such a way that the bottom platform is fixed on the palm via elastic tapes, while the end effector can freely move along the palm within the boundary of the base platform. And the vibrations motors are fastened to the fingertips via elastic tapes with velcro. The VR setup includes HTC Vive Pro base stations and head-mounted display (HMD), and Leap Motion controller attached to the headset for tracking the user's hands motion in VR.

3 VR APPLICATIONS

We created several VR applications with different scenarios of userobjects interaction to demonstrate the various types of provided tactile feedback. The applications were implemented with the Unity game engine. During the demonstration user will wear TouchVR haptic interface in both hands and HTC Vive HMD. The first application is designed to demonstrate interactions with different objects in the VR room. The user can feel the motion of a spider in any direction and its weight on the palm or pulse beat and shake of the dragon egg reproduced by the haptic stimuli on the palm of the user by DeltaTouch display and vibration motors (Fig. 2).

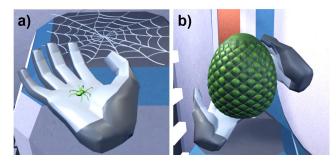


Figure 2: Interactions with VR objects: a) AnimalFeel application, b) Interaction with the shaking egg.

The application BallFeel is designed to demonstrate the sensation of bouncing the ball in the hands of the user to get the immersive experience of VR games (Fig. 3). In the MatrixTouch application, the user can immerse into the digital matrix, representing a 3D array of running lines (Fig. 1 (c)). The RoboX application allows the player to operate the object at a distance via gestures of the hand with the help of tactile feedback. During the collision of the robot with obstacles, the player feels the vibrotactile feedback (Fig. 1 (d)).



Figure 3: BallFeel application.

4 CONCLUSIONS

We have proposed a Virtual Reality system augmented by a novel haptic interface with multimodal tactile feedback. A wearable haptic display can present 3D force vector at the user palm and multimodal stimuli (contact, pressure, slippage, texture) at the user's palm, while vibration motors provide the vibrotactile feedback to the fingers. The future work will be aimed at expanding the multimodal feedback. The additional modality will be provided by attaching a Peltier element at the tip of the haptic display. Thus, the user will be capable of experiencing continuous thermal feedback along the palm skin during motion of DeltaTouch. The haptic interface can be applied in medical and rehabilitation systems, teleoperation, and VR simulators (e.g., NurseSim [Nakagawa et al. 2014]). The developed wearable cutaneous interface can potentially significantly improve the immersion into VR experience.

REFERENCES

Inrak Choi, Heather Culbertson, Mark R. Miller, Alex Olwal, and Sean Follmer. 2017. Grabity: A Wearable Haptic Interface for Simulating Weight and Grasping in Virtual Reality. Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology - UIST '17 (2017), 119–130. https://doi.org/10.1145/3126594.3126599

Inrak Choi, Elliot W. Hawkes, David L. Christensen, Christopher J. Ploch, and Sean Follmer. 2016. Wolverine: A wearable haptic interface for grasping in virtual reality. IEEE International Conference on Intelligent Robots and Systems 2016-November (2016), 986–993. https://doi.org/10.1109/IROS.2016.7759169

Ronan Hinchet, Velko Vechev, Herbert Shea, and Otmar Hilliges. 2018. DextrES: Wearable Haptic Feedback for Grasping in VR via a Thin Form-Factor Electrostatic Brake. In Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology (UIST '18). ACM, New York, NY, USA, 901–912. https://doi.org/10. 1145/3242587.3242657

Y. Nakagawa, D. Tsetserukou, and K. Terashima. 2014. Development of VR simulator for nurse training. AIP Conference Proceedings 29 (2014), 29–39. https://doi.org/10. 1063/1.4866615

Bukun Son and Jaeyoung Park. 2018. Haptic Feedback to the Palm and Fingers for Improved Tactile Perception of Large Objects. In Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology (UIST '18). ACM, New York, NY, USA, 757-763. https://doi.org/10.1145/3242587.3242656

D. Trinitatova and D. Tsetserukou. 2019. DeltaTouch: a 3D Haptic Display for Delivering Multimodal Tactile Stimuli at the Palm. In 2019 IEEE World Haptics Conference (WHC). 73–78. https://doi.org/10.1109/WHC.2019.8816136