FacePunch: Experiencing Pressure Forces on Face with HMDs

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Figure 1: (a) FacePunch presents a pulley system incorporated with HMD providing pressure on face. (b) Our system pulls the belts of HMD to generate discrete/continuous and weak/strong pressure stimuli to enhance e.g., (c)(d) boxing and (e) diving experiences in virtual environments. In (c)(d)(e), the face icons indicate the displayed force on face.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**; *Systems and tools for interaction design*;

KEYWORDS

virtual reality, haptics on face, pressure force feedback

ACM Reference format:
Hong-Yu Chang, Wen-Jie Tseng, Chia-En Tsai, Hsin-Yu Chen, [1]Roshan Lalintha Peiris, Liwei Chan. 2018. FacePunch: Experiencing Pressure Forces on Face with HMDs. In *Proceedings of SIGGRAPH '18 Emerging Technologies, Vancouver, BC, CANADA, August 12 - 16, 2018,* 2 pages.
https://doi.org/10.1145/3089269.3089271

1 INTRODUCTION

Simulated haptics is a key component to enhance immersion in virtual environments. Previous research has proposed various mechanisms to generate different haptic feedbacks. While many were deployed on limbs e.g., through wearable interfaces or handheld controllers, recent researches started to explore displaying haptics directly through HMDs. Examples include thermal [Peiris et al. 2017; Ranasinghe et al. 2017], vibrotactile [de Jesus Oliveira et al. 2017] and force [Gugenheimer et al. 2016] feedbacks.

We present FacePunch, a pulley system incorporated with a HMD to display pressure forces on user face. Unlike GyroVR [Gugenheimer et al. 2016] and HangerOVER [Kon et al. 2017] which enabled tangential/rotational force on user head, FacePunch's pulley system creates normal force on the face region covered by the HMD. The main concept of FacePunch is shifting torque provided by the two motors to a normal force pushing on face. As displayed in Figure 1. This normal force triggered by the motors pushes the HMD into user face resulting in pressure feedbacks on the face.

The contributions are as follows: (1) We present FacePunch, a system incorporated with HMDs and is designed to render the haptic sensation of normal force acting on user's face in VR. (2) we implemented two experience scenarios for FacePunch. A boxing experience represents discrete and instantly normal force acting on face and a diving experience demonstrates continuous normal force, i.e. the pressure feelings triggered by water flow.

2 SYSTEM IMPLEMENTATION

FacePunch consists of two components, (1) a VR display using HTC Vive VR set and (2) two DC motors connected to the head belt of Vive HMD with 3D printing models being the actuator for pulling HMD, such that the system can generate normal force pushing on face. Details are described as below.

2.1 Motor Actuator System

FacePunch system was implemented by two 12V, 170RPM DC motors, which are controlled with rotary encoders and driven by a VNH2SP30-E motor driver and controlled by an Arduino UNO board. As displayed in Figure 2, the motors are attached on the left and right sides of the HMD with 3D printing models. We designed the 3D printing actuators to connect the motor shaft and the belt of HMD, such that the torque generated by motor will be transferred into the force pulling the belt of HMD. While the HMD is pulling by motor, users can experience the HMD pushing on her/his face.

At the initial state, we place two actuators paralleled to the direction of user-facing forward. The rotation space ranges from 0 to 180 degrees. The strength of normal force is determined by the rotated angle of the motors and the duration of normal force is determined by the rotating speed of the motors. With the two parameters, FacePunch can produce discrete/continuous and weak/strong stimuli. The stimuli provided by our system allow for a variety of haptic feedbacks on face for VR application.

SIGGRAPH '18 Emerging Technologies, August 12 - 16, 2018, Vancouver, BC, CANADA

ACM ISBN 978-1-4503-5013-6/17/07.
https://doi.org/10.1145/3089269.3089271

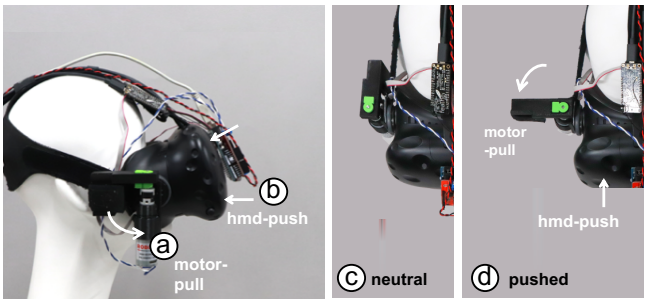

Figure 2: The FacePunch's pulley system enabled with two motors controlled with rotary encoders. Each motor connecting a belt via a 3D printing part allows to (a)(b) translate a belt-pull a the hmd-push, resulting in a normal force on face. (c)(d) Neutral and push states of the HMD.

2.2 Normal Force on Face as Haptic Feedback

Our implementation demonstrates the novelty of embedding kinesthetic normal force acting on face. Instead of adding external device to give pressure on user's face, we found the contact region inside HMD itself is a natural haptic space. Through our design, the system was incorporated with HMD altogether.

3 EXPERIENCE DESIGN

Based on FacePunch, we introduce two VR gaming experiences embedded with normal force haptic feedback on face. The interaction in the experiences depends on the duration of haptic feedback, i.e. discrete and continuous normal force acting on face.

3.1 Discrete Normal Force: Boxing

Discrete normal force simulates an instantly pressure acting on face, such as being hit by others. We applied discrete haptic feedback on face in a boxing scenario. The user stays in standing posture. She/he will be located in front of an avatar in a virtual boxing ring, which throws a punch to the user. The punch hit at the left area, right area, and middle area of the user's face would trigger the left motor, right motor and both motors, respectively (Figure 3ab). The hit area and the strength of a punch are calculated in real time from the avatar's boxing motions. We mapped the strength of a punch onto the angle of the motors. At the moment of being hit, the camera will shake instantly as visual stimulus, and the motors will rotate according to the strength and hit area simultaneously, which provides haptic feedback on face.

3.2 Continuous Normal Force: Diving

Continuous normal force simulates pressure acting on face in a time span, e.g., water flow acting on face during swimming creates a pressure on face continuously. In this experience, we created a diving scenario to demonstrate the haptic feedback of the pressure of water flow acting on face. The player seated on a chair wears wrist straps on both forearms; each wrist strap is attached with a Vive tracker. The Vive tracker records the orbits of hand positions. When the user does hand-pulling postures of breaststroke, orbits

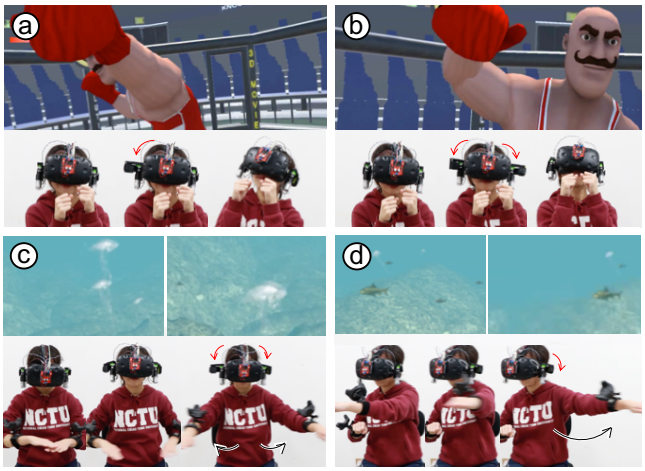

Figure 3: (a)(b) Boxing experience: a punch hit at the left and middle areas of the user face triggers the left and both motors respectively. (c)(d) Diving experience: the user advances underwater with with arm strokes of both hands, and turn left with right-arm strokes.

of the two trackers are used to calculate the moving direction and speed of the player. Left-arm stroke leads to right turn and right-arm stroke leads to left turn. If the user does arm strokes with both hands, she/he will move forward (Figure 3cd). Meanwhile, the corresponding normal force is generated to simulate the water flow acting on face. For example, while swimming to the right, the right motor will give stronger force to the belt of HMD than the left. The user will experience that her/his right side of face receives more normal force than left side. If user is moving forward, both motors start turning to a specific angle and keep holding the belt.

4 ACKNOWLEDGMENTS

This work was supported by Ministry of Science and Technology, Taiwan under Grants MOST103-2218-E-002-024-MY3.

REFERENCES

V. A. de Jesus Oliveira, L. Brayda, L. Nedel, and A. Maciel. 2017. Experiencing guidance in 3D spaces with a vibrotactile head-mounted display. In *2017 IEEE Virtual Reality (VR)*. 453–454. https://doi.org/10.1109/VR.2017.7892375

Jan Gugenheimer, Dennis Wolf, Eythor R. Eiriksson, Pattie Maes, and Enrico Rukzio. 2016. GyroVR: Simulating Inertia in Virtual Reality Using Head Worn Flywheels. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology (UIST '16)*. ACM, New York, NY, USA, 227–232. https://doi.org/10.1145/2984511.2984535

Yuki Kon, Takuto Nakamura, and Hiroyuki Kajimoto. 2017. HangerOVER: HMD-embedded Haptics Display with Hanger Reflex. In *ACM SIGGRAPH 2017 Emerging Technologies (SIGGRAPH '17)*. ACM, New York, NY, USA, Article 11, 2 pages. https://doi.org/10.1145/3084822.3084842

Roshan Lalintha Peiris, Wei Peng, Zikun Chen, Liwei Chan, and Kouta Minamizawa. 2017. ThermoVR: Exploring Integrated Thermal Haptic Feedback with Head Mounted Displays. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 5452–5456. https://doi.org/10.1145/3025453.3025824

Nimesha Ranasinghe, Pravar Jain, Shienny Karwita, David Tolley, and Ellen Yi-Luen Do. 2017. Ambiotherm: Enhancing Sense of Presence in Virtual Reality by Simulating Real-World Environmental Conditions. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 1731–1742. https://doi.org/10.1145/3025453.3025723