WEIGHTED WALKING: PROPELLER-BASED ON-LEG FORCE SIMULATION OF WALKING IN FLUID MATERIALS IN VR

EMERGING TECHNOLOGIES: SIGGRAPH ASIA 2021 EMERGING TECHNOLOGIES

IPHD 110003818 林巖

ACM Reference Format:
Pingchuan Ke, Shaoyu Cai, Lantian Xu, and Kening Zhu. 2021. Weighted Walking: Propeller-based On-leg Force Simulation of Walking in Fluid Mate- rials in VR. **In SIGGRAPH Asia 2021 Emerging Technologies** (SA '21 Emerging Technologies:), December 14-17, 2021. ACM, New York, NY, USA, 2 pages.
https://doi.org/10.1145/3476122.3484842

https://www.scm.cityu.edu.hk


Weighted Walking: Propeller-based On-leg Force
Simulation of Walking in Fluid Materials in VR

INTRODUCTION

“Deploying haptic and embodied feedback along with high-quality visual and audio contents in virtual reality (VR) can effectively improve users’ experience and immersion.

Many researchers investigated the hand-based haptic feedback devices to simulate the touch sensation in virtual reality [Cai et al. 2020; Heo et al. 2018; Je et al. 2019].

On the other hand, the lower limbs, such as legs and foot, are another important body parts for us to explore experience the real world. “

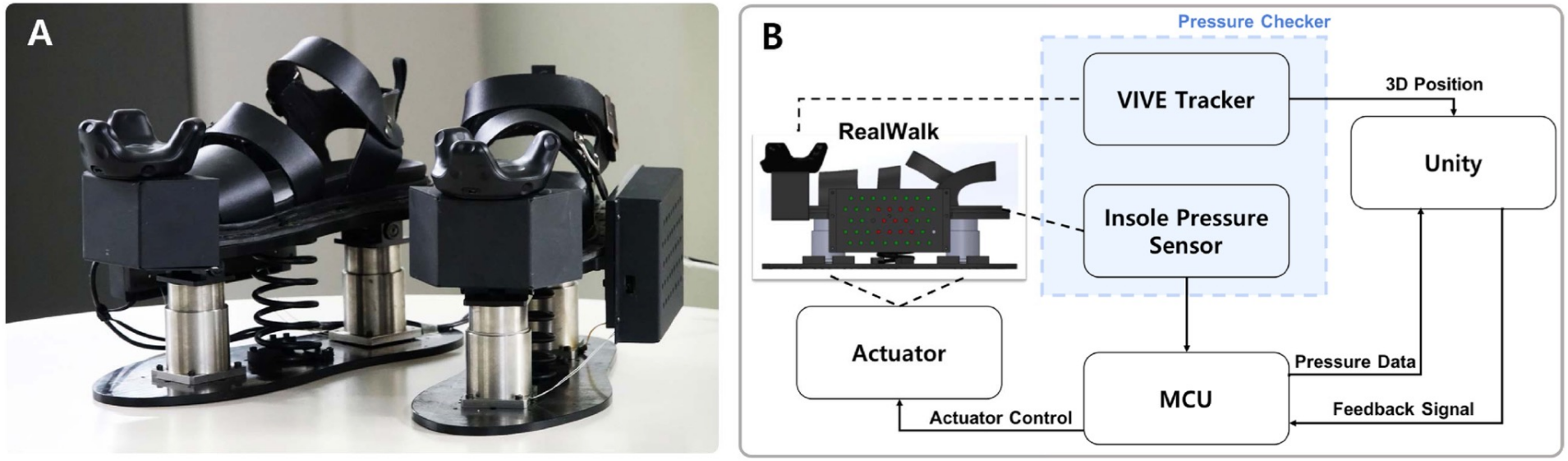
“The early works on locomotion interfaces in VR [Miyasato 1999; Roston and Peurach 1997] could simulate the walking experience in different solid surfaces with grounded setup, but most of their hardware are bulky to install. “

Figure 1. The Rutgers Ankle Haptic Interface. © Rutgers University 2002

Figure 2. System setup. © Rutgers University 2002

Source: Haruo Noma Tsutomu Miyasato. 1999. A new approach for canceling turning motion in the locomotion interface, ATLAS. Proc. ASME Dyn. Syst. Control (1999), 405–406.

“Later, to reduce the bulkiness of grounded system, researchers explored the installation of light-weight actuators [Serafin et al. 2010; Yang et al. 2020] in the shoes and on the soles to provide foot-based haptic feedback in VR. “



Source: Yang et al. 2020 Magnetorheological Fluid Haptic Shoes for Walking in VR

SYSTEM DESCRIPTION

“Weighted Walking is a leg-based wearable haptic system which could provide buoyant and resistant force feedback on users’ lower limbs while walking.”

Devices:

- Each calf sleeve with two ducted fans (one for upward airflow and another for downward) with two respond direction

- High-power ducted fan (model: EDF 70mm pro) which includes a 12-blade propeller and a 2300KV brushless motor(ϕ28.4 × H87.7mm, Weight: 178g, Max Voltage: 25.2V, Max Current: 65A).

- Each Fan can generate the force up to 22.4N (2.24kg) with the driven current of 65A. With low latency for the airflow force generation (from 0 to 22.4N within 1 second).

The control system

- The electronic speed-controller (ESC) boards (model: HOBBYWING SkyWalker, rated at 80A)

- Controlled by **Arduino UNO** using the Pulse-Width Modulation (PWM). Based on the FAN PWM information to reference the data in the system for further information for leg movement information.

- An external **DC power supply** (24V, 80A) is used to drive the brushless motors.

- **Unity** (2019.1) to build the virtual reality application. The development Engine for 3D game and other application would help on some VR with Sensor data management.

https://unity.com/solutions/gaming-services

Methodology from the Author from this paper: “

In this equation, $\vec{F}_{drag}$ represents the drag resistance (i.e., resistant force) by the fluid and $\vec{F}_{buoyancy}$ is the buoyancy of the liquid; the direction depends on the leg movement. Both the buoyancy and drag resistance could be calculated as Eq. 2 and Eq. 3:

$$\vec{F} = \vec{F}_{drag} + \vec{F}_{buoyancy} \quad (1)$$

$$\vec{F}_{buoyancy} = \rho V g \quad (2)$$

$$\vec{F}_{drag} = 6\pi\eta r v \quad (3)$$

where ρ is the fluid density, and V is the volume of the displaced body of liquid; g represents the gravitational acceleration. In our case, we fix V as the average leg volume of human - 13000ml [Drillis et al. 1964].

” by author

Connection and Comments:

- This Application in technologies used some known technology about the FAN control methods with data resource.
- Some experiences with sensitive sensor usage in the VR for the game application with Low weight design enhance original design in similar requirement for movement.
- This kinds of mindset to use other sensor or devices to enhance some traditional devices that we used in previous also help to initial some innovation in next.