

Curl Clash: Simulating Realistic Sensations for a Comprehensive Curling Experience

Hsin-Yi Wang

National Taiwan University of
Science and Technology

Taiwan

samwang9199@gmail.com

Cheng-Peng Huang

National Taiwan University of
Science and Technology

Taiwan

Yu-Liang Tang

National Taiwan University of
Science and Technology

Taiwan

Wei-Qing Chi

National Taiwan University of
Science and Technology

Taiwan

Tse-Yu Pan

National Taiwan University of
Science and Technology

Taiwan

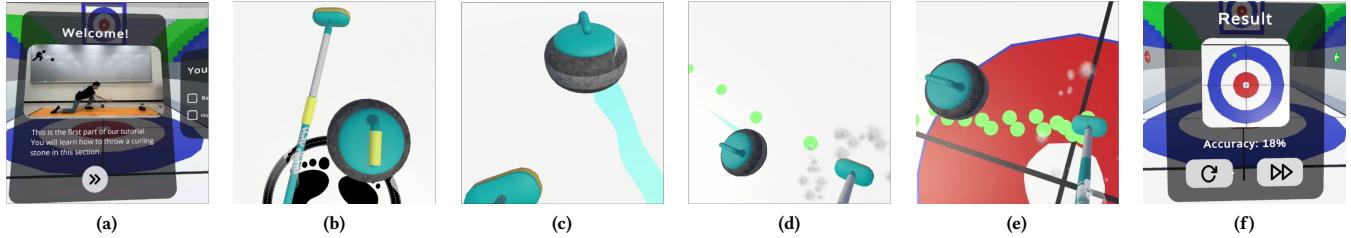


Figure 1: Screenshots of the Proposed System. (a) Tutorial user interface (b) User following the indicator to find and grab the equipment (c) Sliding and throwing (d) Sweeping with particle effect (e) Stone delivered to the house (f) Accuracy score.

ABSTRACT

Curl Clash is an XR system designed to provide an immersive curling experience with a unique focus on realistic sliding, a feature rarely implemented in VR sports. Our system incorporates sliding mats and shoe covers to simulate the slipperiness of ice, translating real-world sliding motions into the virtual environment. Additionally, custom-made props and motion trackers enhance the experience of throwing and sweeping. Targeted at beginners, Curl Clash features three practice levels to develop essential curling skills. By combining visual, auditory, and haptic feedback, our system offers a comprehensive and accessible way to learn and enjoy curling.

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1 INTRODUCTION

Sliding, a movement commonly performed on ice and snow, is rarely implemented in VR with full-body movement. Wang et al. [3] explored directional kinesthetic force feedback on feet, using foot movement as input to control the player's direction in a VR ski game. Similarly, Nozawa et al. [2] proposed a virtual reality ski training system using an indoor ski simulator that controlled the direction by swaying the lower body. However, these approaches still constrained player movements to some extent, simulating sliding only partially through body motion. In another study, Kennard et al. [1] investigated the effects of real-time visual biofeedback to enhance curling sports performance, yet body sliding was absent in the study. Based on these previous works, we propose our system, Curl Clash, a system that allows players to execute sliding movements. Additionally, we custom-made throwing and sweeping props using a water bottle and a bathroom brush. These setups enable players to experience the sport in limited spaces without compromising feedback quality.

2 DESIGN AND IMPLEMENTATION

To convey realistic sliding, we use sliding mats and shoe covers to simulate the slipperiness of the ice surface. As players slide on the mats, their motion data is transferred to our virtual world. In addition to sliding motion, we incorporated custom-made props to enhance the curling experience. Multiple trackers are mounted on the props to capture their actual position. Here is a breakdown of our hardware and software:

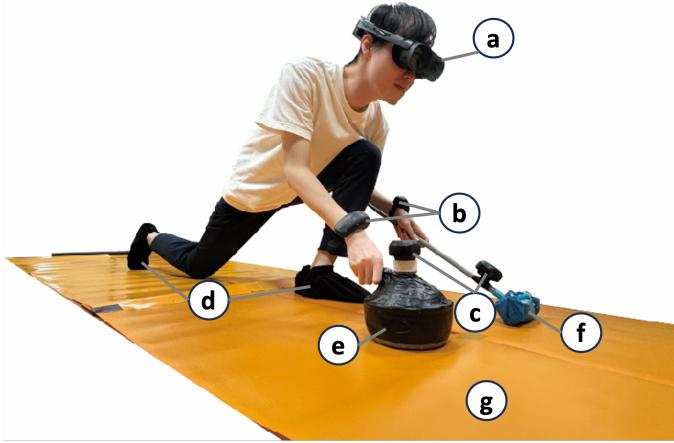


Figure 2: Hardware: (a) HTC Vive XR Elite, (b) Vive Wrist Tracker, (c) Vive Ultimate Tracker, (d) Shoe covers, (e) Throw ing prop, (f) Sweeping prop, and (f) Sliding prop.

Hardware: Our curling system consists of three components: (1) an XR headset using HTC Vive XR Elite, (2) trackers better to track the player’s and props’ motion, (3) customized props that aim to replicate the real curling stone and broom, details are described below: In curling sports, players keep balance while sliding by holding the broom at the left back side of the body. In this case, the left hand might lose track since its position is outside the headset’s maximum tracking range. To address this issue, we use Vive Wrist Trackers to precisely capture the motion of both of the player’s hands. To track the real-world position of our props, we use Vive Ultimate Trackers and mount them on our props. Besides, we made a throwing and sweeping prop to present realistic feedback. **Throwing prop:** We cut a PET water bottle, kept the bottom and part near the bottle-neck, and then connected glue and tape. The bottle was filled with water to simulate the weight of the real curling stone and prevent the inertia caused by liquid movement. In addition, we cut off the handle of a fretsaw and fixed it to the side of the bottle with glue and tape. Finally, we drilled a hole in the bottle cap and attached the base of Ultimate Tracker using a screw. **Sweeping props:** We wrapped a cloth around the head of a bathroom cleaning brush and secured the cloth with zip ties to provide realistic feedback. Besides, a screw was fixed by glue and tape to the pole near the brush head, then attached the tracker base to the screw. Just simply snap the Ultimate Tracker to the base when in use.

Software: We developed the system on Unity 2021.3.21f1 and integrated the VIVE Wave SDK to implement the essential functionalities of our system, such as sliding, throwing, and sweeping. The player’s position data and initial sliding distance are used to calculate the sliding speed and then transfer to the movement in the virtual world. When the player starts sliding in the real world, the sliding movement will also be displayed with additional impetus in the virtual world to create speed and immersion. To simulate the inertia on ice, the sliding motion in the virtual world will not stop even though the player stops sliding in the real world. The speed and direction of sliding and the force applied by hand will determine the stone’s trajectory after release. Different trajectories

can be created through various hand rotations, sliding directions, and force applications. As for sweeping, the player’s camera automatically follows the stone, positioning it ahead of the stone approximately one step. When the stone almost stops, the camera will stop following to prevent motion sickness. The tracker on the sweeping prop tracks the motion and detects whether the player is sweeping the ice. If so, the virtual ice surface’s friction gradually reduces, slowing down the speed reduction of the curling stone and producing rotation to change the trajectory. Every subtle change in sliding, throwing, or sweeping can significantly affect the result of the curling stone’s throw. Moreover, sound and particle effects are presented to deliver player feedback. All the designs aim to provide players with the most realistic feedback possible, encompassing physical, visual, and auditory experiences.

3 APPLICATION

At the beginning of each round, a video demonstration accompanied by a text description outlining the task at hand is presented to the player. Next, the player follows the indicator to find the curling stone and broom. Once the player is positioned in a sliding stance, they can slide forward and release the stone before reaching the hog line. Then, the player will be informed to stand up and switch to sweeping mode. Subsequently, the player’s camera automatically follows the stone, positioning ahead of the stone approximately one step. The player can control the direction and rotation of the stone by sweeping the ice surface. To deliver the stone to the house (target), players should carefully control their sliding speed and adjust their hand direction and rotation while releasing the stone. Finally, deliberately sweep to manage the friction of the ice surface and the direction of the stone to ensure the stone arrives at the ideal position. An accuracy number will be calculated and then presented with the top view of the house in the summary UI. Players can refine their movement and challenge again and again to advance their skills.

4 SUMMARY

Curl Clash is an immersive curling XR system that provides a realistic sliding experience. With XR devices and real props, users can learn important curling sports movements, such as sliding, throwing, and sweeping.

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