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Curved - free-form interaction using capacitive proximity sensors

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Abstract

Large interactive surfaces have found increased popularity in recent years. However, with increased surface size ergonomics become more important, as interacting for extended periods may cause fatigue. Curved is a large-surface interaction device, designed to follow the natural movement of a stretched arm when performing gestures. It tracks one or two hands above the surface, using an array of capacitive proximity sensors and supports both touch and mid-air gestures. It requires specific object tracking methods and the synchronized measurement from 32 sensors. We have created an example application for users wearing a virtual reality headset while seated that may benefit from haptic feedback and ergonomically shaped surfaces. A prototype with adaptive curvature has been created that allows us to evaluate gesture recognition performance and different surface inclinations.

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Keywords: Curved surfaces; capacitive sensing; gestural interaction; virtual reality

1. Main text

Large interactive surfaces have been a research interest for several decades, with various applications in research, commerce, and industry. Typically, they are controlled using various touch gestures. However, there are some varieties that enable hand tracking above the surface[1,2]. The last few years have seen a revived interest in virtual reality (VR) systems. Sensor-augmented headsets improve the user experience and numerous commercial systems either have arrived on the market, or are about to do so.

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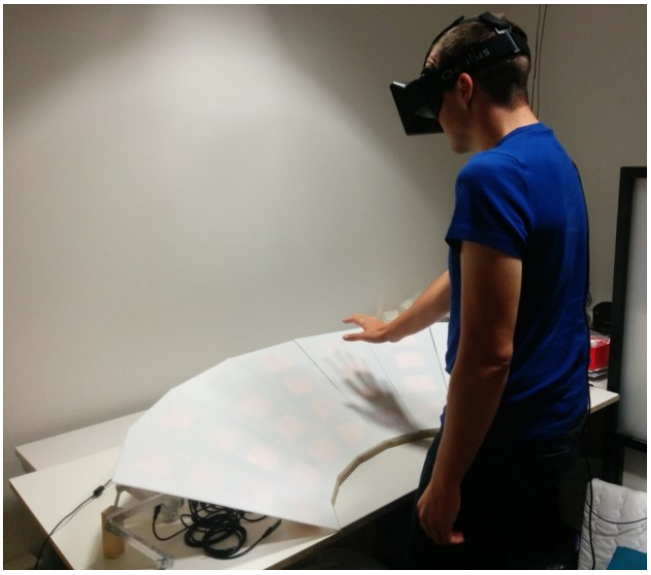

Fig. 1. Person interacting with Curved in a VR application

Visual cues are an important aspect in human-computer interaction (HCI). Knowing the position of interaction elements is achieved, either by visual identification or by learning their positions. There is no straightforward way to provide these for VR systems. Most commonly this limitation is overcome by relying on haptic feedback devices, or providing visual feedback in the virtual world[3].

Combining interactive surfaces and VR has a number of potential applications, ranging from 3D manipulation to configurable haptic user interfaces. However, so far these surfaces rarely consider the body kinematics and remain flat or shaped non-ergonomically[4]. In applications, where prolonged use is necessary, a device that allows for haptic feedback can help reducing fatigue, by letting the user rest his hands. This is not directly supported by common hand tracking devices, such as the Leap Motion or the Microsoft Kinect[5,6].

In this work we present Curved - an interaction device with a curved surface, based on capacitive proximity sensors (Fig. 1). It is able to detect presence and position of one or two hands at a distance of approximately 20 centimeters from the surface and distinguishes mid-air and touch gestures. Curved is comprised of eight modules with four capacitive sensors each. The inclination of the modules can be adapted, so it is suited for persons sitting or standing in front of it. We have created a demonstration application in VR that visualizes the effects of different lighting systems and their impact on the energy consumption in a home environment. In addition, the gesture classification module was tested with ten users. In short, we propose the following scientific contributions:

- A novel free-form interaction system, whose shape follows the kinematic range of a person's hands,
- whose shape is adaptive for sitting/standing persons and supports touch/mid-air gestures, and a
- VR demonstration application for visualizing energy consumption and user evaluation

2. Related Works

Curved display systems have been of commercial and research interest in the past few years. Improved display technologies, such as OLED or eInk can be applied more flexibly, which has resulted in various curved displays on the market, from small smartphone screens to home theater systems[7,8]. The University of Groningen created the Reality Touch Theater - a large area system with a curved projection area that supports touch interaction from multiple users that move around the area[9]. The system is designed for collaborative multi-user interaction with the vertical surface, not taking into account individual kinematic constraints.

Researchers have been active in creating large-area interaction systems for standing or sitting persons. Rekimoto used an array of capacitive sensors to build SmartSkin, an early example of a flat interactive surface[10]. More