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Foot Motion Sensing: Augmented Game Interface Based on Foot Interaction for Smartphone

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Abstract

We designed and developed two games: real-time augmented football game and augmented foot piano game to demonstrate a innovative interface based on foot motion sensing approach for smart phone. In the proposed novel interface, the computer vision based hybrid detection and tracking method provides a core support for foot interaction interface by accurately tracking the shoes. Based on the proposed interaction interface, two demonstrations are developed, the applications employ augmented reality technology to render the game graphics and game status information on smart phones screen. The players interact with the game using foot interaction toward the rear camera, which triggers the interaction event. This interface supports basic foot motion sensing (i.e. direction of movement, velocity, rhythm).

ACM Classification Keywords

H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Author Keywords

augmented game; smartphone game, foot interaction, motion sensing.

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Overview

Recent research in mobile phone computing has led to a number of input techniques that allow for spatial input by hands beyond a touchscreen. For example, SideSight [3], Abracadabra [8], and SixthSense [13], as well as motion sensing based research, such as camera phone based motion sensing [16], motion sensor based motion sensing [4] [2], hybrid motion sensing [7] [15] all provide a level of spatial input in a mobile setting. A series of industrial mature products (i.e. Kinect, Leap motion) are already popular, but they haven't provided ubiquitous interface for smartphone and novel projected glasses yet.

Figure 1: A block system diagram of augmented foot interaction game on smartphone.

Figure 2: Foot Motion Sensing Computing chart.

We use feet along with hands in various everyday tasks and coordinated control mechanism of both modalities has been proven effectiveness in human computer interaction. Inspired by early research [14], various foot gesture detection and tracking system have been proposed such as multitoe [8], kick [6], foot tapping [5], Daft Datum [9] and Real-World Mappings for Foot-based Gestures [1], each of which explore something unique available through foot-based interaction while connecting users to a system in new ways or identifying gestures that would allow this to be done in future systems. We believe that foot gesture interaction can provide augmented interaction experience on portable devices such as smart phone (Fig. 1). The game 'augmented football game' and 'augmented foot piano game' on smart phone is developed based on this interface. In the two games the player uses foot interaction behind the rear camera. The foot is detected and traced by a core foot motion sensing approach, which supports basic foot motion sensing (i.e. direction of movement, velocity, rhythm).

Augmented Foot Interaction Interface

The core foot motion sensing approach is a computer vision based real time foot detection and tracking algorithm. Our algorithm execution time is real-time and is accurate even when the foot/shoe is moving fast and in image blur cases. This method can detect almost obscured foot and also all kinds of the foot-gesture in the football game. We already proved the high-success-rate of real-time detection and tracking for foot [11] by running test on large number of video captured on multi-context in our previous work. The high performance and high efficiency make the interface be enable to achieve foot based motion sensing interaction. We use a linear method to calculate the foot motion as in figure. 2, where D is the distance of the movement, T is the time consuming of the movement, α is the tilt angle of the movement on behalf of the movement direction, which can be calculated by relation between the movement on X and Y axis. Velocity V can be calculated fast by $V = D/T$.

Augmented football game

We developed a real-time augmented football game application on android phone.

Game Rules

The players use foot to kick the ball on the smart phone screen, meanwhile, they guard the goal post area using finger. The game rules are as following:

1. The player foot must be in mobile camera view in 10 sec for detection and localization. After the foot is labeled on the smart phones screen, the user should press start button on the screen.
2. The football will always bounce back and forth on the whole screen area till end of the game. The player should try to keep

Figure 3: The function of Eye-open/shut button

Figure 4: UI of Augmented Foot Piano

the football (using kicks) under his/her control and always prevent it going to goalpost. The kicking direction is shown on screen by a red arrow. 3. In order to prevent the ball entering into the goalpost, the player should dribble the ball and shoot to different direction of the goalpost. 4. The player will get 1 score if kicking the football once. The game will be over if the football enters into the highlighted goalpost.

UI introduction

Eye-open/shut button: shown on the right-top corner when the game is running. Eye button open status decides if the camera view shown status. When the player close the camera view, the shoe icon in the game is still be controlled by the player foot. As in Figure. 3.

Augmented Foot Piano

The game scenario namely Augmented FootPiano is developed to demonstrate the rhythm control of augmented foot interaction interface. This game gives an option to play a music on the users android based smart phone using foot-gesture. There is a circle progress plate on the right-top corner of the screen, which is used to show how long the user press the piano key, eg. a circle is one mora, semi-circle is a half mora. When the volume up button is pressed by 'Press The Key' gesture, the application starts to look for the movement of the foot through android camera.

When a collision is detected with any of the augmented piano-key, the music note related to that key is generated and wave to the top of the screen, and the circle progress plate whirls until the user release the piano key by 'Release The Key' gesture. After the press of every note of the music, the users can play the

music at once. As in Figure 4.

We have conducted user study to confirm the augmented foot interaction is intuitive and controllable, and evaluated the usability and social acceptability of the augmented foot interface and the proof-of-concept applications [11] [10]. Our solution provides a low-cost solution for the foot interaction on portable device, even the novel wearable device such as projected glasses. The football application was presented at [12].

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