Walk-in-Place Locomotion Interface using Footprint Images

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1 INTRODUCTION

Many locomotion interfaces which have been proposed need sensors attached to the body or expensive special equipments. This paper proposes a simple and low cost locomotion interface using a USB camera. This interface only requires a USB camera, a stepping stage and a PC. This locomotion interface allows users to move in VR space using walk-in-place. Purpose of this demonstration is to experience effect of this system.

2 OVERVIEW

2.1 System configuration

The system configuration of this locomotion interface is shown in Figure 1. This system consists of a PC, a stage for walk-in-place, and a USB camera which is placed at the rear of the stage on the floor. The stage uses an acrylic board on it to project a shadow on the back of the board.

2.2 Footprint images processing

Footprint images are obtained by the USB camera. Image processing below uses OpenCV. Footprint raw images are given projection transformation and background differencing. The image noises are removed by opening-filter. The footprint raw images are binarized as Figure 2. In this system the locomotion direction and the velocity are obtained by the images changing with time.

The determination of direction is shown in Figure 2. The direction of foot print (right or left) is decided by comparing the number of white pixels in every corner of a circumscribed oblong surrounded with lines parallel to x-axis and y-axis. If the number of white pixels at the upper right and lower left corner is larger than that at the upper left and lower right, the rotation direction is assumed right. If the number is reverse, the direction is assumed left. Then this system approximates the rotation angle (θ) as shown in equation (1),

$$\theta \approx \sin^{-1}\left(\frac{X_f}{\sqrt{x^2+y^2}}\right)-\tan^{-1}\left(\frac{x}{y}\right) \qquad (1)$$

where X_f shows width of the circumscribed oblong, and x and y show width and height of foot initially obtained respectively . If a user steps with rotating one's foot, the projected image on the screen moves with rotating by calculated angle.

The relation between footprint patterns and locomotion velocity is shown in Figure 3. If one footprint image is detected, the locomotion velocity and the direction are applied. To move continuously if two footprint images are detected, the locomotion velocity is decayed with time not to be 0 soon.

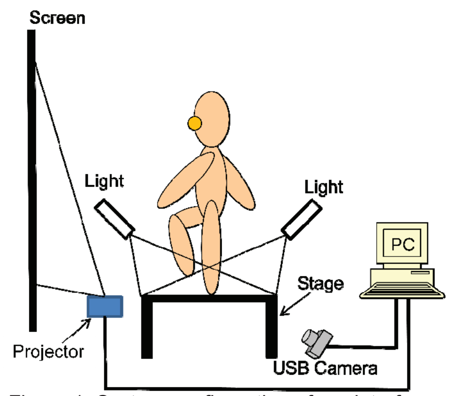

Figure 1. System configuration of our interface

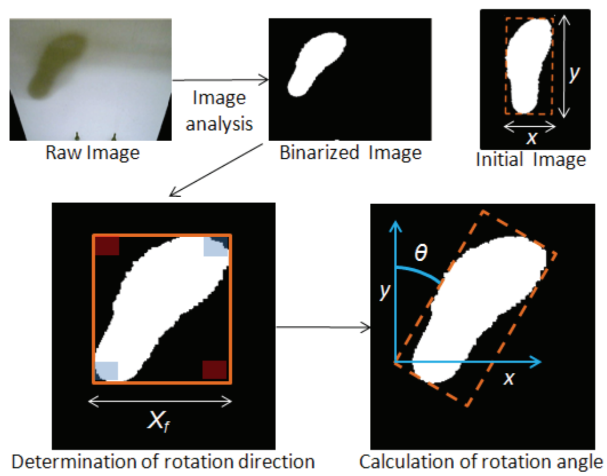

Figure 2. Determination of direction process

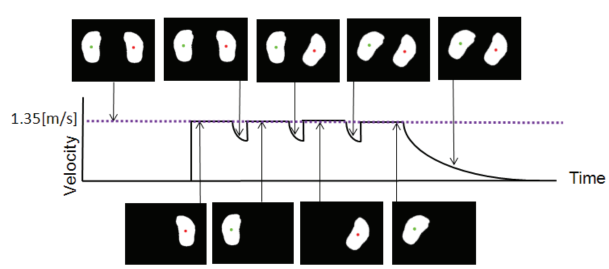

Figure 3. The relation between footprint patterns and locomotion velocity

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