Forehead Retina System

Hiroyuki Kajimoto* The University of Tokyo
Yonezo Kanno† EyePlusPlus, Inc.
Susumu Tachi‡ The University of Tokyo

1 Introduction

The goal of our project is to provide a cheap, lightweight, yet fully functional system that provides rich and dynamic 2D environmental information to the blind. The Forehead Retina System (FRS)-composed of a small camera and 512 electrodes on the forehead-captures the view in front, extracts outlines from the view, and converts the outlines to tactile sensation by electrical stimulation. Using this device, the users can "see" the surrounding environment with their forehead skin, without using their eyes.

2 Related Works

The vision to tactile conversion system was first developed by Collins [Collins 1970], who used 400 vibration motors on the skin of the back and a CCD (Charge Coupled Device) camera. He called the system a tactile vision substitution system (TVSS).

However, although many similar systems have been proposed since then, they have not become widely used for the following two reasons: One is the technical aspect of the stimulation. For tactile devices using a large number of mechanical actuators, the system becomes heavy, expensive, and requires a considerable amount of power. To solve this problem, we applied electrical stimulation. The electrical stimulation is lightweight, cheap, scalable, and consumes much less energy. At the same time, it does not generate sound and is free from mechanical resonance.

The other reason pertains to the region of stimulation. Many previous proposals placed vibration motors on the back. Although a waistcoat with the motors is definitely "wearable," its use is not so effortless. For this problem, we propose to use the forehead as a stimulation point. Although electrical stimulation has a long history, stimulation of forehead skin is a new approach. However, in reality, it is quite reasonable because of the ease in putting the system on and taking it off. Furthermore, if the stimulation is applied on the back, finger, or tongue, the coordinate system transformation to change the image on the skin to that on an absolute coordinate system is complicated. However, if we use the forehead, this transformation becomes unnecessary.

3 System

A CCD camera attached on a pair of sunglasses captures the view in front. A laptop PC extracts the edges and converts it to a tactile stimulation pattern. The pattern is transmitted to the driver circuit via a standard serial port. 512 electrodes (Fig.1)are driven sequentially to create the tactile pattern. The entire process is triggered by the image capture event, which occurs every 33 [ms] (30 [fps]). The basic electrical stimulation technology is inherited from "SmartTouch"[Kajimoto et al. 2003] which is a visual-to-tactile conversion systems for the skin on the finger.

*e-mail: kaji@star.t.u-tokyo.ac.jp
†e-mail:kanno@eyeplus2.com
‡e-mail:tachi@star.t.u-tokyo.ac.jp

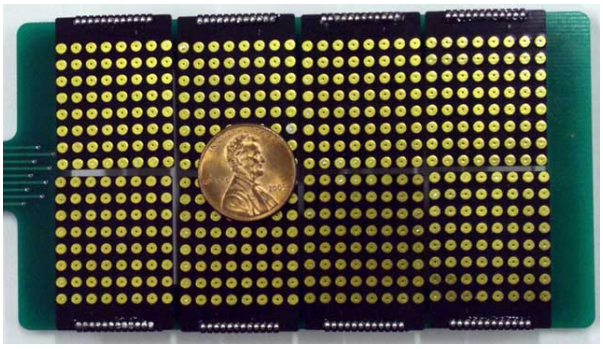

Figure 1: 512 (32×16) electrodes module for the forehead.

Figure 2: Wearing Forehead Retina System (FRS).

In one case, the luminance information is used for edge extraction. In other case, color key is used to extract specific color. The outline edge is extracted by an ordinary Laplacian of Gaussian (LOG) filter. After that, the image is scaled down to a resolution of 32×16. Using threshold, we obtain a black and white binary pattern.

We must note that although many useful algorithms have been proposed in the field of computer vision, we cannot always use them unconditionally. The processing must be performed realtime (at most 33 [ms] or one frame latency), and the system must be small and power efficient for portability. Therefore, we believe that rather than incorporating elegant but expensive algorithms, the combination of bare minimum image processing and training is practical. We are beginning to test the system with the visually impaired to determine the most appropriate balance as good human interfaces have always achieved.

References

COLLINS, 1970. Tactile television - mechanical and electrical image projection. *IEEE Trans. Man-Machine Systems MMS-11*, 1 (Mar.), 65–71.

KAJIMOTO ET AL., 2003. Smarttouch: A new skin layer to touch the non-touchable. In *Conference Abstracts and Applications of SIGGRAPH*, CD–ROM.