Smart Cane: Face Recognition System for Blind

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ABSTRACT
We propose a smart cane with a face recognition system to help the blind in recognizing human faces. This system detects and recognizes faces around them. The result of the detection is informed to the blind person through a vibration pattern. The proposed system was designed to be used in real-time and is equipped with a camera mounted on the glasses, a vibration motor attached to the cane and a mobile computer. The camera attached to the glasses sends image to mobile computer. The mobile computer extracts features from the image and then detects the face using Adaboost. We use the modified census transform (MCT) descriptor for feature extraction. After face detection, the information regarding the detected face image is gathered. We used compressed sensing with L2-norm as a classifier. Cane is equipped with a Bluetooth module and receives a person's information from the mobile computer. The cane generates vibration patterns unique to each person as to inform a blind person about the identity of the detected person using the camera. Hence, the blind people can know the person standing in front of them.

Author Keywords
Real-time system; Human assistance system; Face detection; Face recognition

ACM Classification Keywords
C.3; J.7; I.4.9

INTRODUCTION
Human visual system plays an important role in recognizing information regarding surroundings. Since visual signal provides with more data than auditory information, visual signals are more effective than auditory signals when the human being perceives information. However, in case of blind people the lack of visual information constrains them in recognizing information. For a blind person to recognize a subject around him depends on the subject to speak something. In addition, even when the subjects speak it is difficult for the blind to recognize the subject for example in noisy environments, since the blind people depend mostly on auditory sense in recognizing information. Hence, blind people are sensitive in auditory sense and do not want to undergo disturbance in listening. To solve this problem and constraints, we propose a system for face recognition embedded in a smart cane for the blind people. This system detects and recognizes the face of human and then informs a blind person of information of person who is standing in front of himself/herself. Blind people can know personal information from the cane that can generate vibration patterns according to each learned person.

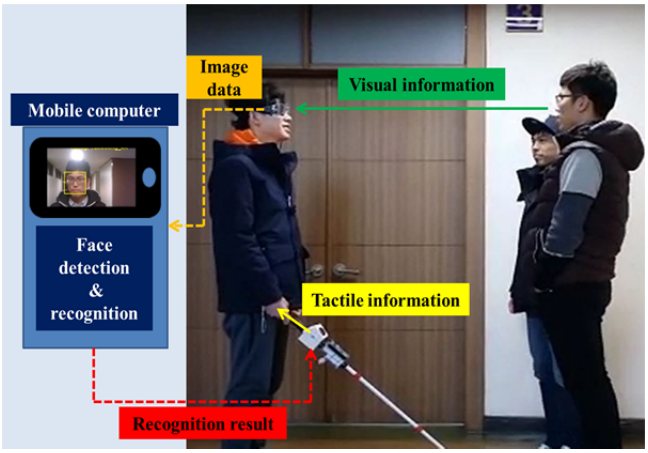

Figure 1. This figure shows a situation that the blind person meets people in the corridor. A glass-type camera captures the front of view of the blind person. The mobile computer gets the front of view from camera through WIFI link. The mobile computer detects and recognizes the person. The mobile computer sends the result to cane using Bluetooth communication. The cane informs blind person of the result of recognition. The blind person can recognize the man who is standing in front of himself/herself by using the cane.

Figure 1 shows an example that is to be expected in the life of blind people. In a situation that the blind person meets people in the corridor, it is difficult for blind person to know who is person in front because there is no information that they can use. If blind person receives information in form of auditory or tactile sense, blind person can know who the person in front is. In case of our system, visual signals are transformed into tactile signals using camera and vibration motor. A glass-type camera captures the front of view of the blind person.

HAI 2015, October 21–24, 2015, Daegu, Kyungpook, Republic of Korea

ACM ISBN 978-1-4503-3527-0/15/10…$15.00.
DOI: http://dx.doi.org/10.1145/2814940.2814952

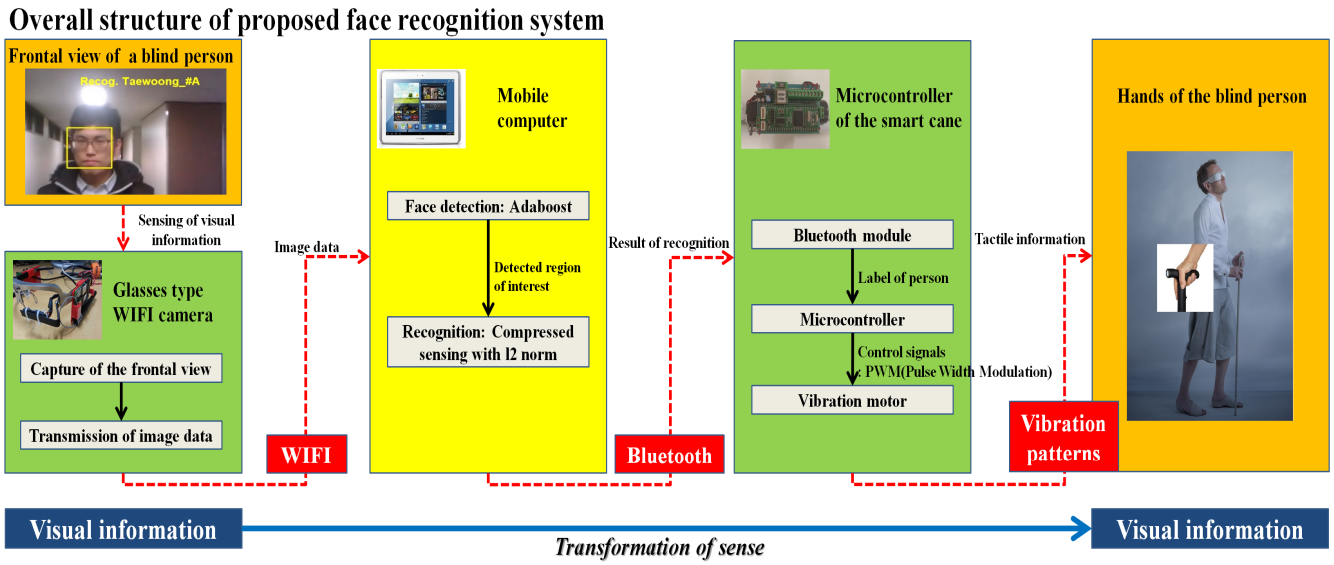

Figure 2. Overall structure of proposed face recognition system

The mobile computer gets the front of view from camera through WIFI link. The mobile computer detects and recognizes face of person and then sends the result to cane using Bluetooth communication. The cane informs blind person of the result of recognition. The blind person can recognize the man who is standing in front of himself/herself by using the cane.

In literature, face detection and recognition algorithms have been extensively studied [10]. In this paper, we used the face detection and recognition algorithms that were already proposed by others [4,6,8]. The main goal of the paper is to propose a smart cane system for face recognition to aid blind people.

Many blind people use cane in order to avoid obstacles. Therefore, we embedded the face recognition system in the cane. Several studies tried to apply to engineering technology to cane for helping blind people. Faria J et. al [3] proposed electronic white cane for blind people navigation assistance. This navigation system guides blind person to destination using RFID tag. Sakmongkon Chumkamon [2] also proposed RFID-based location and tracking system for navigation in a building for blind people or visually impaired.

This paper is organized as follows. Proposed system section presents the proposed system: face detection and face recognition modules followed by their hardware implementation. Experimental setup and result section presents the experimental result in real situation. Final section gives conclusion of the paper.

PROPOSED SYSTEM

The proposed system is designed to transform visual face information into tactile information to help the blind in recognizing human faces. We used face detection and recognition algorithms [6,8], camera and vibration motor in order to transform visual data into tactile information.

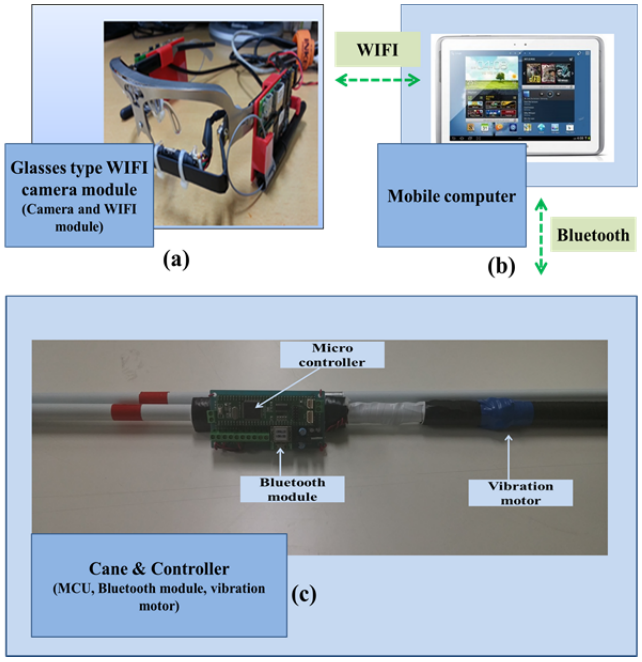

Figure 3. Proposed system: (a) Glass type camera and WIFI module (b) mobile computer (c) cane, micro controller and bluetooth module
Camera is linked to mobile computer by WIFI.
The cane (Micro controller) is linked to mobile computer by bluetooth communication.

The proposed system consists of a glass-type WIFI camera, mobile computer and cane that equip Microcontroller, Bluetooth module and vibration motor. As shown in Figure 3 (a), the glass-type WIFI camera is aligned to the direction of the user's view. The WIFI camera is connected to mobile

computer via wireless network shown in Figure 3 (a), (b). The camera sends the frontal view to the mobile computer. The mobile computer detects and recognizes faces of the person. Recognized result is sent to microcontroller of the cane using Bluetooth communication. The result of face recognition is given in a form of number. The cane consists of a microcontroller, vibration motor and Bluetooth module as shown Figure 3 (c). Microcontroller generates vibration pattern using vibration motor according to result of face recognition.

HARDWARE IMPLEMENTATION OF CANE

We implemented the smart cane to inform blind person of the result of face recognition using vibration pattern instead of visual or auditory information. The blind people can know person in front through tactile information generated by the vibrator.

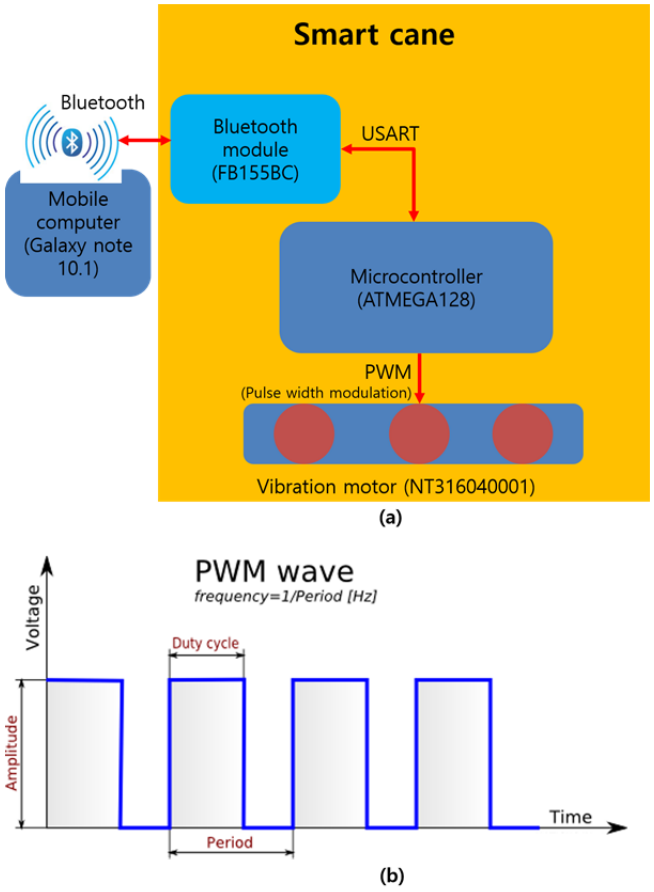

Figure 4. (a) Proposed smart cane hardware: Smart cane is consisted of Bluetooth module, Microcontroller and vibration motor (b) PWM wave for vibration motor. Vibration pattern is determined by duty ratio during a period.

As shown Figure 4 (a), smart cane consists of Bluetooth module, microcontroller and vibration motor. The Bluetooth module gets result of face recognition from the mobile computer via Bluetooth communication. Bluetooth module sends the result of face recognition to microcontroller using USART. According to the result of face recognition, the microcontroller controls vibration motor using PWM(Pulse Width Modulation) wave[5,7]. We made some vibration pattern to distinguish results. Vibration pattern is determined by duty ratio during a period [1]. The blind people can know result of the face recognition through vibration patterns.

FACE DETECTION AND RECOGNITION

We used already proposed algorithms by others [4,6,8]. To detect faces in image of front of view, we used Viola's approach [8]. Viola's boosting algorithm is one of the fastest and most successful approaches in this field. We used the modified census transform (MCT) descriptor as a feature extraction [9].

We used compressed sensing with l2-norm as a classifier. l1 sparse representation can classify robustly in noising condition such as changing illumination, occlusion, and transportation, since it can effectively deal with corrupted data within the same sparse representation framework. l1 sparse representation is hard to adapt in real-time system because obtaining optimal solution of sparse representation takes very large computational load. To reduce the computational complexity and improve the speed of classification, Sin Qinfeng et. [6] suggested compressed sensing with l2-norm to adapt in real-time. Sparse representation with l2-norm for face recognition performed as almost robustly as l1-norm and with a lower complexity.

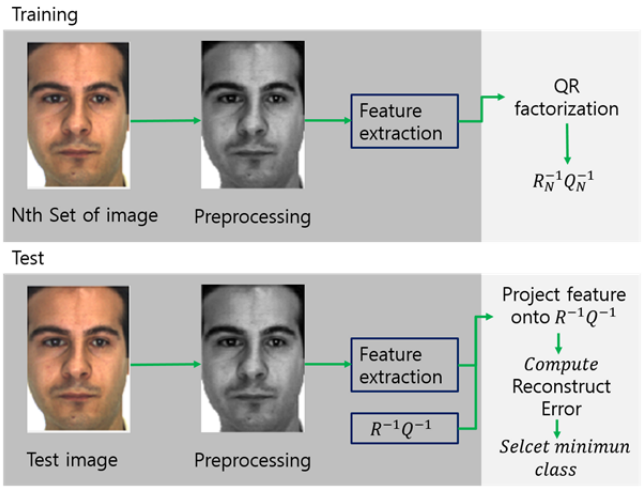

Figure 5. Overview of face recognition system

EXPERIMENTAL SETUP

We experimented on our system in the indoor environment. Face detection and recognition algorithms were examined by others. In the other paper [4,6,8], face detection and recognition algorithms that we used show high performance. We just examined our application system to verify that our system can inform blind person of the result of face recognition using vibration patterns. We implemented 10 kinds of the vibration patterns. Period of vibration patterns is 2 second. Vibration pattern is determined by duty ratio during a period [1,5,7]. 10 people are learned in our face

recognition system for experiment in advance. We verified the system by asking a person cover his/her eyes and to recognize person in front of him/her.

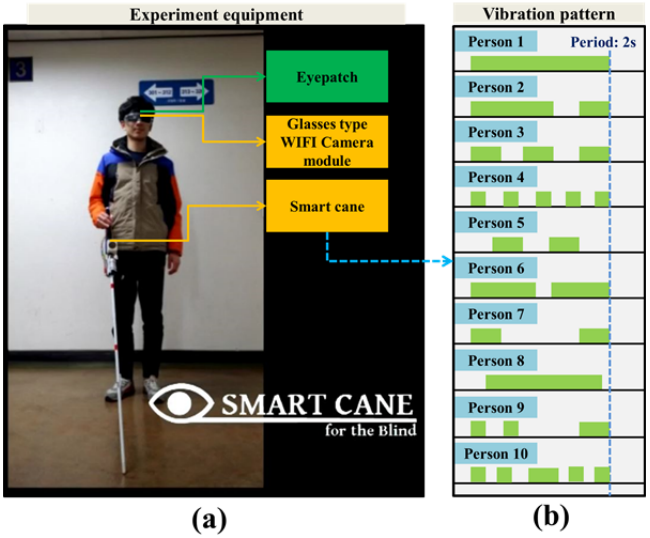

Figure 6. Experiment equipment and vibration patterns

Figure 6. (a) shows the person wearing the proposed experimental equipment. Figure 6. (b) represents the form of vibration patterns. We matched vibration patterns with label of the learned people. Therefore, vibration patterns are generated according to a recognized person.

EXPERIMENTAL RESULTS

Table 1. shows results of experiments. In the Table 1, S represents the number of successful recognitions. Criterion of success or failure is if the person covering his/her eyes using patch knows who is person right in front of himself/herself. The person covering his/her eyes should distinguish 10 learned people and 1 unknown person. 6 people participated in our experiment. Experimental results show our face recognition system can inform blind person of the result of face recognition successfully using vibration patterns made by smart cane.

Experiment participator	Number of test	Result(S/F)
1	20	18/2
2	20	19/1
3	20	19/1
4	20	18/2
5	20	18/2
6	20	20/0
Total	120	112/8
Ratio of success		93.33%

Table 1. Face recognition experimental results (S: success to recognition / F: failure to recognition)

CONCLUSION

In this paper, we proposed face recognition application system in form of cane and glasses. This system is designed to help blind people. The experimental results show that our system can help blind people when they recognize person who is around themselves. For future works, we will solve limitation of vibration motor. Vibration patterns by made vibration motor just can express few people. To solve this problem, we will implement braille generator to express many people.

ACKNOWLEDGMENTS

This work was supported by the Industrial Strategic Technology Development Program (10044009) funded by the Ministry of Trade, Industry and Energy (MOTIE, Korea).

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