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INTELLIGENT COMMUNICATION BETWEEN HEARING DISABLED PEOPLE AND VISUAL DISABLED PEOPLE

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Abstract

The population of disabled people is increasing day by day as a result of wars, illnesses and genetic problems. It is known that %10 of the world population is disabled and a large portion of this have sight and hearing problems. Although there are some studies in literature on sight and hearing disabled people communication methods (Braille coding, sign language) as discrete systems there haven't just been a system which becomes a bridge between these groups yet. This project will be the first one that will provide computer-based communication between hearing disabled people and sight disabled people using first degree Braille and sign language finger alphabet.

1. Introduction

Disabled individuals can communicate with people who have the same handicap in a better way compared to the rest of the society. Because of this, it is very important to develop a computer-based intelligent communication system among visually and hearing disabled people.

In this study, the main focus is automatic communication between visually and hearing disabled people with contribution of physically normal people. The *Braille code* used by the sight disabled people and *Sign language* used by the hearing disabled people are transformed into common text in two ways to perform this communication. Here two ways transformation means that Braille code can be translated into text and then sign language and vice versa. The recommended system is composed of two main modules: *Braille Code Analyzer and Sign Language Analyzer*.

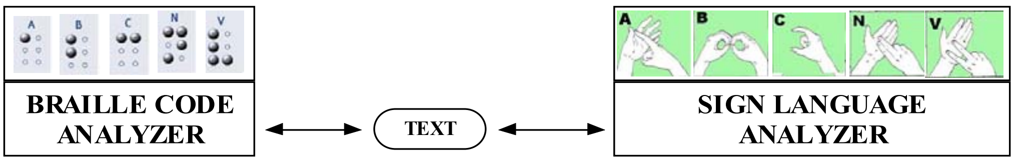

Figure 1. System structure

There are some studies in literature on providing communication between disabled and normal people. In their studies *A. Sterr*, *L. Green* and *T. Elbert* evaluate the perception of Braille coding among people who are sight disabled and who aren't [2]. *M. Jiang et.al* researched the transformation of the Braille codes into Chinese characters with the help of the Viterbi algorithm in their studies, *V.Nabiyev* investigated the translation of Braille code into Turkish text based on natural language processing [3,1]. *C. Lauenstein* studied the linguistic processes among congenitally and adventitiously sight disabled people [4].

Many researchers have attempted to recognize sign language. However, in these projects, some basic problems were defined and limited results were obtained. For handshape recognition, several methods e.g. neural network (NN) based, linear discriminant analysis based, etc. have been proposed in the literature. NNs have been widely used for fingerspelling handshape recognition. *Beale and Edwards* [5] and *Hienz et al*. [6], and *Allen, Asselin and Foulds* [7] used NNs to recognize static handshapes using vision-based approaches. A three-layer feedforward NN was used by *Wu and Gao* [8] to recognize 30 handshapes in Chinese Sign Language, using data acquired by Cyberglove. For handling the dynamic aspects of sign language recognition, hidden Markov models (HMMs) have been widely used. Starner et al. [9] used HMMs for sentence-level American Sign Language (ASL) recognition with a 40 sign lexicon in a vision-based approach. *Bauer et al*. [10] achieved 91.7% recognition rate on a lexicon of 97 signs in German Sign Language (GSL). *Eun-*

Jung, Lee and Owens [11] proposed an automatic Australian Sign Language (Auslan) recognition system, which tracks multiple target objects (the face and hands) throughout an image sequence and HMMs were used to recognize Auslan phrases. *Haberdar* [12] proposed the system recognizes Turkish Sign Language (TSL) gestures.

Consequently, with some restrictions, studies are only based on the communication between sight disabled people – normal people or hearing disabled people – normal people. There is no study about communication among disabled people who speak Turkish or closely relative languages. The properties of embossed writing and sign language are going to be mentioned in the next section to clarify the subject.

2. Braille Coding and Sign Language

2.1. Braille Coding

Up to now, several alternative alphabets such as Moon, Morse, Braille systems are recommended for the sight disabled people with a good sense of touch to read and write. The most current one among these is Braille Coding.

Braille is a writing system composed of six embossed dots put on a rectangle carrying two columns. Related with location of the dots, 2^6=64 combinations can be created totally.

Because the Braille coding is a phonetic based alphabet, there are much more differences in countries using alphabets such as Arabic, Greek, Russian, Chinese, etc. compared to the countries using alphabet such as Latin. A list of standard Braille characters for Latin alphabet is given in Figure 2.

Braille coding has three different degrees:

- The First Degree; has standard 29 characters and punctuation marks. In this degree characters can be transformed into Braille code as they are.
- The Second Degree; similarly, has 29 standard characters and punctuation marks. Different from the first degree abbreviations of concept, appendix and syllable are used not to extend the words.
- The Third Degree; is a special crypto coding used in private writings.

2.2. Sign Language

The sign language is a visual language that the deaf use along with body language and mimics while communicating with each other. Hearing disabled people use various communication methods including finger alphabet, face mimics, sign language and lip reading. Dactylography or finger alphabet was proposed by *Carden, Pons, Bonet* (Spanish philosophers) in the 18th century. In dactylography, words are formed by coding each letter with one hand or two hands. Communication is provided by using these words which are putted together to form sentences. It's known that there are over 40 different finger alphabets in the world. International finger alphabet was formed in 1963. In general, a dactylography used in a country has strong connections with the country's alphabet and every country has its own sign language. For example, each of 29 characters in the Turkish alphabet has a corresponding finger character. Turkish finger alphabet is shown in Figure 3. A complete sign language should be consist of words, mimics and gestures.

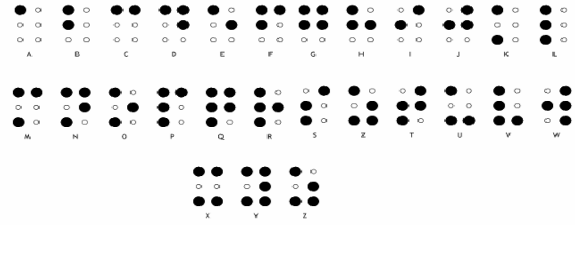

Figure 2. Standard National Braille Characters

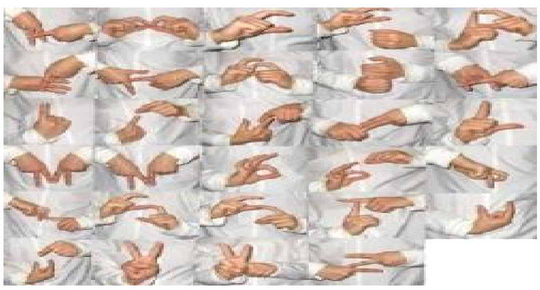

Figure 3. The Turkish finger alphabet

3. System Overview

In the recommended system, automatic transformation between the first degree Braille coding and finger alphabet is studied. As a result, with the interpretation of the embossed writing image, the equivalent of each character of finger alphabet is determined, and corresponding Braille code is produced for finger signs taken from the camera.

3.1. Braille–Character Transform

The system has two different transformations: (a) Character– Braille and (b) Braille–Character transforms. The Character–Braille transform is carried out easily by using a specific Braille code, image or font for each character. For this reason, Braille-Character transform is focused here.

Since the Braille code will be read optically, Braille code may have little changes because of different fonts, point and noise. So, the image should be pre-processed (thresholding, enlargement, framing characters, normalization, thinning, and character recognition) in the first stage. Processes in Braille – Character transform; transform of embossed writing image taken from optical reader into gray scale, determination and recognition of Braille pattern.

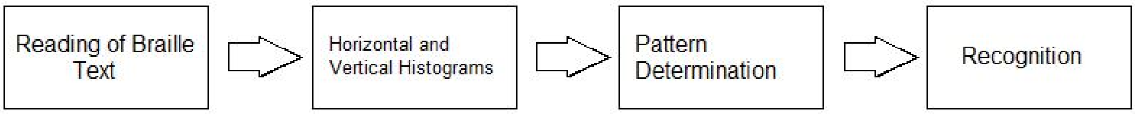

Figure 4. Braille – Character Transform

In Braille writing, with the help of vertical and horizontal histograms, chamber patterns of Braille characters are determined because characters are at the same line in Braille writing. Framed data is evaluated according to the determined pattern and transformed into number series. Number series are looked for in a database of Braille character and the equivalent of it is produced as the output character.

3.2. Sign Language

The system in this paper is a static and a signer independent system. The recognition of characters of TSL alphabet is especially concentrated. Because the background data negatively affecting the result of the artificial neural network in testing and training process, is first eliminated from the images due to the image-processing (IP) module. The artificial neural network module (ANN), core module of the system, is used to classify and recognize the sign language characters.

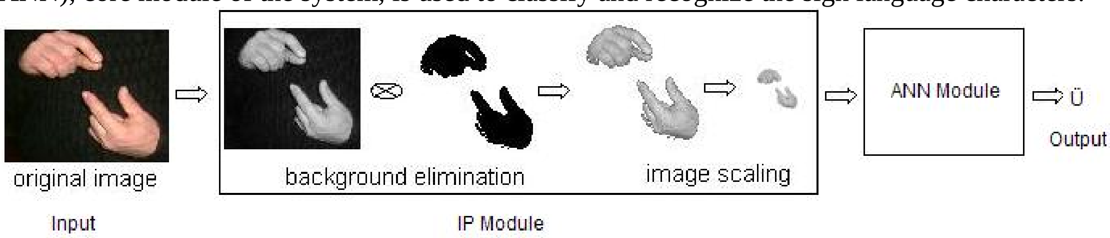

Figure 5. Turkish Sign Language (TSL) finger spelling recognition system

Firstly, in image-processing module, the original image is converted into an 8-bit gray-level image. Then a binary image is made by setting a threshold value. The threshold values are automatically determined from gray-level histogram by using Otsu algorithm. In the next stage, the background of the gray image is eliminated by using the binary image like a mask. Finally, the resulting image is reduced to size of 25x25 pixels.

An artificial neural network contains a number of input and output neurons. There will almost certainly be one or more hidden layer of neurons between the input and output layers. The number of inputs is 625 values representing the 25x25 pixels. The number of neurons in the hidden layers is 40. At the output layer, outputs define numbers of characters. Unipolar sigmoid functions are used as the activation function for hidden and output layers. The ANN is trained by using a back propagation algorithm.

4. Results

In the study realizing the system, based on the communication between first degree Braille coding and finger alphabet is investigated. Input data is the signs of the sign language taken from camera or the image of Braille codes. The system using sign language with little variations achieved 96% of success. Here, the shape of hand images is very similar with training data of artificial neural network. But in situations the signs are recorded from different angles or locations, the success rate decreases down to 80%.

On the hand above 90% of success is achieved in recognition of Braille code images with little noises by using computers. But in situations with relatively more noises and the angle of camera is changed, it is seen that the success rate decreases. In Figure 6 showed screen image of our system.

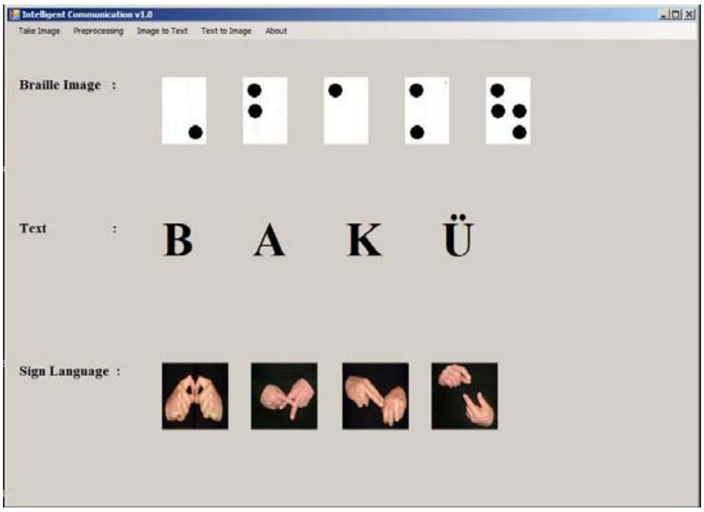

Figure 6. Sign Language – Braille Communication System

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