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Fuzzy image processing scheme for autonomous navigation of human blind

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Abstract

The main objective of this work is to develop an electronic travel aid to assist the blinds for obstacle identification in their navigation. This navigation assistance for visually impaired (NAVI) system presented in this paper consists of a single board processing system (SBPS), a vision sensor mounted headgear and a pair of stereo earphones. The image environment in front of the blind is captured by the vision sensor. The image is processed by a new real time image processing scheme using fuzzy clustering algorithms. The processed image is mapped onto a specially structured stereo acoustic patterns and transferred to the stereo earphones in the system. Blind individuals were trained with NAVI system and tested for obstacle identification. Suggestions from the blind volunteers regarding pleasantness and discrimination of sound pattern were also incorporated in the prototype. The proposed processing methodology is found to be effective for object identification and for producing stereo sound patterns in the NAVI system.

Keywords: Electronic travel aid; Blind navigation; Fuzzy clustering; Pattern recognition; Sonification; Vision substitution; Image processing

1. Introduction

The loss of eyesight is one of the most serious misfortunes that can befall a person. The visual information forms the basis for most navigational tasks and so with impaired vision an individual is at a disadvantage, because appropriate information about the environment is not available. The number of visually handicapped persons worldwide would double from the present 45 million by 2020 [1]. There are a quarter of a million registered blind people in the UK. However, the UK has nearly one million people entitled to register as visually impaired and about 1.7 million are with vision difficulties [9]. This represents over three percent of the UK population. The vision aid for blinds had been under extensive research with restricted achievement since 1970's.

Electronic travel aids (ETA) are electronic devices developed to assist the blind for autonomous navigation. Early ETAs use ultrasonic sensors for the obstacle detection and path finding. Recent research efforts are being directed to produce new navigation systems in which digital video cameras are used as

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vision sensors [2–4]. Peter Meijer [5] presented The voice in 1992 in which sine wave generator is used for sound producing. The image pixels captured by the camera are scanned from left to right and column by column. The top portion of the image is transformed into high frequency tones and the bottom portion into low frequency tones. The intensity of the pixel is transcoded into loudness.

All the earlier works in the direction of capturing the image of environment and mapping the image to sound, do not undertake any image processing efforts to provide the information of the objects in the scene [3,5]. Instead, the captured image is directly sonified to sound signals. In general, background fills more area in the image frame than the objects, and hence the sound produced from the unprocessed image will contain more information on the background. It is also observed that the background is usually of light colors and the sound produced on it will be of high amplitude compared to the objects in the scene. This may be one of the reasons for blinds finding difficulties in understanding the sound produced from camera based earlier ETAs.

In this paper, a pattern clustering method is proposed for object identification and applied towards the development of Navigation Assistance for Visually Impaired (NAVI) system. Human auditory system has enhanced frequency and intensity discrimination. It is talented even to infer sound patterns like music or speech in exceptionally noisy environment. Several studies have also indicated that the blind individuals are better than sighted individuals at auditory discrimination. With this anticipation, a procedure by which visual information is given to blind in terms of sound patterns is presented.

2. Developed NAVI system model

The model constructed for this vision substitution system has a vision sensor mounted headgear, a pair of stereo earphones and a single board processing system (SBPS) in a specially designed vest. The user has to wear the vest. The SBPS is placed in a pouch provided at the backside of the vest. SPBS selected for this system is PCM-9550F with Embedded Intel® low power Pentium® MMX 266 MHz processor, 128 MB SDRAM, 2.5'' light weight hard disk, two Universal serial bus and a RTL 8139 sound device chipset, all assembled in Micro box PC-300 chassis. The weight of SBPS is 0.7 kg. Constants 5 and 12 V supply for SBPS are provided from a set of rechargeable batteries placed in the front packets of the vest. Vision sensor selected for this application is a digital video camera, KODAK DVC325. A blind individual carrying the headgear and processing equipment in the vest is shown in Fig. 1. The work is progressing to miniaturize the size of the equipment, so as to be more convenient for the blind individual to carry.

3. Fuzzy based image processing

Digital video camera mounted in the headgear captures the vision information of scene in front of the blind user and the image is processed in the SBPS in real time. The processed image is mapped to sound patterns. Image processing should be properly designed to have effective sonification. Since the processing is done in real time, the time factor has to be critically considered. The image processing method should require less computation. In industrial vision system applications, there can be a priori knowledge on the features of objects to be detected, such as contour or size; thus with the known features, the object of interest is identified by eliminating the background [7]. In the proposed vision substitutive system, the features of objects to be identified are undefined, uncertain and time varying [10]. The classical methods for object identification and segmentation cannot be used in this application. The main effort in the NAVI system is to identify the

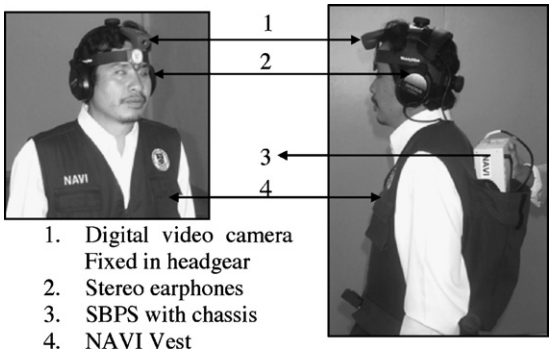

Fig. 1. Blind volunteer with NAVI system.