A SECONDARY AID THAT HELPS TO CREATE CONGNITIVE MAPS FOR VISUAL IMPAIRED PERSONS.

N. Reyes-Ayala, N. Félix-González
H. Pérez-Ponce
Department of Electronics, Universidad Autónoma Metropolitana-Azcapotzalco, DF, México

Abstract- **Mautly Pathfinder is a system designed to obtain images of the surrounding world presented to a blind person by any video camera and to manage those images to obtain only the significant information for the user such as the shape, size, position and relative movements of possible hazards. This information is transmitted to the user by a vibrating matrix located on the abdominal region of the body. Furthermore, pulses in which frequency varies depending on distance between such hazards and the user are sent to a vibrating interface located on the chest of the impaired person. The purpose is to give enough information to the user to create a cognitive map of the local environment. The system is designed to be wearable and to work at real time, which means that the data processing and the results delivering of such information are done almost instantly.**

I. INTRODUCTION

Recent researches have shown that Electronic Aids for visual impaired persons must provide to the user only small amounts of information in order to benefit the mobility performance without interfering with the information already gathered through other senses and aids like canes[8] or dogs[9]. In other words, Electronic Aids must be thought as a secondary mobility aid. This means that Electronic Aids should work together with primary aids (canes and dogs).

Researches performed by the psychologist Alfred Leonard, the founder of the BMRU (Blind Mobility Research)[1] have shown that small amounts of relevant information can turn the long cane performance into a smooth, graceful and safe performance. Leonard describes three basic problems found on the use of primary aids: orientation with respect to the general environment, orientation with respect to the local environment and the detection of hazards not detected by use of the primary mobility aids.

Therefore, *Mautly Pathfinder* has been designed to give information to the user about the hazards located in front of him/her. The user will be capable of creating a cognitive map[2] of the local environment by estimating the sizes, positions and distances of hazards located on his/her surroundings. Also the visual impaired[4] user will be capable to know if hazards are moving and will know the path of those movements and the speed. Of course the acquisition of these kind of data have to be improved by training.

The system consist of two subsystems: video subsystem and an ultrasonic subsystem. The first one uses a video camera which takes images of the world presented to the visual impaired person[4]. The processed images are delivered to the user through a vibrating matrix located at the abdominal

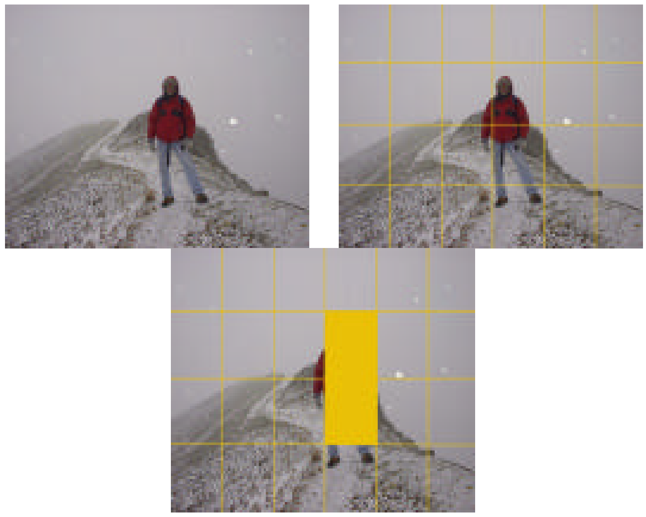

Fig. Example of how one image is sampled.

region of the body. The matrix has been built with 6x4 motors and those motors will be turned on and off depending on the results of the image processing. This means that the video resolution will be reduced to 6x4 black and white where each pixel will correspond to one motor. In the other hand, the ultrasonic system is composed of an ultrasonic device which purpose is to measure the distance between the user and the hazards located in front of him/her. This measured distance is used to vary the frequency of a square signal that feeds another motor (vibrating interface) located now on the chest. So depending on the operation frequency of this motor, the impaired person will know the distance between him/her and the hazard. Furthermore with the use of the video subsystem he/she could know the size and position of the hazard on the local surrounding and also the speed at which he/she will reach this hazard or the hazard will reach him/her in case that the hazard moves toward him/her. Notice that if the hazard presents movements to the right, left, up or down, the user will notice them by the use of the video system only. But if the hazard presents movements frontward or backward, they will be detected by the use of both subsystems (video and ultrasonic systems).

II. METHODOLOGY

Mautly Pathfinder is a system controlled by a microcontroller[5] and a PLD (programmable logical device)[7]. The system is composed by an ultrasonic sensor[6], which is in charge of measure the distance between the impaired person and the hazard located in front of him/her, and a video camera, which is capable of delivering a

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25 Oct 2001	N/A	-

Title and Subtitle A Secondary Aid That Helps To Create Congnitive Maps for Visual Impaired Persons	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Department of Electronics Universidad Autonoma Metropolitana Azapotzalco, DF, Mexico	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom. , The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
4

Fig. System worn by a user.

video output with NTSC[3] (National Television Systems Committee) standard. The video information is treated by the PLD[7] in such a way that the resolution of images are reduced to a matrix of 6x4 black/white to be represented on a matrix of motors, which will work as a vibrating matrix located on the abdominal region of the body. Meanwhile the distance information is treated by a microcontroller[5] that transforms the information into frequency variations that turn off and on the ultrasonic interface (motor) in a faster or slower way. This interface is located on the chest.

Ultrasonic system:

The idea of the ultrasonic system is to measure the distance between the impaired person and any hazard located in front of him/her, so that the person can estimate how far an object is. Therefore the use of one motor that works at specific time intervals will be the interface for the ultrasonic system. This motor is located on the chest of the impaired person and the time intervals will depend on the distance measured by the sensor.

This ultrasonic sensor[6] after measuring the distance is capable of sending the data through a serial communication port that uses the standard of communications RS-232. Then a microcontroller[5] is used to receive the distance measured by the sensor and depending on the data it modifies the timing of the intervals for turning on and off the DC motor, being shorter for closer objects.

The microcontroller[5] sends the character "M" (0x4D) to the ultrasonic sensor[6] via the serial communication port. Then the ultrasonic sensor performs the measuring and returns 5 characters corresponding to the measured distance. After the 5 characters have been received, the microcontroller[5] changes the hexadecimal representation of each character to their decimal representation. Then a mathematical operation using the decimal representation of each character is performed to obtain a float number. The resulting float number is multiplied by 17 and divided by 10000 so that the result obtained is the distance in meters. This number is used to calculate a time delay which varies the frequency of the pulses applied to the motor. The frequency depends linearly of the measured distance.

Video System:

This part of the system manages the input video signal received from the video camera in such way that the necessary information for the reduction of resolution can be pulled out. The main idea is to reduce the resolution of the video frames to 6x4 black/white. Thus the video can be managed through the motor matrix located at the abdominal part of the body of the impaired person.

Firstly, the video signal received from the video camera is treated by a video sync separator, which separate the horizontal/vertical synchronization [3] and odd/even components[3]. These components are used to synchronize the system clock to the video signal, so that if the video signal suffers an alteration, the system will be able to follow the alteration and recover the synchronization again.

The horizontal synchronization signal activates one oscillator, which works as the system clock. When the horizontal synchronization signal's state is "1", the oscillator is activated and during the clock cycles, the video signal begins to be sampled. When the end of one line of one image is reached, the oscillator is deactivated and the sampling of video signal is stopped. Subsequently, at the beginning of the next line the clock is activated again. In this way, the system can be synchronized to the video signal to guarantee that the sampled data belongs to the video information.

To activate the system clock one BJT transistor (NPN) is being used as a switch. The oscillator is a logic inverter arrange connected through an RC circuit. The clock's operation frequency is given by:

$$f=1.23RC$$

where f=1.03MHz which is equal to a video line / 58. That means that 58 samples are taken out from one video line.

During each clock's pulse one sample is taken out from the video signal to determine if it will be consider as a black or white point.

So, using the horizontal synchronization signal the PLD program[7] is able to know which line is being sampled and also the system clock is synchronized to the video signal.

On the other hand the odd/even signal[3] indicates the field that is being sampled depending on the logic state of this

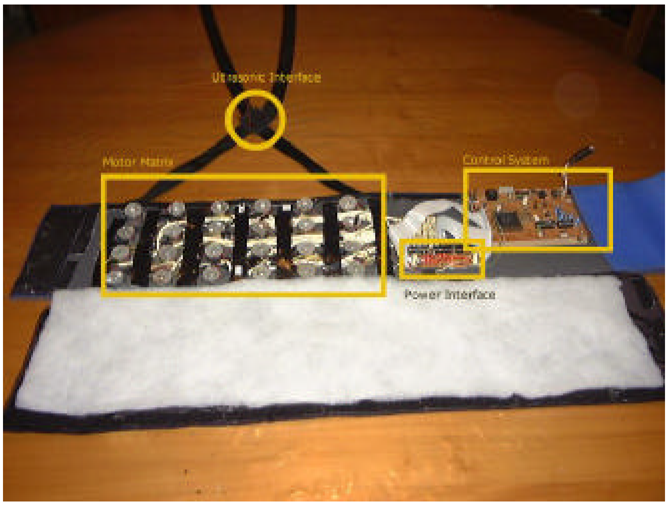

Fig. Internal structure of Control System and User interface.

signal. Considering NTSC format[3], the information of one image is sent using two fields. The first field starts form the left upper corner (line 1) and ends at the middle of line 263 (lower part of image). The second field starts from the half of line 263 (upper part of image) and ends at the lower right corner (line 255). On this way, when the information of field one is being sent, the odd/even signal remains on high state and while the second field information is being sent, it remains on low state.

Therefore, this signal is being used as a reset signal for the video system. When a high state remains (receiving field 1 information) the PLD program runs[7]. But when the odd/even signal[3] state changes (receiving field 2 information) the system is reset and remains like that until the state of odd/even signal change again.

The field No. 1 as the field No. 2 goes over the whole image. Therefore, the PLD only consider the data belonging to the field No.1 cause the final output resolution is very low (6x4). So there is not need to sample both fields.

Each sample taken from the video signal on each clock pulse is evaluated through a basic comparator that is able to compare high speed signals. A fixed reference voltage is being used to compare the input video signal. So that, a video camera with automatic brightness control must be used to compensate the possible brightness variations on the images. The comparator output indicates if the sample taken from video information will be considered as a white or black point.

All the signals mentioned before are used by the PLD to reduce the video resolution to 6x4 black/white.

The program wrote for the PLD uses the VHDL language [7](Very High Speed Integrated Circuit (VHSIC) Hardware Description Language). This is a modular high-level language that allows making a hardware description.

Firstly, the program describes how many inputs and outputs the system will require. Totally, there are 24 outputs, which will activate the motors placed on the 6x4 matrix. The state of these outputs will depend on the quantity of black points detected at the corresponding image zone (one still image will be separated onto 6x4 zones to be treated).

There are 4 inputs which are connected to the video signals resulting from the video decomposition. The connection of these signals with the corresponding inputs are described next:

?? The input "clk" is connected to the clock signal resulting from the oscillator circuit.
?? The input "cmp" is connected to the comparator output, which is sampling the video signal determining whether it is a white or black point.
?? The input "rsth" is connected to the horizontal synchronization signal to count the lines that will be sampled.
?? The input "rstv" is connected to the odd/even signal to know from which field the information is being received.

After declaring the outputs and inputs of our system, eight variables have to be created so that the image can be evaluated using zones. The variable *Count gives* information about the point that will be sampled into a line. The variable *line* counts the number of lines that will be sampled. While the variables *C1* to *C6* keeps the number of black points detected in each image zone. We have to remember that the final resolution is 6x4, therefore each variable *Cx* keeps track of black points found in the corresponding column of the matrix. Then, the system remains on reset while the signal *rstv* remains low (information of field 2 is being sent). When the state of this signal changes to high (information of field 1), the PLD start working and the system starts sampling the video signal at each clock pulse, meanwhile the variable count is being increased. If any black point is detected during sampling, the corresponding Cx variable is increased by one. The variable count is used to know which Cx variable will be increased; C1 is incremented for values between 1 and 13 of count variable, C2 is increased between 14 and 22, C3 is increased between 23 and 31, C4 between 32 and 40, C5 for count between 41 and 49 and finally C6 between count values of 50 and 58.

At the end of the sampling of one line, the variable *rsth* change its state to low, clearing the variable count to start with the sampling of the next line. That means that the line variable is increase by one meanwhile count variable is set to zero. When the variable rsth returns to high state at the beginning of the next line, the system starts sampling the next line and so on for the next lines until the line 63 is reached. At this moment the Cx variables are cleared so that the next six image zones can be sampled. The same process is repeated between line 64 and 133, line 134 and 199 and at last line 200 and 264. That means that on line 63,133 and 199 a block change is generated.

While variables Cx are being updated, depending if black points are being found or not, the value of these variables is checked at each clock pulse to know if they are higher than 330. In case of being higher, the corresponding output state will change to high. Each block of the 6x4 matrix has 660 points in it, so if more than half of points are black, the block will be consider as a black block. For this reason if the block, suppose *C1-block1* has more than 330 black points, the B0 output corresponding to motor1 (1,1) of 6x4 matrix will be activated, provoking that the impaired person notice that a dark object is located at this image zone. In the opposite case, if the block have less than 330 black point, the motor1 (1,1) remains off, provoking that the impaired person notices that a light object is located at this image's zone. The same goes for the *C2-Block1*, the motor2 (1,2) of the matrix will be turned off or on depending on the number of black points located at the image's zone. And so on for the rest of zones.

Finally, when all the zones have been sampled, the input rstv state will change to low, resetting the system so that the field one can be sampled again.

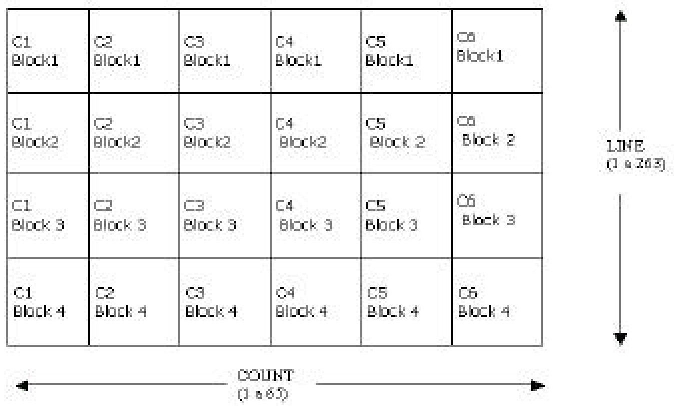

Fig. Simplified Image Matrix

III RESULT

The system is still a prototype, that means, that better and smaller devices can be used in order to reduce size and weight of the entire system. Nevertheless, the price of the system can increase dramatically. But the fact is that the system is now totally portable and can be reduced more in size and weight with low power consumption. Also notice that the electronic control is totally independent, that means that no computer is needed to be connected to the system. The use of a 12V battery let the system to be totally portable and practical, and the battery can be recharged at night.

The ultrasonic device used now is not the optimal one due to the dimensions of hardware. Also the video camera is too big to carry for a long time. But rememb er that the system have been built as a prototype therefore any video camera with NTSC video output and auto-brightness control can be used giving a wide range of selection. The ultrasonic device can be changed for a smaller one, preferment from Senix Corporation. The only requirement is that the data must be transferred via serial port working with RS232 standard. So the system is flexible on these points.

V. CONCLUSION

The basic characteristics of secondary aids are covered by the system, it can be used together with primary aids: canes and dogs, giving the user the freedom to use of his/her other senses. The audio sense is not interfered by the system as well as the use of both hands which are the most important tools for a visual impaired person. The user would be able to combine and use the information gathered from primary and secondary aids without being redundant. Obtaining information about hazards on short and long distances so that cognitive maps could be easily created. But as everything, training on the use of the system would be required for extracting all the capabilities of the system.

The system was also thought to be such wearable so it can be used as underwear. The idea is to make the user feel as comfortable as possible with this electronic aid, in such a way that it can be use as another clothe. Remember that the user interface works with vibrating signals, therefore it is recommended not to use thick clothes under the motor matrix.

Nevertheless the validation with patients must be the next stage for the project.

VI. REFERENCES

[1]Heyes A.D., *Auditory information and the mobile blind*, University of Nottingham, England, 1979.

[2]D. Jacobson and R. M. Kitchin, *GIS and people with visual impairments or blindness: Exploring the potential for education, orientation, and navigation,Trans. Geographic Information Systems*. Available on-line (PDF file).

[3]Kellin J. Kuhn, *Conventional Analog Television- An introduction*,www.ce.washington.edu/conselec/ce/kuhn/ video/498.htm

[4]S. Harper, *Standardising Electronic Travel Aid Interaction for Visually Impaired People*,M.Phil. in Software Engineering Thesis, Univ. Manchester Inst. Science and Technology (UMIST), 1998. Available on-line (PDF file).

[5]Atmel, *AVR RISC microcontroller databook*, USA, 1999.

[6]Senix Corp, *Senix Ultra-U series datasheet*, Vermont U.S.A.

[7]Altera, *FLEX 10K Embedded Programmable Logic Family Data Sheet, ver. 4.01, March 2001 (1,967 KB)*, http://www.altera.com/literature/ds/dsf10k.

[8] *National federation for the blind*, updated info available at http://www.nfb.org

[9] *Guide dogs of America*, updated info available at http://www.guidedogsofamerica.org