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Design of a FPGA based Virtual Eye for the Blind

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Abstract—**Till date blind people struggle a lot to live their miserable life. Their problems have made them to lose their hope to live in this competing society. They seek help from others to guide them whole day. This project aims to make the blind person fully independent in all aspects. The proposed system is based on "Programmable Gate Arrays (PGA) and Detectors". This constitutes a virtual eye which communicates to the outside surrounding through a camera. The camera acts as a constant source of information to the system. The data received through the sensors and cameras located in legs and on the head respectively. The received signals from the input devices are processed by gate arrays located in the main processing unit that responds to the blind person through speech processing units. The processed information about surroundings will be informed through the headset (output unit) by which blind people can move and make their work easily on their own. If the person suffers from additional disability, being deaf as well. Then small vibrators can be placed on his legs, based on vibrations he can move safely.**

Keywords- Major Proccessing Unit (MPU); Virtual Eye (VE); Object Detector (OD); Infrared(IR); Passive Infrard Detector (PID).

I. INTRODUCTION

Sight is considered to be the most essential of all the senses, people lacking this sense are looked upon with pity by others. Visually impaired persons face numerous difficulties to perform their day to day task. They are totally or partially dependent on someone for help.

Till date blind people are managing to travel with walking stick and obstacle detecting cane and other devices. These have improved their lifestyle significantly from nothing to something but haven't set them totally free. They show them odd among other people, which leads to complexity in them. Thus the assisting devices available in present scenario are not sufficient for supporting them completely.

In order to overcome these drawbacks, we have designed a system which would be of immense advantage in comparison to the devices that are used by blind people today. This system is capable of fulfilling all the requisites of visually impaired and helping them in becoming independent like normal humans. This system acts as a virtual eye for the blind people and sets them free in all aspects.

REAL TIME DIGITAL EYE SYSTEM

Fig No-1

The implemented system will be as in Fig.1, indicating the blind person seeing the object virtually through camera. The image shows a blind person handling objects in front of him easily. The camera over head captures and OD recognizes the coffee mug placed on table and thus data is sent to user as voice.

II. OBJECTIVES

The main aim is to design a system which would help the visually impaired people to function on their own and to make them behave like normal human being without any support. He/she would not require assistance for walking and other activities. They will come to know about the happenings around them by speech signals. As the available aids are not so advantageous, our system will be overcoming those hindrance faced by the past and present. In order to process the received signals with zero or minimum delay, FPGA (field programmable gate array) is being used.

This project has features which helps the visually impaired to acquire an artificial vision through sense of hearing. The person can move independently to any location he/she likes without asking the traveling route from others. All things which are being done by normal humans can also be done by differently talented people too. This projects when implemented can change the life of the needy.

III. METHOD AND MATERIALS

A. Sensors and Camera

Sensors are placed on both the legs to detect the obstacles in the path travelled by using LADAR and PID sensors. The sensors are placed at 6-8 inches above the surface level. The **LADAR** (*Laser Detection and Ranging*) is used mainly for locating objects distance from the VI person. It is same as RADAR, LADAR uses laser waves to determine the object range by measuring the time delay between transmission of a pulse and detection of the reflected signal [1]. The wavelength of LADAR is selected as 1550nm as they are harmless to humans.

PID (Passive Infrared Detector) is a PIR-based motion detector that measures infrared (IR) light radiation from objects in its field of view [2]. Thus LADAR and PID sensors support the system in gathering information about the path.

Virtual object detector (VOD) is used for recognizing the object viewed by the camera. For this purpose specific application software's are being preferred for detection. This is achieved by comparing the acquired image with the online database. This virtual detection is done by interfacing user supporting software's with the system.

The Camera placed at head and Sensors placed in legs serve as input to the MPU unit. Camera is placed over the head since the angle of coverage viewed is best. The field of view is of major concern because it decides the area covered to be transferred to the user as in Fig.2. These cameras are chosen with a pixel value of 8-10. Image resolution required for this module is moderate because only variations and transformation in the location of objects in image are considered. The angle of view is given to be as,

$$\alpha = 2 \arctan \frac{d}{2f}$$

Where,
Angle of view *α, s*ize of the film *d*, effective focal length f.

ANGLE of VIEW

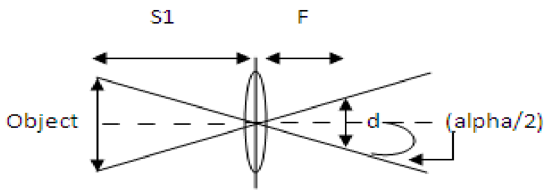

Fig No-2

B. Data processing in FPGA

The MFU is designed in a PCB consisting of FPGA and ZIGBEE receiver with required voltage providing circuits. FPGA is the main processing unit (MPU). It functions as "heart of the system". It is programmed using application software's likes Xilinx. Programming languages like verilog and vhdl are used suitably to program the FPGA, to process the input obtained from camera and sensors.

The voice system consists of mic and headphone acting as input and output of the MPU unit. This establishes a contact between the blind person and device allowing them to interact. The input signals from mic are analyzed by using speech processing software's in FPGA [3]. Data segments are correspondingly matched with those in primary memory and thus output sequences are generated.

The locator unit consists of GPS. Global positioning system is used for identifying the user's location and it intimates to him in predefined voice format. FPGA is programmed to interact with locator unit to fix his/her destination. It is capable of receiving the destination, from user where he/she wants to go [5]. This process is entirely guided by voice commands. These signals are collected from online as programmed. The entire computation in MFU is processed within few ms, thus providing lesser delay when compared to other computing architectures.

Additionally vibrators are provided in both legs. This is used in the case of noisy environment. Thus blind persons can be independent in all kinds of environment.

IV. BLOCK DIAGRAM OF DIGITAL EYE SYSTEM

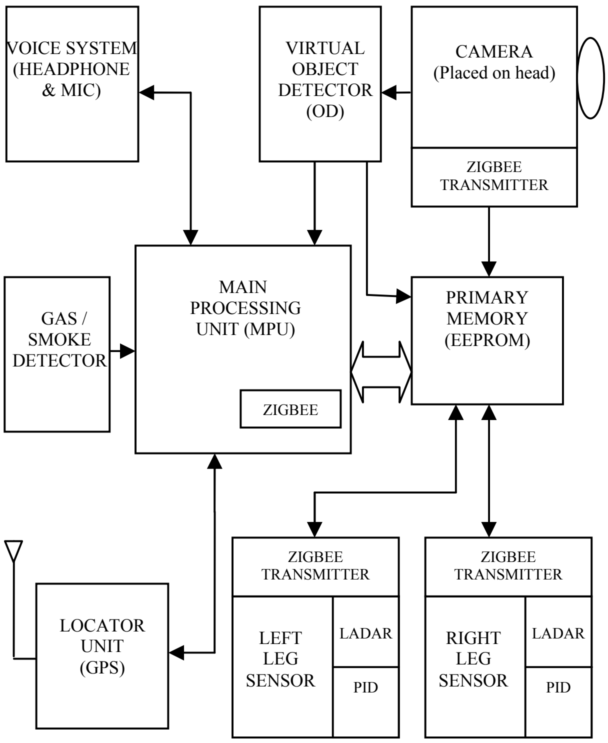

Fig No-3

The interconnections between each unit are clearly depicted above. The data obtained at each segment is sent to MPU. The wireless system is shown by arrows for tracing the path travelled by data from each block. The arrows with one head points a half duplex and double head denotes a full duplex two way data exchange.

V. WORKING

The important function performed in this project is the processing of images and signals acquired from camera and sensors. Among the inputs, visual images are considered to be most important. Image acquired from camera is in video format. This is considered in set of frames as stills of image, separate photographs. The image received first from camera is assumed as Input 1 (I_1) and is being saved initially in the memory (EEPROM), denoted as 'M', the succeeding input of I_1, the second image obtained is termed as I_2.The second image is also saved in memory. In general image can be shown in matrix form as below,

Representation of image

Let

$$I = \begin{vmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{vmatrix}$$

Similarly each image (I_1, I_2, I_3.......$I_{n-1,}$ I_n) will be having its own specific matrix value. These values are calculated for each image in MFU (FPFA) and compared to previous one. The camera is rotated in a circular fashion to obtain information about entire surrounding. All these data are sent to the processing unit. Their resulting values indicate change in the location of an object or a motion of vehicle in the path. Depending on the value of 'X' in the direction from which image is procured.

DIRECTION CONTROL OF CAMERA

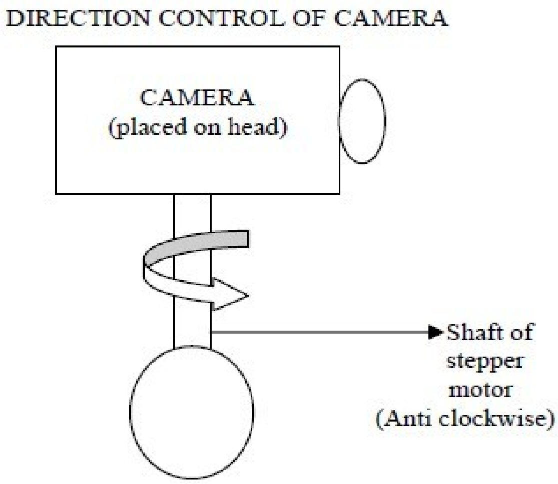

Fig No.4

The design of this system is shown in Fig.3. The possible values for output are based on 'X', this influences the movement of the person.

Manipulation at FPGA,

$$I1\text{-}I2 = X \quad \left\{ \begin{array}{c} \text{If } X=0, \\ \text{No Movements Detected} \\ \text{If } X \neq 0, \\ \text{Movements detected} \end{array} \right\}$$

From the value of X the output for moving ahead is given, if no movements are detected i.e. value of X is zero. The variation in the value of 'X' specifies the change in location of object in the surrounding. The process of estimation is done in FPGA only after storing the value of X initially in memory. The FPGA manipulating unit compares the value of X with pre-defined specification. By monitoring the variation in the values of matrix the movement of object can be detected. The direction of the camera is clearly intimated to the user through voice system. The camera functions continuously and analog signals are generated, by which it constantly images are received. The blind person is guided for move forward and other movements.

Also the values of transmitting and receiving pulse duration from LADAR sensor and the medium present in front is found by PID sensors. These are sent to the MPU by

ZIGBEE transmitters [4], where it is compared with image manipulations and then the corresponding voice signal for movement is given.

A. Image acquisition

In order to obtain the entire information about the surroundings, the camera is placed at elevation on the shaft of a stepper motor. This setup provides a good coverage of the path in front of the blind person [7]. The DC motor is programmed by using suitable microcontroller, so that the camera can be rotated to view the images behind the person too. The rotation of camera is in such a way that prior importance is given to the front phase of travelling path as in Fig.4. This process is done only when the signal is obtained from the MPU, when the sensors at leg give its input.

The person can proceed further 'x' steps or more depending on the LADAR reception time. The signal from MFU serves as the control signal for the micro controller (camera rotation). The angle of rotation is confined to counter clockwise direction.

B. Object Detector

Signal from camera is given as input to OD. The OD (Virtual Object Detector) unit obtains input from camera. It recognizes the objects focused under the digital device. The object detector identification is done by using specific user friendly software and then the detected report it given to the MPU, where speech signals are generated by voice system fused in it. The details of the objects recognized are obtained from online resources. It also checks the image from camera by checking with previously stored images and also searches for data online [10]. If the person's image is stored already then the camera detects it by OD and sends the data to FPGA. The person's image is analyzed using face recognition techniques and intimation through headphone is given. These detected objects can also be stored and retrieved, if they are frequently referred.

C. Sensor mechanism

The sensors in leg function based on LADAR and PID systems by which they exactly determine the distance to move freely and presence of objects even during night. The sensors located in leg will be monitoring the presence of obstacles in path by using laser, this phenomenon of using light for distance measurement and obstacle detection is termed as LADAR (Laser Detection and Ranging). This technique measures the distance from the object by light that has been reflected back. Passive Infrared Detector is a sensitive device used to find the movement of humans even in complete darkness as they emit infrared waves of very low frequency. This would be of immense help to the blind person, for finding the presence of unwanted persons in dark, where a normal person is unable to see.

Eye-safety is a major requirement for most of the applications using laser. The laser of range 1550 nm is used which are eye-safe even at much higher power levels since this wavelength is not focused by the eye. These data's are transmitted to the MPU (FPGA unit) by wireless ZIGBEE transmitters. FPGA manipulates the data perceived from high resolution cameras, LADAR and PID Sensors.

D. GAS/SMOKE detectors

An additional feature of our system is gas/ smoke sensors. These sensors for gas/smoke detect the presence of toxic gas or any leak of LPG gas at home. And the presence of any smoke caused by fire accident can also be detected easily by alarms or vibrators fixed in the system. Fixing alarm at a loud sound enables the surrounding people to also be alert. So it might help to save not only the life of the person wearing the system but also others as well.

This sensor if activated during an emergency status detected by the detector, it sends the alarm signals to MPU which is programmed to call emergency numbers immediately and also instructs the blind person to vacate from that area by giving commands for exit.

E. GPS System

The locator unit comprising of a GPS device by which the user can identify his present location and also fix his destination. The GPS device helps the client in locating the state of his position along with latitude specifications [8]. In case if he needs to go to a specific place he can give input to MFU unit by voice input so that the instructions for his/her travel is provided by connecting to online resources.

In case of emergencies like theft, medical aid, fire accidents he/she can contact the concerned authorities by using voice commands. The inter connectivity between every unit is linked by ZIGBEE technology for high speed data transmission.

VI. LAYOUT

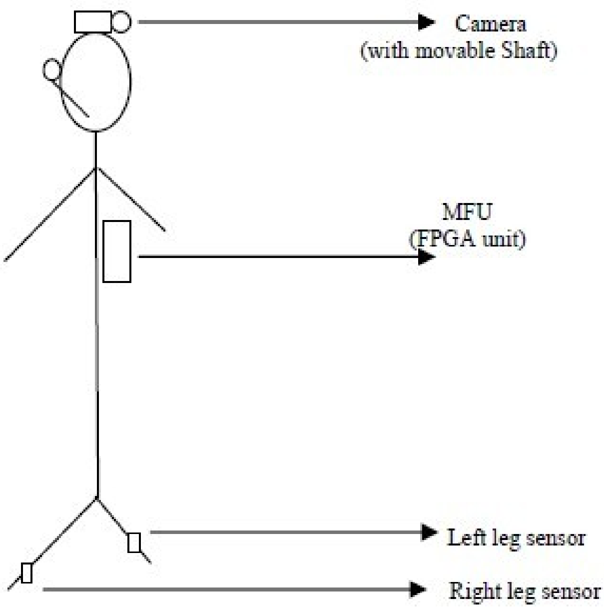

Fig No.5

The main I/O system (headphone and mic) is selected as a single sided type, such that it would be convenient as well it won't be looking odd. The sensors in legs are of miniature type and wireless so they may be placed over the knee or below depending upon his/her wish as in Fig.5.

The design of placing each unit is shown above, camera is being placed over the head as it is the right place for providing the best coverage angle. The MPU unit is fixed with the abdominal region so that the visually impaired person does not feel any harm in carrying it as a separate entity.

VII. CONCLUSION

This proposed model enables the visually impaired person to function independently like normal humans. This device for blind people will improve the quality of their life. The problem with the existing system is the delay encountered and the efficiency of it is not sufficient. The main aim of serving the mankind is achieved by providing sense of sight to the needy by this project. This vision system is designed on basis of an efficient scale, superfast computations and minimized device modules. The system is compact in nature ensuring portability that blind people don't look different, while they wear it. This design articulates the user to behave casually and individually without any restriction. The hardware devices used in this project are carefully selected in such a manner that it does not cause any harmful radiations. The laser wavelength used does not affect the user or other people by its hazardous properties. All these result in a compact, safe, portable, cost-effective, totally a user friendly module satisfying the needs of the needy.

VIII. FUTURE ENHANCEMENT

- FPGA unit can be added with a Bluetooth transceiver enabling device control in an automated area.
- Nanotechnology can be used to minimize the dimensions of the module.
- Medical monitoring system (ECG, BP, Sugar level) may be added to care the visually impaired patient.
- The travelling route of VI person can be tracked for monitoring him.
- System can be designed to interact with ATM machines in voice for convenience.

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