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Obstacle and Color Object Identification by means of Wireless Electronic Perceptible Assistant System

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Abstract The EPAS is vision substitution system. A description of EPAS system which is for independent navigating for Blind person in identified and unidentified environments has been presented in this paper. This system incorporates the GPS receiver to access the spatial data of local environment by the server to the user. According to available spatial maps of the environment the user can freely move around the map. For this system, the implementation of optimal path planning using D*lite algorithm, estimate the direction and orientation of the user moves has been discussed. Time to time new environment map is stored in the spatial database. The database gives the fast information response to users using this D*lite algorithm when the path is revisited. In addition to this, the system has been established the ZigBee nodes for the home environment. According to ZigBee nodes, user can aware of the home environment using the server. The system gives the position, location and orientation of information to the server. Observations can be recorded for each and every movement of the user by sitting behind the server and monitoring the user's movement by using specialized software which was already incorporated in the system, and user can also perceive the above mentioned information through audio signals. The head height vision sensor perceive objects and recognized color and foot level proximity sensors, perceive the information of the obstacle through the audio cues.

Keywords EPAS, ZigBee, GPS, Spatial Data, Path Planning, D*Lite

INTRODUCTION

According to National Federation for Blind (NFB) and American Foundation for the Blind (AFB), the estimated number of legally blind people in the United States is 1.3 million and the total number of blind and visually impaired is approximately 10 million with around 100.000 to be students. Worldwide more than 160 million people are visually impaired with 37 million to be blind. The need to for assistive devices was and will be constant. There is a wide range of navigation systems and tools available for visually impaired individuals.

During the past decades, various researchers have introduced devices that apply sensor technology to progress the blind user's mobility in terms of safety and speed. Examples of these devices,

Electronic *Travel Aids* (ETA's) - Devices that convert information about the environment that would normally be relayed through vision into a form that can be communicated through another sensory modality.

Electronic orientation aids (EOAs)-Devices that provide orientation prior to, or during the travel. They can be external to the user and/or can be carried by the use.

Position locator devices (PLDs- which include technologies like GPS.

PROPOSED SYSTEM CONCEPT

This system, is a combination of Electronic Travel Aid (ETA), Electronic Orientation Aid (EOA) and Position location Device (POD) named as **—Electronic Perceptible Assistance System(** EPAS)[1]. This system can be simply implemented by making the user carry both the NAVI [3] and GuideCane[4] at the same time. The main aim of our system is to create a wireless system that is easy to carry and help the blind to navigate autonomously. This system gives the information of the obstacle from head height to foot level; hence, the system follows ETA guidelines [2]

Therefore, the authors propose to build wireless ZigBee network for closed environment and connect with Bluetooth. The Global Position System (GPS) for position and location and also select the optimal path algorithm can be connected to the user to navigate smoothly in known and unknown environments. It also includes the headphones and mike to user who can receive and inform messages in the form of audio signals. Suppose the user wants any information about environment, the system can provide the same.

SYSTEM ARCHITECTURE

Fig 1 shows the overall system architecture of proposed EPAS system. The EPAS system composed of two main subsystems.

1. The first subsystem is the user EPAS main system consists of vision camera mounted on the headgear and holds the mobile cart with hand at ground level. It gathers information about the surroundings and also sends the requests from the user to the system and user receives the commands from the server through the DSP based MPU.

2. The second subsystem is the EPAS server, processes the collected information from the ZigBee network and also the information received from the user, which are vision sensor information, sensors information and the GPS data i.e. spatial data to generate the output to direct the user to the requested target

The system will sense, evaluate and process the gathered information from the user activities in order to provide proper guidance through commands. These guiding commands are based on user location at real time.

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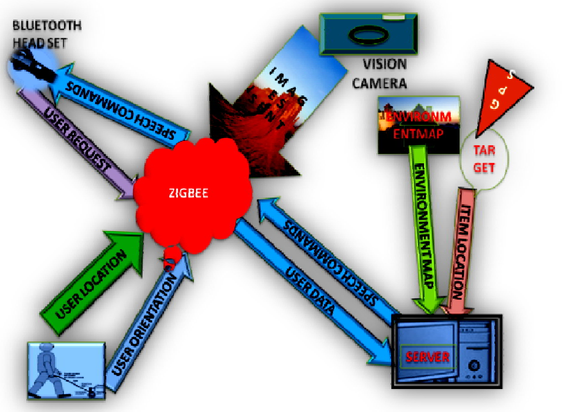

Fig 1: EPAS System Architecture

Fig 2 shows the block diagram of the EPAS main system. This system consists of FPGA based DSP Processor, vision sensor, ZigBee transceiver, Bluetooth headset and transceiver, GPS receiver, ZigBee network, proximity sensors, ultrasonic sensors, servomotor and Server.

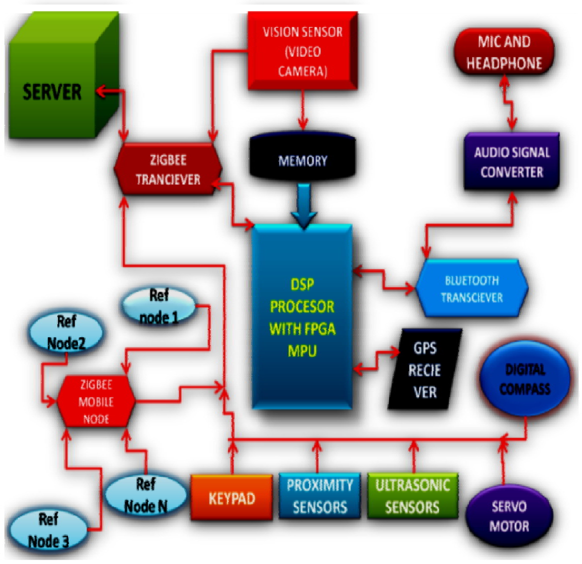

Fig 2: EPAS System Block Diagram

The mobile cane incorporates ZigBee blind node and corresponding reference nodes are fixed in each every room of the user and navigating areas like his/him house, office etc.

1. The ZigBee reference nodes shown in fig 3 are static and places in the known area are likely fixed in four sides of the wall in every room and in corridors, these nodes are fixed in two sides of the wall. It is a node that knows its own position and can tell other nodes on request its coordinates. A blind node is which collects signals from all reference nodes corresponding to a request and read the respective RSSI values and feed the collective values to the hardware engine. Afterwards it reads out the calculated position and sends the information to the server via the control application This will form the ZigBee mesh network

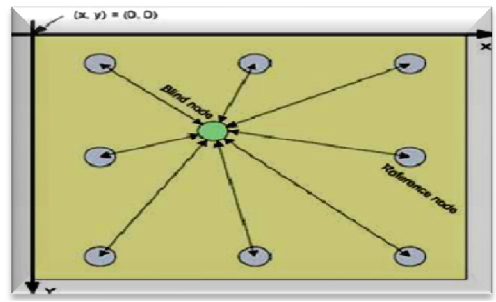

Fig 3: ZigBee Blind Nodes and Reference Nodes

2. ZigBee blind node estimates the location [7][8][9][10] of the user with respect to predefined maps of the known closed environments. The users may generally stay and steer around his/her house and office areas. The potential destinations are stored and their locations are saved with respect to the virtual map of the system. The ZigBee mobile node uses the power estimation algorithm that is based on range measurements using received signal strength from fixed reference nodes. The orientation of the user is acquired from the Digital compass attached to the mobile cane in order to allow the system identify the direction on the map from the user current location to the target location. Concurrently, the ZigBee mobile nodes and Digital compass will detect the user position and orientation. The above two readings will be processed by the DSP processor in mobile cane and transmit them via ZigBee mesh network to the server. The ZigBee coordinator connected to the server and collects data and feed it to the EPAS system. The DSP processor receives information from the ZigBee interface and sends that to audio signal converter through Bluetooth to generate voice commands in words and users heard by means of headphones.
3. At the ground level a user can hold the mobile cane which incorporates the Keypad, ZigBee blind node, digital compass Proximity sensors, Ultrasonic sensors and Servomotor. The Sensors which are fixed in mobile cane, at 120^0 degrees, with the proximity sensors and the Ultrasonic sensors alternatively. During operation, the user pushes the mobile cane forward while traveling, and sensors detect obstacles in a 120^0 wide sector ahead of the user through the ZigBee transceiver.
4. This mobile cane can detect the obstacles in front of the Blind person at the ground level and measures the distance between obstacles and user using Proximity sensors.
5. When the obstacle is detected the mobile cane can change the path of the user by instructing the inbuilt servomotor to steer left or right using the obstacle avoidance [11][12] and the optimal path planning algorithms[5][6].
6. When the user wants to navigate, using the mobile cane, the Keypad which acts as a controlling element. It has four buttons (Left, Right, Top and Bottom). The Left Button acts as a left steer, right button acts as a right steer, top button acts as straight way and finally bottom one acts as a brake.

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7. The information received from detected obstacles is processed by the DSP Processor and can be converted into sound signals and then stored in server through the ZigBee transceiver.
8. The user can wear the Vision sensor (video camera) on the head that capture the images in front of him/her. These images can be sent to the FPGA based DSP processing unit (MPU) through the Wireless Connection ZigBee transceiver.
9. Before sending the images to the MPU, the images have to be store in memory unit. Vision sensor continuously captures 24frames (video image) per second. These images are first stored in the memory unit and then sent to MPU for image processing.
10. The MPU processes the images with the image processing concepts such as preprocessing(resize of image into 256 x 256 pixels), Edge detection(using canny detection algorithm), Edge linking(The two edge pixels are linked by the candidate edge pixel thus forming an edge link), Object enhancement(Flood Fill operation), noise elimination(Morphological operations, erosion and dilation are employed to eliminate noise in the image)., disparity calculation(Area based stereo matching is performed over the stereo image pair) and object preference(the object, the central of image pixel area is called as iris area this will calculated using Fuzzy logic). The designed fuzzy system produces three outputs, which are low, medium and high preferences.
11. With these image processing concepts, the background objects of the image can be suppressed and foreground objects are considered. The foreground and background objects have different frequencies such as low and high respectively. The image with pixels of high intensity will produce sound of higher amplitude. On the other hand, image with pixels of low intensity will produce sound of lower amplitude. The foreground objects with low frequency indicate objects that are closed to the Blind person. Due to the above reason, the close object image can be converted into sound signals. These signals are stored in server.
12. The development of color object identification module for EPAS system is motivated by one key factor "color object identification". From the processed image, objects are divided into three preferences. As to avoid uncertainty to the user, the intended color identification element aims to identify color of identified object in the image. Color can be described as an attribute of visual perception consisting of any combination of chromatic and achromatic content. This attribute can be expressed by chromatic color names such as red, green, blue etc., or by achromatic color names such as white, grey, black, etc. Three criteria are identified to be considered for color module in EPAS system.
   - *Functionality*
   - *Accuracy*
   - *Simplicity*

   Achromatic colour such as black, grey and white are determined by comparing the difference in R, G and B value. Usually the differences in these values are relatively small. Chromatic colours are determined by comparing four criteria, which are the maximum mean values, the difference between red and green, the difference between red and blue, and the difference between green and blue. The result from colour detection is transformed into voice output.
13. The image sound signals and obstacle sound signals, color identification which are stored in server, are converted as audio signals in the audio converter and sent to the Bluetooth Headphones.
14. The Global Positioning System (GPS) gives the information about the location and positions of in an open environment. In an open environment the user can navigate through in any location. The user navigating locations can be updating time to time in the server. The ZigBee mesh network only gives the information about location and position of the closed environment, because the GPS doesn't work in closed environments. According to this application for closed environment we use ZigBee localization [7][8][9[10] technique by using ZigBee mesh network. This information is stored in the server through the MPU.
15. Once the user sends a request for a desired destination or object, the server will identify the location of that object.
16. The server will use a routing algorithm[5][6] to create a path between the user and the desired object in a virtual map.
17. Using the generated path, the server will prepare a set of voice commands to direct user to the requested target.

Fig 4. Shows Server System block consists of Several Blocks

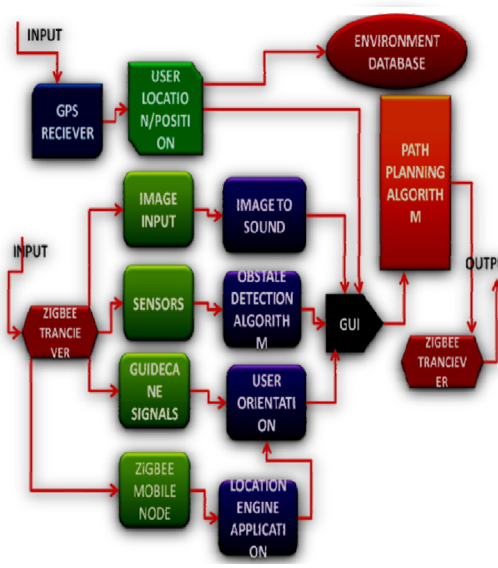

Fig 4: EPAS System Server

1. The server receives data from the ZigBee reference nodes arranged in a mesh network mounted at the fixed closed locations like four side walls of the room and two sides of the corridor in offices and houses. The server receives user locations to update his location with respect to predefined virtual map of closed environment.

2. The possible destinations will be stored in the server and their locations are saved with respect to predefined virtual map of the closed environment.
3. Using the generated path, the server will prepare a set of voice commands to direct user to the requested target. The server will send voice commands, while in the mean time it will update the position of the user based on the received data from him.
4. When the user is near an obstacle, the proximity sensor, ultrasonic sensor and server give obstacle detection algorithm will generate a caution command through the Bluetooth headphones that increase according to the distance between the user and the obstacle.
5. ZigBee Transceiver receives other signals like Keypad and Servomotor signals processed in the MPU sent for storage in server this gives the user orientation. The user orientation is calculated by using the path planning algorithm. Here the best path planning is implemented is D* lite algorithm [5][6].
6. ZigBee Transceiver receives input from the vision sensor (video camera), image processed signals are sent to the Server for the storage of sound converted signals. In front images are converting to sound signals; these sound signals are stored in the server, and then converted to audio signals like, verbal commands by using audio converter which is connected to our system.
7. The GPS receiver collects data from spatial databases. It gives the information of the position and location of the user. The server can collect spatial data from the Google maps of the user locations, which is connected to the internet and have a navigator application in server. The user will navigate from one location to another location, time to time in open environments. Each and every spatial data (Location Map) is stored every time in server. Each time D* Lite algorithm [5][6] calculates the path planning. If the user request is the old requistation then no need to calculate path again. The stored and calculated spatial data in the server must be faster than path planning [5][6] calculation of the new one.
8. D* Lite algorithm[5][6], that repeatedly determines shortest paths between the current vertex of the EPAS and the goal vertex as the edge costs of a graph change while the EPAS moves towards the goal vertex. D* Lite[5][6] does not make any assumptions about how the edge costs change, whether they go up or down, whether they change close to the current vertex of the robot or far away from it, or whether they change in the world or only because the knowledge of the EPAS changes. The goal-directed navigation problem in unknown terrain then is a special case of this problem. This algorithm is developing to provide this capability, but in real-time. This is a planning algorithm that produces an initial plan based on known and assumed information, and then incrementally repairs the plan as new information is discovered about the world.

All the above information are monitor in the Personal Computer (PC) or Laptop with a GUI software and the server also gives the Optimal Path Planning [5][6] to the EPAS system through the ZigBee Transceiver.

HARDWARE

The set of major components that have been utilized to develop such system are:

a. *Vision Sensor*: Vision sensor, which is used for this system digital camera.

b. *Micro Processing Unit*: This is the main unit for the entire Blind Assistance Electronic Travel Aid. For this application, we use the FPGA based DSP processors because it processes the image and audio signals.

c. *Analog Converter*: In signal processing, an audio converter or digital audio converter is a type of electronic hardware technology which converts an analog audio signal to a digital audio format, either on the input (Analog-to-digital converter or ADC), or the output (Digital-to-analog converter, or DAC).

d. *Zigbee Transceiver*: The CC2520 is TI's second generation Zigbee/ IEEE 802.15.4 RF transceiver for the 2.4 GHz unlicensed ISM band. This chip enables industrial grade applications by offering state-of-the-art selectivity/co-existence, excellent link budget, operation up to 125°C and low voltage operation. In addition, the CC2520 provides extensive hardware support for frame handling, data buffering, burst transmissions, data encryption, data authentication, clear channel assessment, link quality indication and frame timing information. These features reduce the load on the host controller.

e. *Bluetooth Transmitter & Receiver*: It is used to connect the headphones and mike.

f. *Proximity Sensors*: A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors.

g. *Ultrasonic Sensors*: Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

h. A *servomotor* is a motor which forms part of a servomechanism. The servomotor is paired with some type of encoder to provide position/speed feedback. This feedback loop is used to provide precise control of the mechanical degree of freedom driven by the motor. A servomechanism may or may not use a servomotor. For example, a household furnace controlled by a thermostat is a servomechanism, because of the feedback and resulting error signal, yet there is no motor being controlled directly by the servomechanism. Servomotors have a range of 0°-180°.Servomotors are not the only means of providing precise control of motor output. A common alternative is a stepper motor. In a stepper motor, the input command specifies the desired angle of rotation, and the controller provides the corresponding sequence of commutations without the use of any feedback about the position of the system being driven.

SOFTWARE

An interface is designed to enable the system administrator to debug the system, or monitor the movement of the blind person for the environment (fig 5). The user icon in the interface continuously follows the location of the blind node, which makes the guidance procedures more accurate. Finally, the software also handles the path-planning algorithm, where Re-active path planning method is used to connect between the user and the desired target. This algorithm is simply connecting between two points, which are the user, and the desired target. However, for enhancement the system has the ability to adapt any complex path planning algorithm

Fig 4. Application Software GUI

CONCLUSIONS

This paper presented for the design of a system that assists the blind to navigate inside a closed environment such as the home and outdoor environment with something like visual perception. The system can be considered as a semi-autonomous device. It provides full autonomy for global navigation (path-planning & localization [8]), but relies on the skills of the user for local navigation (Obstacle avoidance [6][7]). This device offers pioneering solutions in order to replace the straight methods of guiding visually impaired person. In addition, it can be easily applied anywhere where it can handle places like malls, Railway stations, bus stand, universities and airports. This system will allow the visually impaired to wander freely and autonomously

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PROFILES

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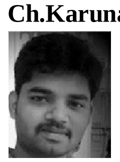

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