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A Guide Cane System for Assisting the Blind in Travelling in Outdoor Environments

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Abstract. In order to help the blind and the visual impaired people to travel outdoor safely, a guide cane system is designed in this paper. It comprises the thin cane as well as the rich remote workstation. When travelling in outdoor environments, the blind could easily set a destination via the voice recognition interface. Meanwhile, the goal and current locations are transmitted to the remote center in real time by using GPS and GPRS modules. After planning a navigation path globally, the route information is downloaded to the guide cane. All guiding information can be expressed to the blind in both auditory and tactile modes. In addition, an RGB-D camera is used to capture dynamic visual environmental information which is uploaded to the remote center for further processing, while ultrasonic sensors are employed to help avoid obstacles around. Testing results show that the system is simple to operation, and has a good usability and reliability.

Introduction

Blindness and visual impairment problem is one of the serious social problems in the world. The number of blind people worldwide is 37million and the total number of visual impairment is 161million, while 124million people suffer from low vision. With the increase in population aging, new hair blind is increasing rapidly [1]. As a kind of special groups in society, their lives have aroused concern and attention.

Researches on blind walking assist systems began in the 1960s. Currently, the most common tool is white cane. It is simple, inexpensive and suitable for most blind people. But they can only relay on their feeling to determine whether there is an obstacle. Blind guide dogs have long training cycles and high costs so that the ordinary family unbearable and dogs cannot plan a route in an unfamiliar area. Besides, the blind road on the street often be occupied, which brings greater difficulties for the blind to travel outside.

In order to solve the difficult problem of blind travel outdoor, many studies have been proposed. The earliest study was ETA (Electronic Travel Aids) which was used to detect obstacles through sound, light waves, such as Binaural Sonic Aid [1]. With the continuous development of GPS, RFID and visual image technology it has been further developed like SWAN devices [2]. However, ETA systems often cannot provide adequate contextual information for the blind. Another kind of studies was blind guide robot such as NavChair [3] assisted wheelchair, ROTA (Robotic Travel Aid) [4], etc. It can obtain enough external environmental information, guide blind man across the street and would get in touch with the service center when come across unexpected problems. But because of the complexity of its structure and large volume and weight, it is not suitable for promotion. Today the wearable guide device like a wearable “stereo vision” prototype system [5] is generated. It can convert the environmental information into tactile information to guide blind people. And even so, it needs to wear at the waist, back or legs, while it is not easy to move freely.

Towards this end, this paper develops a guide cane system for application of assist the blind and visual impaired persons walking outdoor. Section 2 describes the architecture. Then we turn our attention to the main focus of the paper, the instantiation of the architecture in section 3 and part of the experimental results in section 4. Last section gives the conclusions and future work.

Guide Cane System Architecture

The guide cane system is based on the white cane with various types of sensors like Ultrasonic sensors, RGB-D camera, GPRS module, etc. Since the target users are the blind and visually impaired, it has a simple operation. The entire system can be controlled by voice and a few keys and can prompt the users via auditory and tactile modes. Fig. 1 shows the overall system architecture.

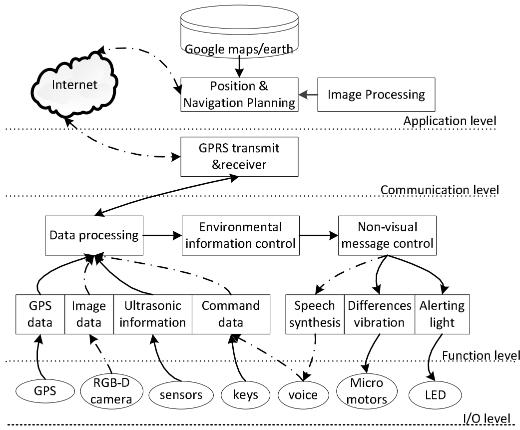

Fig. 1 Guide cane system architecture

The Guide Cane system has four parts, including an application level, a communication level, a function level and I/O level. I/O level is the lowest level which including an input portion which is made up of a GPS receiver, a RGB-D camera, several Ultrasonic sensors and a few keys and an output portion which is used to execute prompt by micro vibration motors, microphone and LEDs. This level has the duty for interacting with outdoor environment. The higher level is function level which is generally used to define and process the data of the external environment acquired by those sensors, coordinate data communication with other modules. In the communication level, this guide cane system may implement bidirectional remote communication via GPRS module. The application level is in charge of navigation planning, image processing and real-time monitoring. Especially, with the capability of RGB-D image analysis, it can plan a partial feasible path and mark out the specific flags as the blind, zebra, crossing [6], etc. To sum up, all the levels apart from the application level are running in the side of the guide cane.

Implementation for Our Scenario

The guide cane system mainly focuses on safe traveling outdoors. Our goal is that the guide cane could guide the users to the destination safely in both familiar and unfamiliar area and inform them the outdoor environmental information through different ways.

I/O Level Instantiation. In I/O level, the GPS receiver is exposed outside to access satellite data. We use the RGB-D camera to get visual information. The ultrasonic sensors are installed at intervals of 45 degrees in the lower end of the cane so that it can detect the obstacles in three directions. We can also install a brightness sensor for determining when to turn on the warning lights. We can speak out the control commands via a microphone when the enter key is pressed. Then the system broadcast it again. If it is confirmed, we press the OK button and the commands will be executed. If not, we should press the enter key to record the command again. The output section served as the implementing agency executes the output commands from the controller. The direction of the navigation and obstacles will be expressed by voice and differences vibration. Therefore, we can convert the visual environmental information into auditory and tactile modes.

Function Level Instantiation. This level contains three sub-modules: data processing module, environmental information control module and non-visual message execution module.

The GPS data we got from the satellite is a string of numbers interval with many commas. We extract these numbers and parse it to obtain the useful message. The coordinate information and the image data will be sent to the GPRS module and then sent out through the internet [7]. The distances to obstacles in three directions can be calculated by the MCU counter according to the ranging principle of the ultrasonic sensor. When the voice command is input, speech recognition module will convert this to a text message which could be recognized by the system. Depending on these data the environmental information control module will issue control commands.

Voice message is synthesized by speech synthesis module. Vibrating alert is produced by the micro motors in the form of vibration armbands. Warning lights light up when the time after 17:00 or the luminance is below a certain value. These messages are controlled by non-visual message control module. Once the system is start, it will execute cyclically until the system is shut down.

Application Level Instantiation. This level is instantiated to providing path planning information, monitor the routes remotely, process the depth image and send message to the client.

It can receive the latitude and longitude information through the GPRS module and the internet. According Google Map/Earth COM API, it can show the coordinates of the position on human-computer interaction. Once the destination is confirmed by the user, route information will deduce by the program. Based on Google Earth navigation application, we using pedestrian mode navigation manner to plan the route and trajectory inflection point navigation manner to prompt the user [8]. The computer specifically starts a thread regular to detect the distance between current coordinates sent by the GPRS module constantly and the predetermined turning point, when it reaches the predetermined point range, it will send message to prompt users the direction of the corner. When the user is away from the target inflection that explains turning completed, it will automatically set the next inflection point and broadcast the distance to the new inflection. If the user deviates from predetermined trajectory, it automatically amendments routes and sets a new turning point then alarm again. Fig. 2 shows the trajectory inflection navigation flow chart.

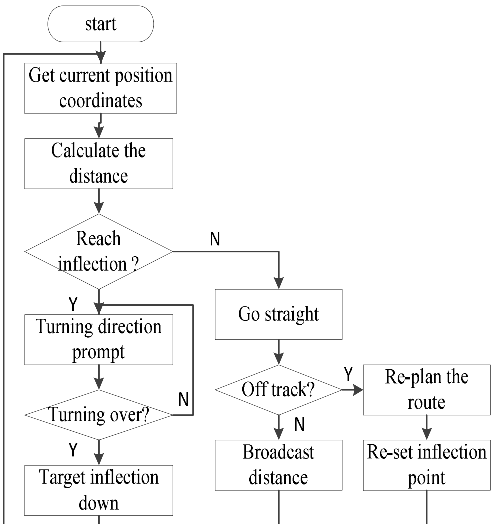

Fig. 2 Trajectory inflection navigation flow chart

Fig. 3 The physical map of guide cane

Experimental Results

In order to verify the practicality and reliability of the system, we select outdoor open area as our test environment. The physical map of guide cane is shown in Fig. 3.

First, we open the start switch of the system then the ultrasonic sensors start to range. When come across an obstacle, the cane alarms it. Then tester pressed the enter key and spoke out a destination while the system broadcasted it again to facilitate confirmation. Tester pressed the OK key to confirm it, otherwise he need to re-enter. After it, the system sent the GPS data and destination information to the internet. We invoked this information and processed online. The navigation program planned the suitable route according to the destination. Fig. 4 shows the route planning from the campus entrance to the laboratory building. When the trajectory deviated from the set point, it broadcast the distance to the changed inflection point. Fig. 5 shows a modified route and inflection point. Walking near the inflection point, the system sent out voice and vibration alert to prompt the turning direction. According to the vibration mode, the tester can easily determine the direction of travel. As a result, the tester safely reached the specified destination in the case of changing the route. Last, the tester sent end navigation message and the guide cane system back to the ranging and alarm stage.

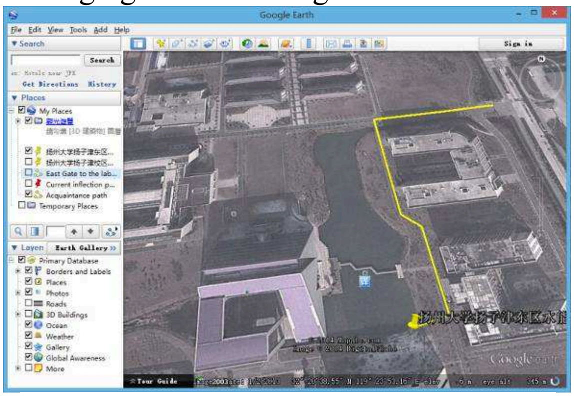

Fig. 4 The initial path planning

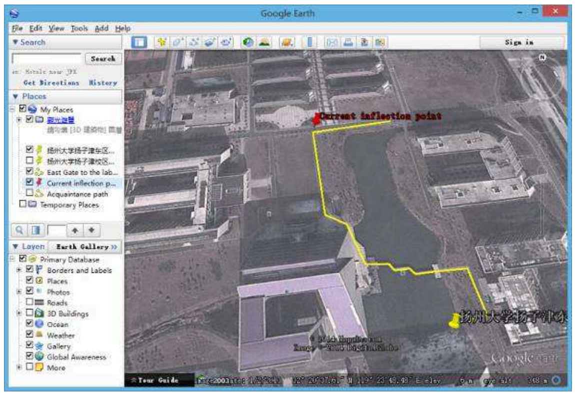

Fig. 5 The changed route and the inflection point after off track

Conclusion

This paper proposes a guide cane system for the blind and the visual impaired to travel outdoor. It combines ultrasonic sensors, the inflection navigation, environmental visual information perception and auditory and tactile display to guide the blind travel outside. We are still working on the processing of visual images. However, there are still limitations of our system. Our system cannot process the image information in real time. Further, we can hardly determine the ladder on the road and the lithium batteries have certain restrictions. The future work in the application of the system includes when to detect and detect what is helpful for safe navigation.

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