SMART MOBILITY STICK

Voice Operated Guidance Systems for Vision Impaired People

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Abstract

The white cane, due to its primitive design, is unable to offer the blind and visually impaired a level of independence that is achievable with modern technology. The Smart walking stick looks to upgrade the white cane by increasing security and usability of the cane while ensuring an affordable price for an older and lower income demographic. This was done by including an GSM -GPS module to pin point the location of the blind person and to establish a two way communication path in a wireless fashion .Moreover, it provides the direction information as well as information to avoid obstacles based on ultrasonic sensor. A beeper, an accelerometer sensor and vibrator are also added to the system. The whole system is designed to be small, light and comfortable . Observations and basic testing confirm the effectiveness of the vibrations in the handle and the accuracy of the ultrasonic sensor up to 1.5 meters past the tip of the cane.

I. Introduction

Medicinal field has made many advancements over the years. But, the use of canes for the visually impaired remains limited. Cane forces the user to be entirely responsible for their safety. This problem can be solved by the technology of object detector thus helping the user by providing safety .In addition, the standard white cane has no range of physical options. It places additional burden on the user by forcing a change in handle grip depending on how crowded the surroundings are. **The white cane thus requires the user to adapt to the cane rather than having a cane that will adapt to the user**. To address these shortcomings, The SMART MOBILITY STICK aims to deliver the visually impaired person a atmosphere of visible world artificially. The goal for the Smart walking stick project is to eliminate this problem by designing, building, and testing a cane for the blind that utilizes computer and sensory technology to provide object detection capabilities and freedom of physical range.

II. Framework

A. The History of the White Cane

The role for the white cane had its origins in the decades between the two World Wars, beginning in Europe and then spreading to North America. James Biggs of Bristol claimed to have invented the white cane in 1921. After an accident claimed his sight, the artist had to read just to his environment. Feeling threatened by increased motor vehicle traffic around his home, Biggs decided to paint his walking stick white to make himself more visible to motorists. It was not until ten years later that the white cane established its presence in society. In February, 1931, Gully d'Herbemontii launched a scheme for a national white stick movement for blind people in France. The campaign was reported in British newspapers leading to a similar scheme being sponsored by rotary clubs throughout the United Kingdom. In May 1931 the BBC suggested in its radio broadcasts that blind individuals might be provided with a white stick, which would become universally recognized as a symbol indicating that somebody was blind or visually impaired.

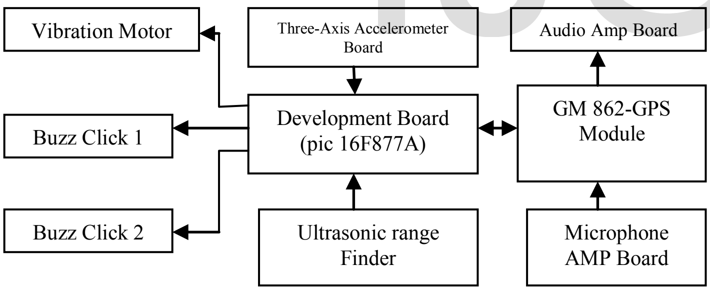
B.Characteristics of the Blind and Visually Impaired

A person who has been clinically determined to have a visual acuity of 20/70 or less in the stronger eye is diagnosed as visually impaired, while a person who is legally blind is defined to have a visual acuity of 20/200 or less in the stronger eye. People whose visual acuity is at either of these levels receive governmental benefits, such as the right to possess a white cane or own a guide dog. A white cane is often carried by the blind and visually impaired to give more freedom to the individual. The two main functions of the cane are identification and safety; it should alert the user to obstructions and changes in their path and also notify the seeing pedestrians and drivers that the user has some degree of vision loss. There are three types of white canes: identification canes, support canes, and long canes. Identification canes are short (reaching only to the user's waist), provide little to no protection, and are generally more popular with the visually impaired who only want to alert others of their impairment. Support canes have the same purpose as identification canes, except that they provide more support and balance for the legs and body of the user. Long canes, the type of cane chosen to be modified into a Smart walking stick, reach the user's sternum and provide the most safety for the user, alerting them of terrain and height changes, walls, doors, and obstacles. They are also the most visible to others.

C. Traditional Cane Technique

Training for white cane use usually focuses on two major topics: grip and arc. For outdoor use, where a person's pace is faster and more regular, the proper grip used to hold the white cane is the palm facing up at waist height with the index finger pointing along the cane and the remaining fingers and thumb wrapping around the cane lightly. When indoors or in a more congested environment, such as a crowded city street, the grip changes in such a way that the user holds the cane as if it were a pencil: upright, at sternum height, and closer to the body. With both grips, the elbows are kept tucked close to the body. The second component, the arc, refers to the sweeping motion of the cane performed by the user. The user sweeps the cane over an area just larger than shoulder width, tapping the ground on the opposite side of the foot currently taking a step in order to prepare for the next step (for example, tapping the ground to the left of the body when stepping forward with the right foot).

III.Block Diagram Of the System



A. GPS(global positioning system)

GPS system consists of three main segments .The first segment is satellite segment is designed to have at least four satellite that function to receive signals at any moment .Hence the GPS receiver is able to provide graphic information in three dimension in order to determine the location stated. Second segment is control segment. Control segment stands from three main stations ,which are master control station, ground antenna station and monitor station. The third segment is the user segment .

FIGURE 1:-Represents the hardware components of the system

B.The Arduino

The Smart walking stick's sensors and motors are powered by an Arduino microcontroller. The Arduino is a programmable electronic platform which allows users to easily create prototypes. Along with a breadboard and other pieces of circuitry equipment, the Arduino can be used to make various electronic input, output, and sensory systems. Aside from basic electronic hardware, a wide range of complex devices, including sensors, are made to be compatible with the Arduino system. The Arduino programming language is C based, and can be used to create a wide variety of programs. The Arduino is also made more accessible by its low cost. Most boards (including the Uno, which the Smart walking stick uses) cost less than 2000RS

C. The Ultrasonic Sensor

The sensor used in the Smart walking stick is the RadioShack Ultrasonic Range Finder. It functions by sending out an extremely high frequency sound wave from one speaker, which is deflected by obstacles directly in its path. Using the speed of sound through air at room temperature, distance of the obstacle from the sensor can be calculated from the time it takes the ultrasonic pulse to leave the sensor, reflect off the nearest object, and return to a second speaker. The specific distance is calculated by the sensor and is outputted to the Arduino. This data is made accessible to the Arduino through code released by RadioShack under a GNU General Public License. The detecting range of the sensor is from 3–400 centimeters, with a detecting angle of 30 degrees.However, the accuracy of ultrasonic sensors is limited not only by distance, but also by the surfaces of detected objects. A surface that absorbs sound or causes echoing, such as foam, would result in inaccurate readings.

D. Accelerometer Sensor

An accelerometer is an electromechanical device used to measure acceleration forces. Such forces may be static, like the continuous force of gravity or, as is the case with many mobile devices, dynamic to sense movement or vibrations.Acceleration is the measurement of the change in velocity, or speed divided by time. For example, a car accelerating from a standstill to 60 mph in six seconds is determined to have an acceleration of 10 mph per second (60 divided by 6). Typical accelerometers are made up of multiple axes, two to determine most two-dimensional movement with the option of a third for 3D positioning. The sensitivity of these devices is quite high as they're intended to measure even very minute shifts in acceleration. The more sensitive the accelerometer, the more easily it can measure acceleration.

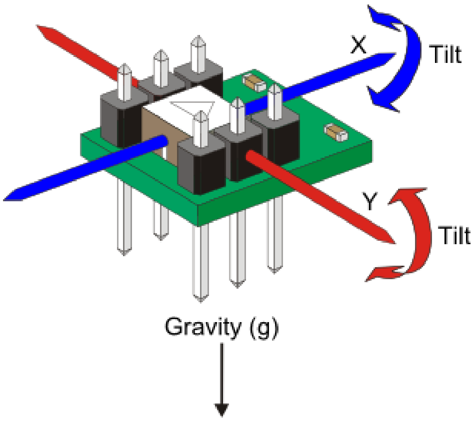


FIGURE 2 :-schematic representation of an accelerometer

E.The Ardumoto and its Applicability

The Ardumoto is a shield, or a circuit expansion board, for the Arduino. It is designed to run two motors, making it a convenient addition to the electronic setup of the project. The Ardumoto is able to control motors in many ways through an analog input for the motor speeds, on and off features, direction features (whether the motors spin clockwise or counterclockwise), and much more. The electronics setup for any motor experiment on an Arduino Uno alone is very complicated, and often requires a tedious search for the right resistors, transistors and diodes to properly control the motor. The Ardumoto simplifies this process significantly when it comes to coding as well as electronic setup.

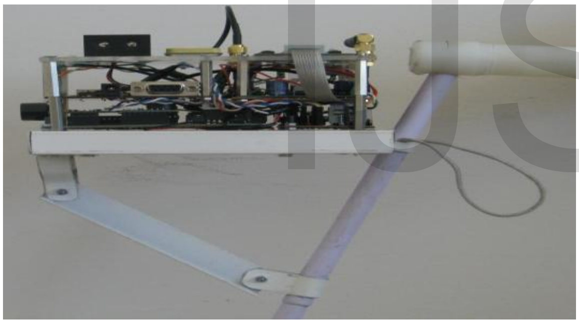


FIGURE 3:-Hardware system when installed on the cane

F. Materials Used in the Traditional Cane

The white cane was originally constructed out of wood, but aluminum quickly replaced the perishable material. However, it was found that aluminum canes bend and break very easily if they get caught in cracks or crevices. In present day, the most popular materials are fiberglass and carbon fiber, both of which have their own individual pros and cons. Fiberglass canes are reasonably priced and can bend slightly, but will ultimately return to their original shape. White canes made of fiberglass tend to be heavier, although new innovations in materials have created types of lighter fiberglass. Carbon fiber canes are more expensive than aluminum and fiberglass canes, but also significantly lighter. While carbon fiber canes do not bend as much as the canes listed above, they are the easiest to break.

IV. Materials and Methods

There were two main components that were the focus of the Smart walking stick design process: updating the basic mechanics of the traditional white cane and integrating technology in order to make it "smart". It was concluded that both would be addressed, first by making the handle adjustable and then by adding a sensor that would extend the range the user could observe. The detection of potential obstacles would then be transmitted to the user through vibrations in the handle.

A. Implementing the Feedback System

The device that alerts the cane's user to objects in their path is the vibration motor. The motor is housed in the handle of the cane, and is connected to the Arduino. The Arduino analyzes data from the ultrasonic sensor, and it is this data that is sent to the vibration motor in the form of a corresponding PWM duty cycle. Depending on the number of pulses, the vibration motor receives varying amounts of power, which causes the vibration motor to spin at differing speeds. These speeds vary discretely instead of continuously, so that a given range of distances will corres pond to one vibration intensity. Additionally, each distance will also correspond to a certain delay between vibrations, with greater distances having greater delays. These vibrations, caused by a weight spinning on the motor, will oscillate through the handle to alert the user.

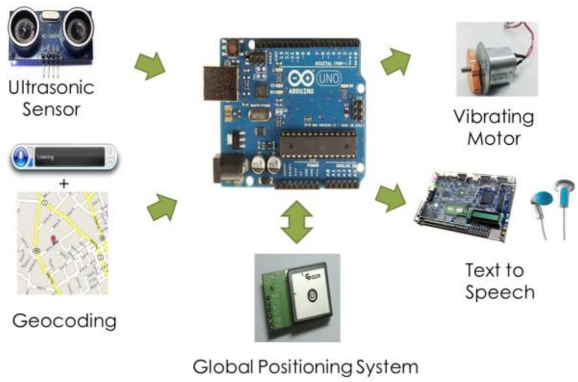
B. Creating the Ergonomic Handle

Besides the sensory system itself, the most innovative and important aspect of the Smart walking stick is the hinged ergonomic handle. The design began with preliminary measurements and sketches. Then, the cane handle was designed and modeled in 3-D using Autodesk AutoCAD software. After being converted to an STL file (the file used by most 3D printers), the cane handle was 3D printed in two parts, the top half and bottom half. This allowed for the Arduino and vibration motor to be placed inside of the cane handle. The handle is made of ABS plastic and is attached to a hinge created with two plastic cable cuffs. Inside the handle are two vibration motors connected to an Arduino board. A hole at the hinged end of the handle allows the wiring from the Arduino and vibration motor to connect to the battery pack, power switch, and ultrasonic sensor no matter what position the cane is in. These wires are threaded through the hollow PVC tubing of the cane. Completing the comfortable design of the handle is a rubber grip that covers the handle and prevents the user's hand from slipping. Overall, the handle was designed with the cane's target demographic in mind; the handle's top design priority was comfort for the average elderly user.

V. Results and Discussion

A. Mobility System

HC-SR04 is used to detect the existence of an obstacle. When the ultrasonic sensor detects the existence of an obstacle, it will send the signal to vibrating motor to vibrate with different vibration strengths.The trigger will send the ultrasound at 40 kHz. When the ultrasound detects an obstacle, it will bounce back and generate an echo. The chart that corresponds to variation of distance of obstacle detected and data that is recorded based on the distance away from the obstacle.The distance between the obstacle and ultrasonic sensor in centimeters can be determined by using the formula distance=time/29.1/2.



No	Measure Distance (cm)	Sensor Detected Distance (cm)	Error (cm)
1	0	0	0
2	5	4	-1
3	10	9	-1
4	15	14	-1
5	20	20	0
6	25	24	-1
7	30	29	-1
8	35	33	-2
9	40	38	-2
10	45	43	-2
11	50	48	-2
12	55	54	-1
13	60	59	-1
		Average Error	-1.154

Tabulation representing the results of sensor detected distance and measure distance

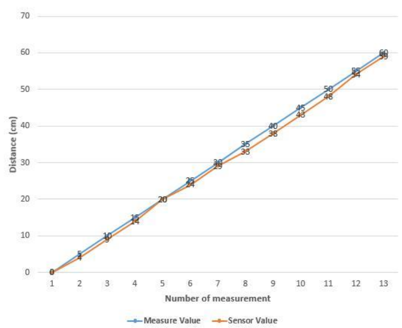


FIGURE 4:-Sensor detected distance versus actual distance measured

B. Geocoding and Speech Recognition

Geocoding is used for obtaining latitude and longitude of a location. The geocoding uses Google Maps. Speech recognition is designed to input the address of a location for geocoding purpose. The speech recognition uses Windows' speech recognition function. Hence, speech recognition library in Windows will be used to activate the Windows speech recognition and used in the program. The address location is input using speech recognition. By using the geocoding, the latitude and longitude of a location can be obtained. The location of an address will be showed in the map. The coordinates of the location will be saved to a text file for further processing

C. Range and Accuracy of Ultrasonic Sensors

To measure the success of the Smart walking stick design, various tests were conducted to see how the cane would detect objects. In particular, these tests check the detection capabilities of the ultrasound given the design and position of the cane. These tests are necessary because they can provide an indication of the situations in which the Smart walking stick would perform inadequately. The first test investigated how well the cane detected stationary objects at varying distances. The cane was placed in the same way it would be if a visually impaired person were holding it. A direct comparison was made by placing objects at different distances from the cane and comparing the observed distances with the distance readings outputted by the sensor. The sensor was tested at distances ranging from 30 to 200 centimeters, with an average percent error of 0.20% and a maximum error of 1 centimeter. The second experiment investigated how well the stationary cane observed a moving object. In the experiment, a small robotic car moved past the ultrasound sensor at 0.8 meters per second. The car was set at various distances away from the ultrasonic sensor in increments of 20 centimeters. It was determined that with this grip and object speed, the ultrasound sensor slowly grew less and less accurate as the distance from the object increased. In addition, the ultrasound distance reading immediately after the measured reading was always completely inaccurate. Although there are some minor discrepancies when the cane is in motion, the discrete mapping of vibration intensities unto distance values means this error will have little or no effect on the vibration felt by the user. The ultrasonic sensor also presented problems with detecting objects reliably while the cane was swept over a unit of area. Since the cane was moving in a circular motion, the sensor could not focus on one
object. The ultrasound would occasionally pick up certain objects and send PWM signals to the motor, causing random vibrations that would serve no purpose to the user–the user needs consistent vibration to react to a nearby object. This problem was addressed by reducing the range of detection of the sensor. The ultrasound still detects objects in a 6-7 meter radius, but it only passes PWM values to the motor for objects within a 2 meter radius. By reducing the radius of detection, the ultrasound was able to do a better job of consistently detecting objects.

D. Issues with Motors

When programming the Arduino, it is difficult to make the vibration intensity change in such a way that the user would notice a significant decrease (or increase) in distance. As with the previously mentioned accuracy problem, this issue was addressed when the vibration intensity was made to change in increments. Because bigger changes are more noticeable than gradual ones, the user would become aware of a significant decrease in distance almost immediately. Additionally, the delays between vibrations would also increase incrementally, so that a smaller distance corresponds to a lower vibration intensity and to a smaller delay between vibrations. Finally, PWM itself was extremely difficult to achieve. On the Arduino Uno board, despite an accurate setup involving a resistor, transistor, diode, and various pins from the Arduino, it was impossible to achieve the necessary PWM. After much experimentation, using the Ardumoto made the process of controlling PWM a success.There were also more construction oriented problems with the motor. The vibration motors used in the prototype are small relative to the entire handle. If the motors are not fixed in place, the vigorous vibration causes the motors to move around in the handle and make loud rattling noises as they collide with the hard surface of the inner walls. This is undesirable because the noise is distracting and it can confuse the user–as stated earlier, the rate of discrete vibrations is an indication of proximity to the detected object, and collision may detract from the user's ability to understand the vibrations. The best solution to this problem would be to simply fix the motors in place with tape.

VI. Looking Towards the Future

A. Changes in Materials Used

The prototype has been constructed under time constraints with a limited range of materials. In the future, mass production of this product can make way for numerous circuitry changes. The Ardumoto (or any microcontroller shield for that matter) would not be necessary. The only reason it was used was because controlling PWM was very difficult on the Arduino alone. In the future, the Ardumoto would be replaced with significantly cheaper components, such as transistors, diodes, and resistors. Additionally, a model could be produced which uses a single-purpose microchip instead of an Arduino. Such a simple microchip would be extremely cheap to produce, ensuring that the Smart walking stick would be affordable to the demographic groups most likely to suffer from visual impairment. Only a small percentage of the
Smart walking stick's users would be able to take advantage of the Arduino's versatility, this change would have no impact on the quality of the product. The commercially produced Smart walking stick which would use the Arduino would most likely contain the Arduino Micro, although other models could be used instead. The Micro, in comparison to the Uno, has equivalent or superior specifications (CPU speed, RAM, Flash, etc.) and the same number of pins (input and PWM), but has different microprocessors. The two major differences that make the Micro more appealing than the Uno are the lower cost and smaller size. The lower cost would make the Smart walking stick even more affordable, while the smaller size would allow the Arduino to better fit inside the cane handle. The programmability of the Arduino in the Smart walking stick would give the user more control over their cane and allow additional hardware (such as GPS or Life Alert ® technology) to be added to the device. The shaft would be constructed out of an affordable variety of fiberglass, which is lighter than PVC pipe or plastic and therefore is more comfortable for the user to hold when sweeping the cane. The hinge used to connect the handle to the shaft would be a locking angle hinge, and the handle itself would be wrapped with a more comfortable and ergonomic material. One of the main advantages of the Smart walking stick over similar "enhanced" white canes is its relatively low cost. This makes it accessible to the demographic groups that are most likely to be visually impaired.

ITEM	COST(in rs)approximately
Insulated wiring(5 feet)	120
Misc,circuit materials(transistor,resistor,diode switch)	<360
Vibrating motor	120
Ultrasonic sensor	300
Arduino micro	1200
Hollow fibreglass cane	1200
Batteries	4200

Following table lists expected costs of the supplies necessary to build the future cane.

It is important to note that these prices are based on current consumer prices, which may be more expensive than what a manufacturing company would pay when buying in bulk. Additionally, costs for certain products, such as the Arduino board, would most likely decrease with time. However, the above listed costs are only supply costs for one cane and do not account for the resources necessary to manufacture the final product.

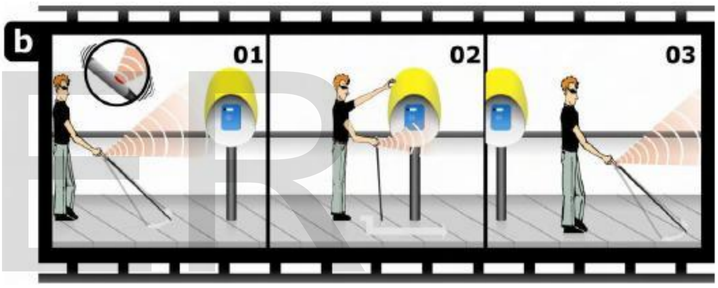


FIGURE 5: Function of electronic long cane

VII. Conclusion

The Smart walking stick's goal is to bring the white cane up to technological modernity while maintaining its affordable price. The Smart walking stick is geared towards an elderly, less affluent demographic group that would demand comfort, accessibility, and affordability from the product. Observations and test results prove that the Smart walking stick reached its goal and satisfied the needs of its target demographic. Using the ultrasonic sensor, Arduino board, and vibration motor, the Smart walking stick greatly increased the object detection range of the white cane, thereby improving the lives of the blind and visually impaired users. Besides the cane's technological improvements, the design was altered to give the user a more comfortable and ergonomic handle. Along with the locking hinge system, the Smart walking stick's handle alleviates the need for the user to change their grip on the handle based on their cane's position. Overall, the Smart walking stick's use of technology and ergonomic design has greatly improved upon the traditional white cane, and has taken a great leap towards improving the lives of the visually impaired.

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