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An IoT-ML based Proactive Walking aid for the Visually Challenged

Srijan Malhotra, Krithika Balasubramanian, H Parveen Sultana, T S Pradeep Kumar

Abstract: ***The numbers of elderly people are rising in countries like India and China. Most of the elderly uses a walking stick for their commuting. Also blind peoples need a walking aid for their day to day life. This work mainly focuses on the design and development of a proactive walking aid for the blind and the elderly peoples. The stick is designed mainly using a ultrasonic sensors which is fit along with the existing hardware. This work analyses various difficulties that a person with disabilities faced in their life. So this work caters or handles most of the aspect an elderly or blind is needed using Internet of Things (IoT). Apart from the ultrasonic sensors it employs a buzzer that beeps when a person or object is approaching in front of the stick. Whenever a person with the stick get hit or stuck somewhere for a predefined time, then an alert along with the GPS coordinates sent to the emergency contact. Most of the literature supports a stick with reactive in nature, this work supports a proactive approach as it predicts the object at a distance rather than after it touches the stick. This system also employs machine learning algorithms to predict the nature of the person using the stick. Our results have shown that the stick can be the only aid that either an elderly or blind people can use.***

Keywords: Visually Challenged, Ultrasonic sensor, IoT, ML, GAIT Analysis.

I. INTRODUCTION

Handicap means limitations in performing social roles i.e. the disability to perform socially structured sets of tasks. For achieving goals and objective in life, independence plays a major role. Visually impaired individuals find themselves in a very difficult situation to go out on their own. There is a countless number of visually impaired people in this world who are in need of help from others. It is very difficult for them to lead a normal life they are constantly dependent on others for help. For a long time, the white cane has become a well-known device to blind people's navigation and later efforts have been made to enhance the cane by adding a different sensor. To address the issues of outwardly debilitated and visually impaired individuals by building effective structure for successful visual guides, it is important to show signs of improvement learning of the size and traits of the population to be served. Such data would be useful for administration as well as for the structure and improvement of visual guides that all the more correctly coordinate the populace needs and the examples of utilization and non-use among these people.

Human has the capability to approximately estimate the distance and size of an obstacle because of the stereo vision of human's eyes. In this system, we propose to use sensors and modules to make an effective walking stick for the visually challenged people. To ensure that they can lead an independent life. Using ultrasonic sensor, modules like GSM and GPS module, Buzzers and LDR sensor, our vision is to make this walking stick more useful and applicable for a real-time environment and also making it an immediate response system.

A. Literature Survey

As of 2010, over 42% of Earth's population suffered from visual impairments, with about 40 million people suffering from complete blindness and about 245 million people near blind. This has led to an increase in advancement in technologies to produce Electronic Travel Aids for the mobility of the visually impaired people. [4] Until present, white canes have been the norm for use by visually impaired people. However, it has presented various challenges. Canes do not detect obstacles above waist height. They are also only capable of detecting obstacles in a very close range, as close as a meter, making it ineffective for crossing roads. [1] Along with canes, guide dogs have also been used for a long time. But they pose challenges too. Many residential and commercial establishments do not allow the entry of pets or guide dogs in their premises, which may prove to be difficult for the person when navigating indoors. Guide animals also require proper training and coordination with their owners which may not be perfect always. [3] Various prototypes have been designed over the years. Ultrasonic sensors, more than one, have been installed and the feedback is conveyed using vibration motors. Voice feedback is also deployed to detect changes in terrain of path and relay the same to the user. [1] Other models have also used other sensors such as infrared sensors, fire detectors, along with voice based feedback and navigation system to assist them effectively. Physical buttons are also used by which the users are able to call for help or send distress signals when needed [2]. The main purpose of the walking stick is to detect the obstacles, holes and any projected surface when the visually challenged people experiencing while they are walking. In [6], the author explains about the various object tracking methods that are used in the machine tool applications by the sensors.

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Here in this work also we will be using a sensor that can detect the obstacles using ultrasonic sensors. We may also consider the power efficiency of sensors so that the battery life of the walking stick can be improved a lot. [5] explains about the various power modeling strategies of sensors that are using in the Internet of Things application.

The walking stick or the aid for the differently abled is designed in various literatures as per the Table 1 given below. Most of the works deals with the design of a GPS and microcontroller based that triggers the alarm or the buzzer that indicates the obstacles.

Table 1. Walking Stick Design

Devices	Technology Used	Cost (Normalized)
GPS Based walking Stick [7]	Ultrasonic and GPS	Medium Cost
App based Walking Stick [8]	Use of Android APP and GPS	Medium Cost
Electronic Walking Stick [9]	LM358 and Atmega Controller	High Cost

B. Literature Inference

As per the Table 1, there are various literatures that design the walking stick either with the help of a Raspberry Pi or Arduino or Atmega microcontroller. Most of these literature deals only with the GPS and ultrasonic based sensors for enabling the walking stick that triggers the buzzer when an obstacle comes in front of the stick. None of these works design the moving pattern of the user and designs the stick. As per the Table 1, [7] uses a GPS based walking stick that is with medium cost and hence the mass production is not that much feasible because of the latency involved in the system. Some of the works design a mobile app powered stick so that the mobile app controls the stick even through voice commands [8] and [9].

II. PROBLEM STATEMENT

The primary reason for sensors is to gather information from the encompassing condition. Sensors, or 'things' of the Internet of Things framework, structure the front end. These are associated straightforwardly or indirectly to IoT arranges after sign change and processing. Be that as it may, all sensors are not the equivalent and diverse IoT applications require various sorts of sensors. For example, digital sensors are direct and simple to interface with a microcontroller utilizing Serial Peripheral Interface (SPI) transport. In case of Analog sensors, either simple to-advanced converter (ADC) or Sigma-Delta modulator is utilized to change over the information into SPI yield.

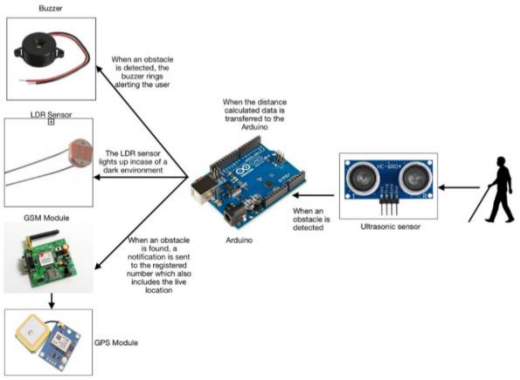

Fig. 1. Design of ML based Walking Stick

III. GAIT ANALYSIS

Technology has advanced in such a large scale that now, we are able to identify people. Using the technology of facial recognition and biometrics, one can identify a person. But for this to work, the person should be physically present in order to scan either his hands on his fingerprint. Also, in order to recognize the person, the person must enroll themselves in a central database. Using this database, one will be able to recover information about that person. But there might be chances when someone who is involved in malicious activities would have not enrolled themselves or given their false identity to such a central database. Hence, a much advanced technology is necessary in order to increase the security. Gait Recognition is a new technology which analyses the body movements of a person using video cameras. Body parts, such as the head, the shoulder, hand gestures, the foot and even the movement of the knee are monitored very intricately to record every gesture of a person. It is the study of human location based on the measurement, description and quality assessment. This will help in understanding a person's body language especially when we can spot people who do not appear natural with their physicality, giving a sense of suspicion. Gait Analysis has always been a central topic of research. The first research on this topic was initiated in the 19th Century and till date scientists have been working extensively on this domain and also incorporate it in various fields – medicinal purposes, security purposes etc. Gait technology can be approached in two ways – Wearable sensors (WS) and Non- wearable sensors (NWS). In wearable sensors, the person is attached with motion sensors which is used to monitor every movement signal. Sensors such as strain gauges, gyro sensors, inclinometers, accelerometers are been used for the analysis. Based on the results obtained, gait analysis can be performed. In the case of NWS, it works using the technology of Image Processing and Floor sensors. Data from the one or more optic sensors is captured and measure the various frameworks using Image Processing. Most widely used equipment for this analysis is Digital or Analog Cameras. Various optic sensors are been used - such as laser range scanners (LRS), infrared sensors and Time-of-Flight (ToF) cameras. In the case of

Floor sensors, sensors like pressure sensors and ground reaction force sensors (GRF) are placed along the floor (also termed as the "floor platforms") which measures the force exerted by the subject's feet on the floor when he/she walks.

A. Working of GAIT Analysis

Gait Analysis mainly records on the following parameters:

1. The pace of their walking
2. Distance travelled
3. Number of falls
4. Number of pauses during the walk
5. Length of short and long steps
6. Swing time for each foot (moment the foot lifts from the floor until it touches the ground)
7. Support time
8. The posture of the body while walking
9. Momentum
10. Force
11. The smoothness of the surface where the subject is walking
12. The amount of time the subject can walk

B. Approach of GAIT Analysis

Gait analysis is taken place using two approaches:

1. semi-subjective analysis techniques
2. objective analysis techniques.

Semi-subjective methods, usually conducted under the supervision of a specialist in a clinical environment. The patient's various gait characteristics are observed and compared while he/she walks on a restricted area.

Objective techniques, includes the utilization of various devices to record data identified with the different gait parameters. These strategies can be separated into three classes: those dependent on image preparing (IP), on floor sensors (FS) and on sensors situated on the body.

Image Processing

In a regular image processing framework, it primarily comprises of numerous advanced and simple cameras which catches gait-related data. Researches resort to image processing as it usually gives accurate results. Ideas, for example, threshold filtering which changes over image into high contrast, the pixel tally to ascertain the quantity of light or dark pixels, or foundation division which essentially removes the background of the image, is used to capture data which helps in measuring the gait variables. There are a few advancements that can be applied for this reason, for example, camera triangulation (stereoscopic vision), laser range scanner and Time-of-Flight strategies. Different studies use organized light and infrared thermography.

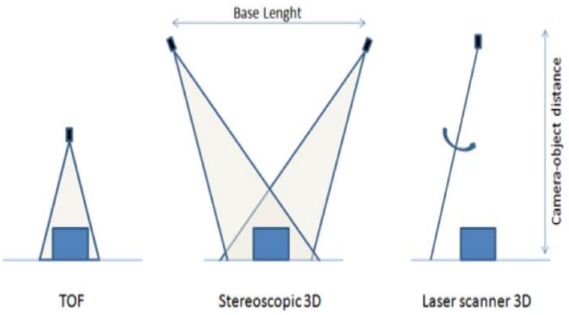

Fig. 2. Approach based on Image Processing

Floor Processing

Floor sensors is a setup where sensors are installed along the floor (also termed as force platforms) to measure the amount of pressure the subjects exerts while the person walks on the walkway. The characteristics that recognize FS-based frameworks from IP-based frameworks is the investigation of power transmitted to the floor when strolling, known as Ground Reaction Force (GRF). This sort of framework is utilized in numerous walk examination ponders.

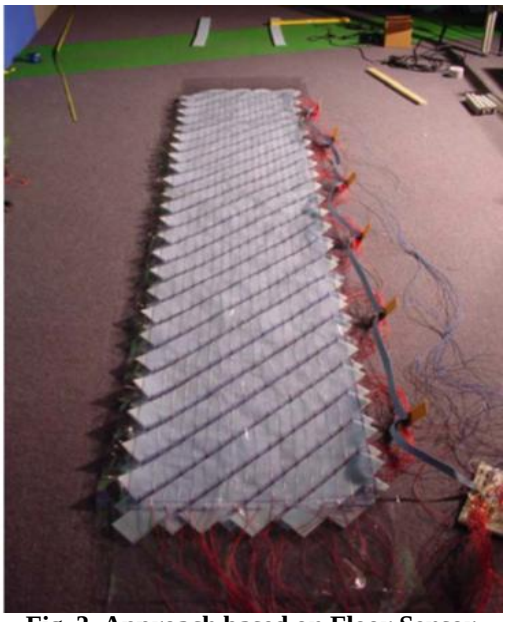

Fig. 3. Approach based on Floor Sensor

Wearable Sensor

In gait investigation utilizing wearable sensors, these are placed on different pieces of the patient's body, for example, the feet, knees or hips to gauge various qualities of the human step. They incorporate power sensors, accelerometers, gyrators, extensometers, inclinometers, goniometers, dynamic markers, electromyography, and so forth. Power sensors measure the GRF under the foot and return a current or voltage relative to the weight estimated. Weight sensors, be that as it may, measure the power applied on the sensor without considering the parts of this power on every one of the tomahawks. The most generally utilized models of this sort are capacitive, resistive piezoelectric and piezo resistive sensors. The decision of sensor relies upon the scope of weight it will stand, linearity, affectability and the scope of weight it offers.

IV. INTEGRATING IN THE PROPOSED MODEL

Gait analysis is usually performed in a lab where multiple sensors and cameras to analyze the body movements of a person. This restricts the movement of the person to a confined area space and would not obtain real-time results. Hence, incorporating gait analysis in the walking stick can enhance an analyst's observation-based gait assessment with use of additional objective and quantitative data. The system will help us to observe the timing, speed and acceleration of the walking stick, and the amount of weight borne on the cane.

The system helps in collecting data obtained during gait analysis which would provide the patient better treatment when using the walking stick, thus reducing wrist and shoulder injuries. The system will give the analyst a better understanding of the walking performance of the patient, by performing gait pattern classification.

A system that has already proposed earlier is the Smart Insole System. Different from gait lab analysis, the smart insole system integrates motion sensing components with- in shoe insoles. With the intelligent analysis algorithm, all important human gait features can be retrieved from the sensor data. Therefore, the Smart Insole system can monitor all types of activities in free-living without disturbing the normal life of the subject. Contrary to the cost of setting up a gait lab, the cost for the Smart Insole system can be under 200 dollars for mass production.

The Smart Insole System consists of 3 subsystems in the architecture:-

First subsystem: Sensors which are cost effective, such as 8 pressure sensors (used to acquire high-solution pressure map under foot), 3-axis accelerometer, 3-axis gyroscope and 3-axis compass (used to obtain information regarding the movement of the patient). Second Subsystem: Signal acquisition and transmission module. Third Subsystem: Sensor aggregation and processing module. They are the physical driver interface, data preprocessing module and data post processing.

The Smart Sole System has the technology to transfer the data from the patient to the main server, allowing the caregiving to maintain a record on a regular basis of the patient's body movement. Taking inspiration from the above system, we can implement gait analysis in our walking system. The goals of this system are:-

(1) Reinforcing therapist clinical evaluations with objective information

(2)Assessing timing and speed of cane placement, acceleration and angular velocity of the cane, amounts of weight borne on the cane and the activity of the person using the cane.

V. RESULT AND ANALYSIS

All in all there are a number of ways that GAIT analysis can be linked with the posture of the people who use the stick. This allows the system to segregate the users in a number of categories, namely:-

(1) Users with fast pace:- The users using the walking stick which is enabled with the machine learning algorithm keeps a check on how fast or slow the user walks and make sure to keep a check on who is using the stick and with what frequency. Also allows the user to keep a track of their pace and control it if something goes wrong.

(2) Users with a sluggish posture: - People with slow walking speed or a sluggish walking posture have certain characteristics that the stick keeps into account. What it checks is if the user who is assigned to the stick is using the stick or someone else as that is what will help the stick to differentiate between the true owners of the stick. Also it allows the user to maintain readings for the same.

(3) Aged users:- People who have lost their visual senses a long time ago have a complete different way and speed of walking which can been easily detected using the stick. This stick then allows the user to easily monitor how the person walks and at what pace and prevents the users from getting into any dangerous accident as if any parameters are beyond usual then the user guardian is intimated.

VI. CONCLUSION

This project was made keeping in mind the visually challenged and so that we could do some good towards the community. What we have achieved here is that the ultrasonic sensor keeps a check of the distance from an obstacle and then intimates the user through the buzzer and the registered guardian through a message which is sent to him with the location of the person. This is done through the GSM Module and the GPS Module. The GPS helps us provide the location so that's its easier for the person to locate the user in times of distress. Finally, we would like to conclude by saying that this project is done in good faith of the community and the people so that, maximum people can benefit from this. Also as an added approach we have tried to inculcate the same with GAIT Analysis wherein the user would be checked on the basis of his posture, the way he's walking to get an accurate match of the user.

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Srijan Malhotra experienced Designer with a demonstrated history of working in the information technology and services industry.

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Dr. Parveen Sultana H is currently working as Associate Professor in the School of Computing Science and Engineering, Vellore Institute of Technology, Vellore. Has more than 20 years' experience in teaching. Co-authored a book on "Cyber-Physical Systems" and authored few chapters on IoT, IoT architecture with paper publications in reputed journals like Inder Science and Walailak. Some of the notable work are '*A Comparative Analysis on Ensemble Classifiers for Concept Drifting Data Streams', 'Cloud based garden watering system'*

Dr. Pradeep Kumar TS A professor in Computer Engineering, an experimental programmer, an open source enthusiast for the past 20 years. Gave more than 10 keynote sessions and more than 70 workshops conducted at various chapters, forums, conferences, etc in the domains related to embedded systems, Networks, Network Simulations, Sensor Networks, Vehicular Networks, Internet of Things and Software Defined Networks. Deployed Virtual programming lab and Virtual Classroom (Big Blue Button) for online code submission system and online classroom sessions respectively that caters to 7000+ users.