i-Umb: An intelligent Umbrella for the Disabled People in Wheelchairs

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Abstract - People with disabilities have common needs and requirements as ordinary people, apart from their disability. Disabled individuals who're in wheelchairs and are willing to travel often. Most of them have to fulfill some special requirements and needs before or when they travel. Some of them need special tools or equipment. Many of them carry an umbrella when they go outdoor, whereas normal people does. Currently, most of them have to rely on using a traditional umbrella as others do, or an umbrella which can fix to the wheelchair. After all, they sometimes find hard to use this equipment when they are in wheelchairs. They do need an assistance of another person. Furthermore, they need to hold the umbrella properly to cover from sun and rain. To overcome the issues, we were able to come up with i-Umb, a new device which helps especially to the disabled people in wheelchairs. This research paper briefly describes the research problem, the observations, and researchers which have done for these issues, the new i-umb device and its functionalities, and how our device would help them to solve those problems.

Index Terms: *Disabled people; wheelchair; umbrella; traveling issues; i-umb*

I. INTRODUCTION

"It is indeed we know that the 'technology' develops day by day rapidly. A vast variety of technological classifications are there but mainly, the ultimate goal is to make human tasks easier. Due to the technological development, people come up with new equipment. This rapid growth makes a keen interest in people to find and develop more technical concepts.

Many people are spending their lives with disabilities. They do need special care and much attention. A disability may be present from birth or occur during a person's lifetime. Individuals with disabilities have the same health needs as non-disabled people [1].A result of research carried out by the Centers for Disease Control and Prevention in the USA states that nearly 53 million Americans have some disability, and among them, around 33 million Americans have a disability that makes it difficult for them to carry out daily activities [2]. There are several types of disabilities. Physical, Sensory, Intellectual and Mental disabilities are examples. A physical disability is a limitation on a person's physical functioning, mobility, dexterity or stamina [3]. This could occur because of genetic disorders, conditions present at birth, serious illness, spinal cord injury, etc. After all, many of them use a wheelchair. Furthermore, they need specialized equipment or assistance to do their daily tasks easily. Although they are intended to do what ordinary people does with their equipment, it sometimes feels hard to do their work with their equipment. At that point, the technology concerns this matter very seriously, and it helps these people in various ways. Many new techniques and equipment are introduced by the technology day by day. This would be surely a big comfort and support for them.

By observing these results, We, as a team have figured out a slight problem they face when they travel. As a regular person, they carry various equipment, and one of the essential equipment they use is an umbrella, especially when they go outdoor. When they use an umbrella, they face several issues. The biggest problem occurs when they travel alone. They have to install the umbrella before they leave, have to keep open the umbrella always, cannot adjust the canopy accordingly, etc. Apart from that, they feel very uncomfortable when they have to travel alone with an umbrella. Such issues affect their day to day tasks very vastly.

Our attempt was to add a solution to these problems by making an intelligent umbrella, for the disabled people who are in wheelchairs. A device which can sense the sun rays / rain and to open / retract the canopy automatically, which can tilt the canopy according to the direction of the sunlight and which can be controlled by the users' smartphone. Furthermore, it has a feature to check the weather condition and alert the user and to do the distance tracking. This document describes a project work aiming to develop a device to do primary functions done by a regular umbrella, which helps people with disabilities mainly who're in the wheelchairs.

II. BACKGROUND AND RELATED WORKS

The development team studied various research papers from different sources initially. There is no similar existing system for this system. Summary of the findings are as followed;

Rainfall Monitoring Using Acoustic Sensors is a Research about the design, development, and field testing of acoustic sensors for rain measurements. An Android-based acoustic sensor has been designed and tested. The sensor can upload data files to a web server and can trigger an SMS alarm when rainfall data exceeds safety thresholds. An Arduino-based acoustic sensor is also designed and tested, which is an alternative, low-cost acoustic sensor for moisture. Rainfall data from the sensors are graphed, analyzed, and compared vis-à-vis to data from tipping bucket rain gauges. It reports, for the first time, the performance of an acoustic rain sensor

and a tipping bucket in the same device integrated with an Android phone. This new configuration shows the difference between a real-time acoustic rain sensor and a tipping bucket, which is an accumulation sensor. The analysis features and performance of the acoustic sensors directs to the development of low-cost devices for gathering rain data, which can supplement standard rain measurement devices [4].

"High-efficiency dual-axis solar tracking development using Arduino," presents the design and development of a high-efficiency dual-axis solar tracking system using Arduino platform. Furthermore, the ultimate objective of this project is to trace the maximum sunlight source to power the solar panel. The project is divided into two stages, which are hardware and software development. In hardware development, five light dependent resistors (LDR) has been used for capturing maximum light source. Two servo motors have been used to move the solar panel to maximum light source location sensing by LDR. Moreover, the code is constructed using C programming language and targeted to Arduino UNO controller. The efficiency of the system has been tested and compared with a static solar panel on several time intervals, and it shows the system react the best at the 10-minutes intervals with a consistent voltage generated. Therefore, the system has been proven working for capturing the maximum sunlight source for high-efficiency solar harvesting applications [5].

"Design for an intelligent control system of curtain based on Arduino"describes an intelligent control system of a curtain, developed in the paper based on Arduino. Throughout detecting and analyzing the factors that include the sunlight illumination, time, temperature, humidity and outdoor environmental conditions, the microcontroller automatically determines the opening and closing of curtains. By experiments, it is proved that the intelligent control system of the curtain has the high practicability and excellent manipulative [6].

"An Arduino based system provided with GPS/GPRS shield for real-time monitoring of traffic flows," implies at proposing a low-cost system based on the GPS signals coming from Arduino-based systems to collect the traffic measurements needed to compute colored traffic map and the minimum path to the destination depending on the current position. The comparison carried between the performance of the proposed system and the one based on GPS signals coming from the user mobiles points out a higher accuracy of Arduino based tracking system. Also, the system may send the user data to the main information center as anonymous messages thus satisfying the privacy requirements needed for a wide activation of such a monitoring methodology [7].

"Bluetooth-Based Home Automation System Using an Android Phone" presents the design and implementation of a low cost but yet flexible and secure mobile-based home automation system. The design is based on a stand-alone Arduino BT board, and the home appliances are connected to the input/ output ports of this board via relays. The communication between the cell phone and the Arduino BT board is wireless. This system is designed to be low cost and scalable allowing variety of devices to be controlled with minimum changes to its core. Password protection is being used only to allow authorized users from accessing the appliances at home [8].

"Solar powered umbrella table"describesa solar umbrella and table apparatus with attached chairs features stand-alone AC power, generated from solar energy. The apparatus features an umbrella having solar collection devices and a table with attached seating chairs. The electrical system of the apparatus converts collected solar energy to an electrical voltage. Batteries store the energy provided by the solar panels. Inverters convert the DC voltage output from the storage batteries to 120 volts AC. Power outlet terminals are located on the umbrella and table apparatus allow 120 volts AC powered devices to access the output of the sine wave power inverters [9].

III. METHODOLOGY

In the 'i-Umb – Intelligent Umbrella System,' the user has a mobile application which includes all the functionalities of the i-Umb The mobile application controls the umbrella over the Bluetooth. The user can select either to monitor the umbrella manually or, to let the umbrella controlled by itself automatically. Besides, the user can check the weather condition in a particular location, and navigate to a location. The user interacts with the umbrella using a program via a GUI. The user uses a touch screen mobile app and the output will provide in real-time.

The High-Level Architecture Diagram (Figure 1) clearly shows the functionalities of the i-Umb System.

The entire system was designed using Prototype Model because the prototype is built to understand the system will able to achieve the policy goals. By using this prototype model, the research team can get a better idea of the system, and can use that knowledge to develop the software (mobile application) to meet its requirements and minimize errors of the system. The goal is of using a prototype model is to develop a system with an overall functionality.

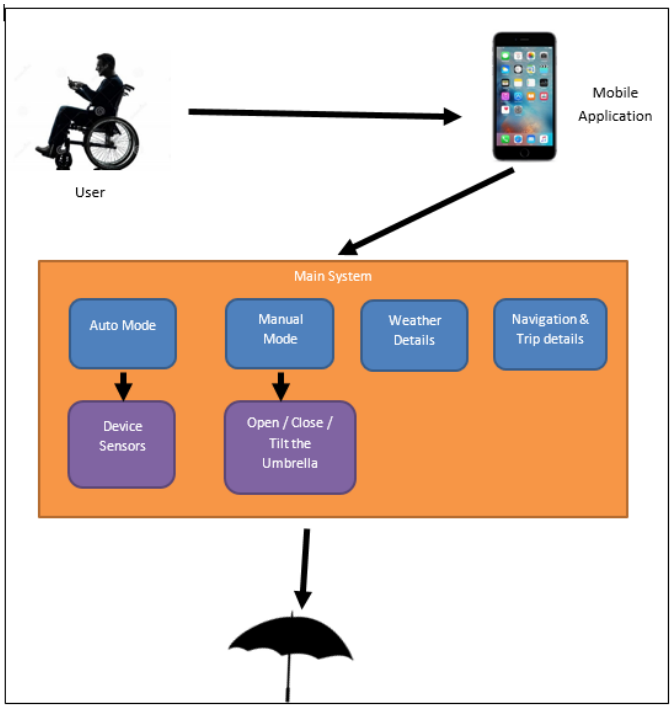

Figure 1: High-Level Architecture Diagram of the system

Planning phase began after initiating the project, where the group decided why and how the project should build. The project scope, problems and the objective were discussed among the panel and were clearly identified, elaborated and refined.

The analysis phase focused on gathering information about the existing system and analyzing the weaknesses and strengths of the system which lead to developing the concept to develop the new system. Requirements of the new system were clearly understood during the analysis phase.

In the requirement gathering phase, we collected information from the relevant people, especially disabled people who use wheelchairs. We tried to study as much as we can on how the activities are being done presently. The team had some brief discussions with them to understand what type of tasks are being done at present. At the same time, we also found out what were their requirements to develop an electronic system to make their tasks easy.

The first task of gathering information was to identify the appropriate people and then to select the suitable techniques. To retrieve the information about disabled people's day to day lifestyle works, we chose a group of 20 disabled individuals who use wheelchairs. Similar researchers were browsed, gathered and analyzed to retrieve information about the existing similar systems. Raw data of the 20 people were collected about their usage of the umbrella and traveling needs. Considering the breadth of information and the number of disabled people, a questionnaire was designed and distributed among them to gather the details. Clear, close-ended questions were included in the questionnaire. The interview questions were designed containing both open ended and probing questions.

After the interview, in the group gathering and discussion it appeared that considering their current requirements, rather than inventing a new method to use an umbrella is more feasible. The methods of using an umbrella in various ways were researched using the internet.

After analyzing gathered requirements, next step was to start the designing phase. Since our system mainly based on Hardware components, we first had to design the hardware structure of our umbrella. Unlike a regular umbrella, this umbrella has to open / close its canopy using a motor, as well as has to tilt the umbrella according to the sunlight's direction. Keeping them in mind, we have had to allocate sensor locations accordingly.

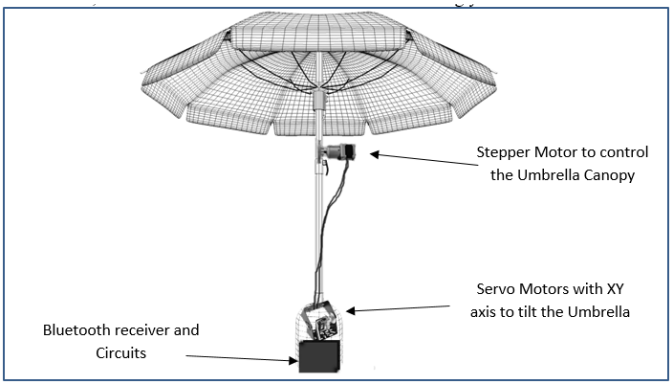

Figure 2 : Side View of the i-Umb Umbrella

After designing the main structure of the umbrella, we have started to design the circuit diagram.

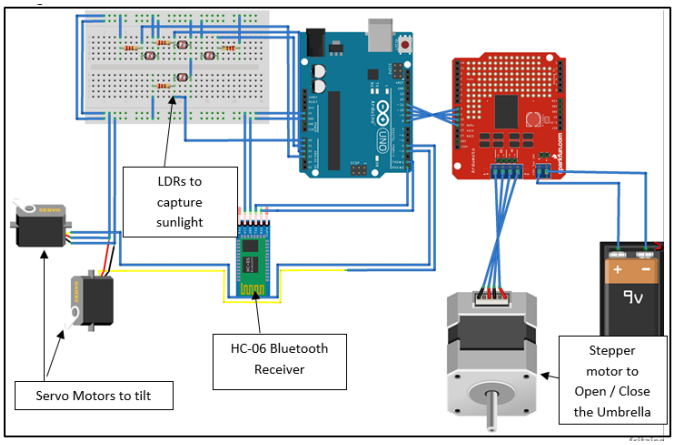

Figure 3: Circuit Diagram of the System

Architecture Design: Initially, the system hardware architecture to be used was selected. Shown above in Figure 1 is the original Architecture Diagram that was designed for the 'i-Umb' system. Interface capabilities, ease of development and the data control methods were being taken into consideration when selecting the strategy to be used. The original architecture designed was altered after the addition of new components to the system during the second iteration of the development.

Interface Design: The User Interface (UI) was designed to be appealing to the user and to be easy to navigate and understand. The basic principles were followed when designing the UI i.e. the layout, content awareness, aesthetics, user experience, consistency and minimal user effort. Interface Design Prototypes was developed for each interface which

includes navigation controls, input and output screens were the next step of Interface designing. Finally, the Interface Evaluation was done to help the group understand the improvements to be done to the interface before the completion of the system.

Implementation: The solution we mapped was broken down into several sub-systems, and each function was assigned to a particular member to run the processes smoothly. It includes the designing, analyzing, coding, and unit testing, etc. The following resources were identified as the basic requirements to install and run the software application.

Hardware Requirements
- i-Umb umbrella Unit
- Android supported Mobile Phone (Bluetooth and Mobile Data/WiFi integrated)

Software Requirements
- Android Operating System (Version 4.1.1 or later)

Deployment requirements
- The user must have i-Umb device to connect.
- GUI's are provided only in the English language
- Only registered users via Bluetooth are authorized to use the i-Umb device.

Testing: Unit testing was done in the Mobile application and the Arduino program to determine if they are fit for use. User interface testing was performed by moving through every menu item in the interface. User scenario testing was performed along with user interface testing by testing the functionality of each user scenario. The Integration test method that was used was the big bang integration where the group focused on integrating the whole system together and testing it afterward. Finally, in the System Testing, members have divided into two groups and one group tested the Mobile Application and other team tested the Main (Arduino) System.

The system was designed with following key points.
- Able to open / close the umbrella automatically
- Able to identify the sunlight direction and tilt the canopy automatically
- The mobile device can be used to open or shut the umbrella manually.
- Able to calculate the distance, navigate a certain direction and get the weather forecast using the mobile app.

IV. Results and Discussion

I-umb umbrella systemwas developed for disabled people who are using umbrellas. Especially individuals who are in wheelchairs by providing an intelligent umbrella to make their daily tasks easier and quickly. This entire product can be utilized as a fully automated system for disable people who are in wheelchairs. While the mobile app is used to control the entire umbrella system manually along with the functions mentioned above via Bluetooth technology, the user can easily open/close the umbrella and tilt the canopy rather than reaching for it. Furthermore, it can be used as a navigation device, as well as to calculate the distance the wheelchair driven, so that the user can easily obtain certain records of travel. Besides, the user will get weather alerts on his mobile phone and then he can control the umbrella accordingly. This whole system of i-umb consists of several main components. It Identifies the sunlight / rain and opens / close the umbrella automatically. It automatically senses the sunlight direction and tilts the umbrella canopy, Control the canopy of the umbrella using a mobile app, Tilt the umbrella canopy using a mobile app, Check weather conditions in mobile app and Calculate the distance the wheelchair driven in the mobile app.

The project is mainly targeting the disabled people who are using umbrellas. Since this is a very different topic, we were unable to find research papers which are directly considering this system. However, in the view of the various functionalities, we were able to find some research details. We used those details throughout our project and came up with the best solution.

We have to advance according to the technology day by day. We use computers to get more information and to know the world and to do our works more easily and efficiently. People who carry umbrellas are facing these above issues constantly. To solve them, it is much needed to develop an intelligent umbrella which resolves all the drawbacks as mentioned earlier. Our device will help to solve the above issues using various methods of sensing equipment, and it will be more efficient to address these problems.

Following images are the screenshots of main user interfaces of the system.

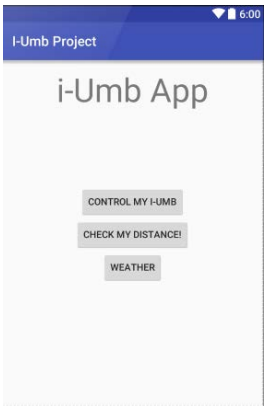

Figure 4: Main Interface of the Mobile App

The above picture (Figure 4) is the Main Interface of the i-Umb Mobile App, which allows you to select the relevant option to go through the app and control the i-Umb.

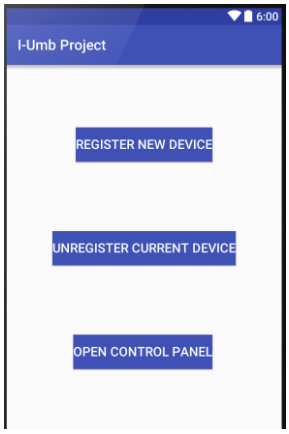

Figure 5: Umbrella Activity Selection

The above interface (Figure 5) will allow the user to select the registration and then go to umbrella controlling panel.

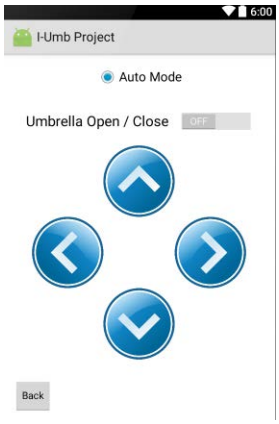

Figure 6: Umbrella Controlling Interface

This interface (Figure 6) will give privilege to the user to control the umbrella. The arrow keys will allow the user to tilt the umbrella, while 'Umbrella Open / Close' button helps umbrella to open and close. The 'Auto Mode' will help users to hand over the controllability of the umbrella to the Arduino system.

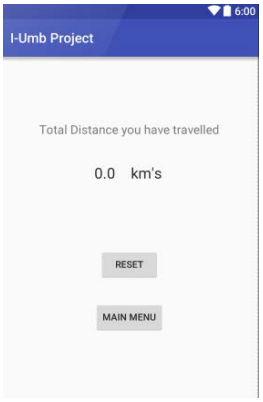

Figure 7: Distance Tracking Interface

The interface above (Figure 7) allows users to check the distance he/she has traveled while using this app.

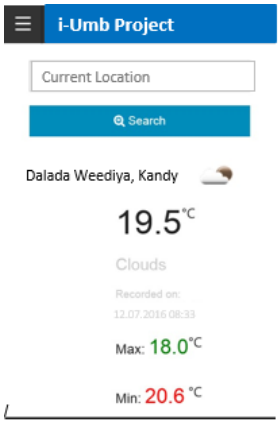

Figure 8: Weather check & Navigation Interface

This function in (Figure 8) allows users to check the current weather condition and the navigation facility to get directions to a particular location.

When highlighting the Reliability, the software does not seem to have any reliability issues, as the software was thoroughly tested and problems occurred were resolved. The system responds to user's commands with a lesser response time. Therefore, there will be no crashing at all within the functionalities and replies, and we have established a recovery plan that will ensure the safety of the system.

The system will be executed as a standalone system. The program will be available so as long the machine is running. The key to maintaining availability will be by ensuring a connection with the i-Umb unit via Bluetooth. Failure to connect to the i-Umb unit will make the umbrella unavailable. The system will be composed of various modules decreasing the complexity of expansion, and the system will be well documented and structured to make it run smoothly and make easier in maintaining.

The i-Umb System shall handle expected and non-expected errors in ways that prevent loss in information and extended downtime period. The mobile application deals with the i-Umb Unit without any fault. Responses to the given instructions/commands shall take no longer than 1 second to show from the device. Use of the system shall not cause any harm to human users as it automatically retracts the umbrella in case of a signal loss or other hardware failure etc.

The members were capable of handling the project but, the knowledge on programming tools was a risk for the project. However, we have tried our best to come up with better solutions to improve the efficiency of the code. Furthermore, major problems occurred when developing the Hardware (umbrella system). Had to consider the hardware components (motors, sensors, etc.) as it makes a large impact on the entire system. Our team members were able to overcome those issues and came up with right solutions.

Major changes were done in coding, (especially in the Arduino program code in the i-Umb unit), due to the adjustments or the requirements. The algorithms and the logic patterns were differed than we planned earlier. Besides, there

were few alterations in the mobile application to overcome drawbacks of main functionalities of the system.

V. Conclusion

To eliminate the problems which we have found during the research, as a solution the system, developers have implemented an automated system for the disabled people who are in wheelchairs. Disabled individuals who are using wheelchairs were the targeted users of this research. Considering about users, much of them facing many problems when using an umbrella when they travel. Through the implemented system, people who use the umbrellas when they travel will get much easiness when using an umbrella. The intention of developing the i-Umb is to help disabled individuals who are in wheelchairs to use an umbrella more reliably when they travel.

Recommendations for the future development of this system are as follows:

- Develop this mobile application in multiple platforms (Apple, Windows Mobile, etc.)
- Develop the system with a new or improved algorithm.
- A communication method to communicate with other i-Umb users
- An SOS button for an emergency

As the research was limited to a specific period,we were able to focus on only a small number of components. In the future, the group is willing to do more researches and develop a method for the mobile application to integrate more features such as Security features etc. Moreover, the system can be built to process using an Artificial Intelligence.

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