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Smart Walker Using Android Application

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Abstract: Elderly, blind or visually impaired people recur to a cane as a traditional ambulation aid. Although useful for maintaining balance, and for pivoting around obstacles, this tool limits the autonomy of individuals. In some extreme cases, using a cane leads to potential hazards, which can be detrimental to the health of the person relying on it. The aim of this project is to introduce a novel automated ambulation tool, entitled "Smart Walker", which overcomes the aforementioned disadvantages. The Smart Walker is equipped with an Android application that wirelessly collects relevant data (blood pressure, heart rate, position of obstacles, etc.) through sensors, and analyzes them. The processing is done in real-time via a pre-programmed Arduino board; the results are relayed back to the application installed on the smart phone; accordingly, the user adjusts his plan of action. The encouraging results set path for extending this work to be implemented in more aid-systems; a fact that is apt to improve the overall health and well-being of old and impaired people.

Keywords: Health, sensors, smart phone, mobile application, arduino

1. INTRODUCTION

In the 21st century, life has become more complex and more complicated with so little time left to watch and take care of old people or those who have certain physical disabilities. The key is to merge various technological branches and advancements in order to obtain an effective system to maximize its efficiency and render our system useful not only for the present but for the near and long future. Nowadays, the advancements in biology and technology are improving the quality of life of the elderly and the blind by creating and optimizing different solutions that not only will help with their daily life activities but also will make the targeted population useful members in the society instead of a burden by constructing a new life design, thus, probably saving their lives or at least improving it. The time spent with families is in gradual decrease; elder care institutions have been always criticized due to their money consumption and unpleasant treatment with elders and was noticeable on a psychological level were elders feel abandoned or imagine the idea that they have no reason to live anymore and for what purpose.

The blind however, face bigger challenges. In a world where human beings designed and developed the basic core of their daily life activities depending on the sense of vision, blind people have managed a limited but realistic success to merge and make their lives active and connected with the society. But unfortunately, all methods used by the blind from Braille reading to moving around using their cane and/or adopting a trained dog to facilitate movement as well has not yet reached a level of success were no other aid and assistance is needed. The traditional cane that the blind population usually uses is effective but sometimes fails to detect what should be avoided while moving around.

The objective is to create a system that will help the elderly move around and be supervised at the same time. This provides an effective and safe way for the user to be able to foresee the dangers before taking place. The system is integrated on a Walker, thus, becoming the Smart Walker as shown in "Fig. 1".

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Figure 1: Smart Walker

2. WHY CHOOSING A WALKER

Walkers assume an important role due to its simplicity and rehabilitation potential. These devices are interesting once they work as a supporting device during bipedestation and, in addition, use the person's own remaining locomotion capability in order to move [7] avoiding the early and deteriorative use of wheelchairs. Walkers are prescribed to improve patients' mobility and help them maintain balance [8][9]. These devices can increase confidence and sense of safety, which can raise a patient's level of activity and independence. There may be physiological benefits of limiting osteoporosis, reducing cardiopulmonary reconditioning and improving peripheral circulation [8]. Static equilibrium is maintained when the body's center of mass is positioned over the base of support. Loss of balance can result when the center of mass is displaced in relation to the base of support because of voluntary movements or external perturbations, such as slips, trips or pushes. Use of a walker increases the base of support, thereby allowing a greater tolerated range for center of mass positions [10]. They can also prevent instability by allowing stabilizing reaction forces such as holding on or pushing against the ground [8]. There are many types of walkers, considering their constitutive materials, accessories, sizes and structural configurations. These are classified in two types: conventional and smart walkers. Smart walkers have emerged with the same structure as the conventional ones but they include additional robotic and electronic components, that promote a better assistance to gait, especially considering navigation, gait monitoring, and partial body weight support [11] [12].

3. LITERATURE REVIEW

A. *Obstacle Detection*

An infrared sensor is an electronic instrument that emits and/or detects infrared radiation that helps in collecting relevant data about the surrounding environment. Infrared sensors are used for the purpose of detecting obstacles. The used sensors have a range of detection that amounts to up to 80 cm. The Smart Walker is equipped with four Infrared sensors, which detect the presence of objects in the vicinity; one sensor for the right direction, one for the left, one for the front right, and one for the front left [1]. The function of these sensors is shown in "Fig. 2".

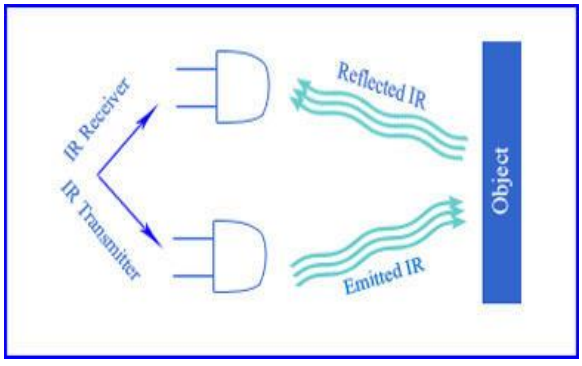

Figure 2: Infrared Sensor Functionality

B. *Health Monitoring*

The majority of the elderly worldwide suffer from aging symptoms along with various diseases. One important tactic to monitor the change in their health's status is by monitoring their heart rate. The pulse sensor is a relatively cheap alternative to present biomedical equipment; its objective is to provide data of the patient's heart rate. Light is absorbed or reflected by our organs and tissues (skin, bone, muscle, blood); some light will pass through human tissues if they are thin enough. When blood is pumped through your body, it gets squeezed into the capillary tissues, and the volume of that tissue increases very slightly. Then, between heart beats, the volume decreases. The change in volume affects the amount of light that will be transmitted. This fluctuation is very small, but can be sensed by electronic devices [2]. The pulse's schematic is shown in "Fig. 3".

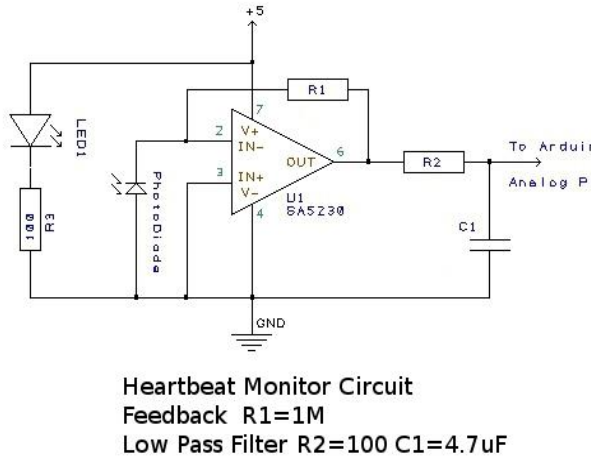

Figure 3: Pulse Sensor Schematic

C. *System Control*

In order to control the system's inputs and outputs, programming codes are used to facilitate the process through the use of an Arduino board. Arduino is an open-source electronics prototype platform based on flexible easy-to-use hardware and software, and that can be connected to a computer via a USB cable which acts as a port to upload the program. An important feature of using Arduino for this project is that it communicates with software running on a smart phone [3]. The infrared sensors along with the pulse sensor will be connected to the inputs of the Arduino Board. The four outputs needed will be dedicated to output 5V in order for the Sound Recording Chip circuits to function. The Ethernet Shield is inserted on top of the Arduino board, "Fig. 4", and is responsible of transferring the values of the pulse sensor, after being calculated, to the router to be read on the Android application on the user's android phone. The android application is developed to capture real time data from the IP camera installed on the walker in addition to the heart beat pulses and the emergency stop button. Moreover, the smart walker is equipped with a 3G router which enables the remote monitoring of the elder person and all his vital conditions in real time and anywhere on the earth by just having an internet connection.

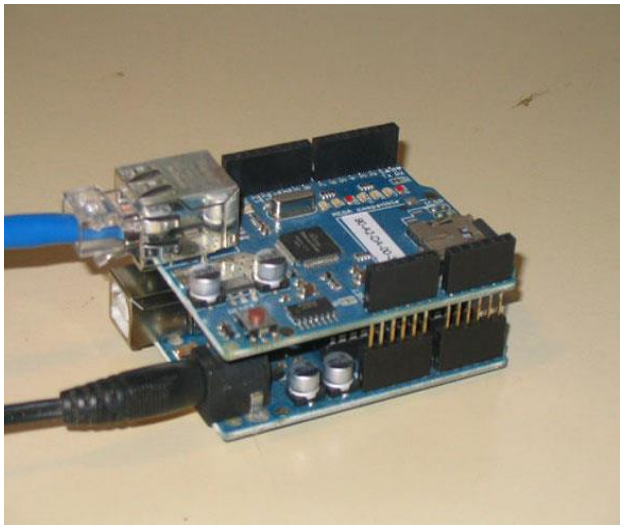

Figure 4: Arduino & Ethernet Shield

D. *Sound Recording Circuit*

Since the blind can't see, an alternative method of communication, which should be based on hearing, must be used. The Sound Recording Chip, "Fig. 5", is the one to use.

ISD2590 integrated circuit are mainly information storage devices used to record and playback a set of voice signals, using on-chip nonvolatile memory that can support up to 90 seconds of speech, and can provide a high quality voice reproduction. This IC can be connected either to switch, microcontroller, or sensor to control its output.

The infrared sensors control the play/stop and playback process of the recorded sound on each IC. In order to trigger the circuits, indirect control using relays is applied. Since the 5V signal that is generated by the output of the infrared sensor doesn't have an enough current to control the two relays of each sensor-IC connection, so 4 PNP transistors were used, and the base of each transistor is connected to the output of the specific sensor. When detection occurs, the output voice signal will remain until the object is released [4].

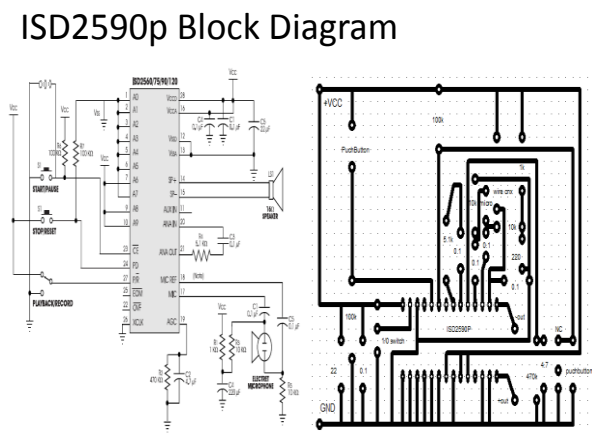

Figure 5: Block Diagram of Sound Recording Chip

E. *Observing Remotely*

An IP Camera or an internet protocol camera is a digital video camera capable of sending and receiving data via a computer network and the Internet; it can also be monitored and controlled remotely via computer or phone sending streams of live video and audio. The IP Camera requires an IP Address (Internet Protocol) to connect and locate the device; it sends video streaming to the android application for monitoring purposes.

IP cameras offer secure data transmission through encryption and authentication methods such as WEP, WPA, WPA2, TKIP, AES.

An important key advantage that an IP camera provides is its lack of dependency on a computer to send the images/video; the ability to compress data with high quality is a major advantage as well [5].

Remote accessibility is not only available but also extremely flexible and doesn't require much effort to put into practice.

F. *Router*

A router is a networking device that forwards packets around networks. A router connects at least two networks; if the router is connected to the internet, the ISP (Internet Service Provider) should be one terminal of the network. Routers are present everywhere from small businesses to homes and hospitals. The router is a main block in the "Smart Walker", connecting the entire pieces together and providing the real-time data transmission required for the process.

The camera's installation with respect to the router is shown in "Fig. 6".

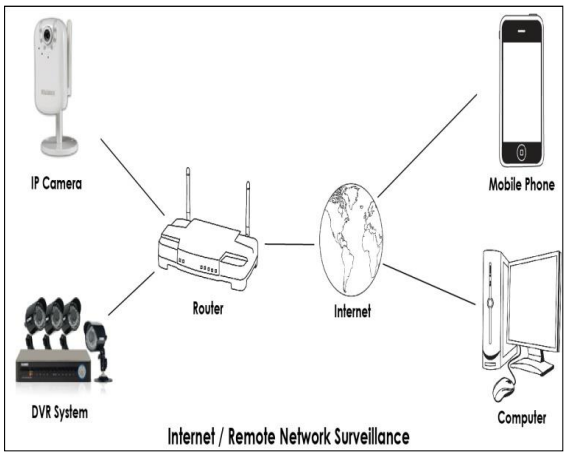

Figure 6: IP Camera and Router Installation

G. *User Interface*

Android is a Linux-based operating system made for the smart phone industry. The android application must be programmed in order to receive video streaming and the measured values of the pulse sensor along with the emergency button sound notification. The reason android is put into use is present in its open-source platform which allows third party applications to be created. Android software has become flexible when it comes to receiving data, and especially video streaming which eases the entire operation [6].

4. PROPOSED SOLUTION

The Smart Walker presents an effective ambulation aid for the elderly and vision impaired people. Using simple electronics circuitry, along with profiting from the proliferation of smart phone applications, a smart mobility system which acts also as a health monitor is recommended. One of the main attractions of the Smart Walker is offering relative independence to people in need, which would reflect on their morale and productivity. The system had undergone extensive testing, and proved to be pretty reliable. A wireless video, the health monitoring mechanism, and low power consumption overshadow the minor disadvantages. Arduino launched a revolution in the ease to assemble and program numerous projects, performing calculations and measurement and even hosting web servers. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Projects can be stand-alone, or they can communicate with software running on your

computer Similar to Arduino usage, Android operating system is based on an open-source platform which enables many users put into effect to create applications and is present on the majority of the Smart Phone industry. In addition, Android is owned and developed by Google, opening wide doors to the largest search engine in the world.

By using these advancements in technology that are present today, simple yet effective inventions can aid the people who are in most need for it.

5. MATERIALS AND METHODS

This project fundamentally consists of two parts: the local system and the remotely controlled system. The local system is responsible for detecting existing obstacles and notifying the blind, while the remotely controlled system will receive video streaming and the heart beat value of the elderly. The two parts with all their constituents are implemented on the Walker. However, the latter part can be monitored abroad using WIFI and/or Internet via a router. In order to work in an organized fashion, it is necessary to envision the project as a whole block diagram, "Fig. 7", to distinguish the different components and phases present, and to engage work efficiently between members.

Early obstacle detection is extremely important for people who use walkers. Due to the effects of impaired balance, sudden changes in terrain can sometimes present serious challenges to balance, even when one is using an ambulatory aid.

Normally, the navigation and obstacles detection employ ultrasonic, vision or infrared sensors capable of detecting static and dynamic obstacles. The control system assists the user in obstacle avoidance by sound or vibration alerts or operating directly on the device's actuators, momentarily changing the path introduced by the user. This function is usually designed to help users with visual problems or to help navigation on environments with multiple obstacles.

The data gathered is sufficient for obstacle avoidance and is simple enough to allow rapid processing and notification. Another specification is that the device can detect descending stairs, not dragging the user after it. This is done by installing an ultrasonic sensor at the lower front size that calculates the distance between the walkers's lower part and the ground in a tilted front way. If the distance increases suddenly, then this will give a notification that a descending stairs is in front.

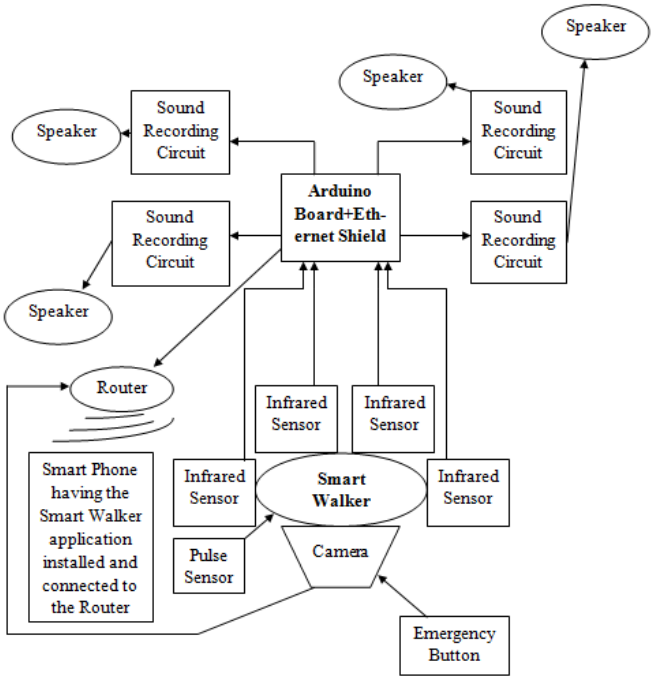

Figure 7: Smart Walker Implementation

6. RESULTS AND DISCUSSIONS

A. *Results*

The results of the project after testing are the following:

The infrared sensors function properly; their output is analyzed by the Arduino board, which sends a stable 5V output to ignite the relays that will make the Sound Recording Circuits function, and inform the user of the direction of the present obstacles.

The IP Camera functioned properly and effectively sent live video to the Android application.

The pulse sensor has also successfully sent data of heart beats/ per minute of the user via Arduino Ethernet Shield and also to the Android Application.

The weight of the Smart Walker is an issue, but is solved by installing wheels that are capable of handling weight and reducing unnecessary wiring and adjusting with a smaller but more effective power supply (Lithium Powered).

B. *Discussions*

During the course of this project a lot has been learned. When it comes to programming the Arduino, the team has learned how to program and test a lot of examples provided by Arduino website, leading to understanding of how to write the code needed for the infrared sensors, to understand the code provided to the pulse sensor from its official website, and to alter the code to comply with the required needs. The IP Camera, on another hand, took a lot of time and effort to function; at first, it was vague as to how to configure the camera, but after connecting it to the computer and providing a static IP instead of the router providing it with an IP, it functioned properly. The router's configuration is not that complex; all what should be done is for the router to become an access point, configure the LAN settings to the same range as the IP Camera and Arduino Ethernet Shield, enable DHCP settings and enable forwarding packets through the router. In the primary test, the IP camera and the sensors on the walker were tested on the android application using the normal wifi connection, thus the rage of communication was limited to the wifi rage which is approximately 100 meters. Then we have installed a 3G router on the walker and connected it to the 3G connection with the configuration of a real IP. This type of connection allowed the remote monitoring of the elder and the walker from anywhere by just having an internet connection to the android application The connection and implementation of the Sound Recording Circuits only needs a little focus and a lot of wiring. It has taken a while before the circuits functioned properly because of the team's ignorance as to how to use the SET and RESET buttons to record sounds and test them. What is really significant in using the sound recording chip is that whenever an infrared sensor detects an obstacle that is about 80cm far from the walker it will send a prerecorded sound notification telling the elder or the blind to change their direction while walking. In addition to that a LED will light when the sensor is active adding a visual way of notification. The application, though has well-functioned, but still has some imperfections. The video stream from the IP Camera has a certain delay due to the complexity of decoding on smart phones because of their limited processing capabilities in comparison to a computer. The emergency button on the walker adds an effective way of notifying the monitoring person with a sound notification on his mobile phone in case of emergency.

7. CONCLUSIONS AND FUTURE WORK

A. *Conclusions*

As a final approach, the Smart Walker project is of great importance. During testing and implementation, there were a lot of difficulties concerning the various interfaces and wiring challenges in such a small area to implement such number of parts. The objectives were fulfilled and especially the learning process of the project. Literally speaking, a blind person can use the Smart Walker and move around in a controlled environment such as a house; the elderly is also capable of being monitored remotely and can feel safe since someone is constantly there to answer to his/her need.
Evaluating the works that were presented in this article, one can infer that, in general, almost all the smart walkers have an assistive navigation system with sensors that detect obstacles, as well as, a design that has been studied to provide and improve a stable gait. This factor is possible with different designs of the guide platform that can have, for example, a forearm support. Another aspect that increases stability is the fact that electronics and other heavy components are put on the center upper part of the walkers, giving a greater balance and stability to the device. Thus, rollators can be easily augmented with simple and relatively low cost instrumentation technologies to provide a wide range of functionality and gait characteristics as Smart walkers, and avoid to inadequately resort to alternative devices, thus contributing to the maintenance or to the improvement of the physical and cognitive capabilities of the user.
The project provided a great platform to work as a team and to be more motivational for other projects in the future.

B. *Future Work*

The Smart Walker has a bright future ahead. The part that has been accomplished is considered by our team a pillar to what will become in the future. Artificial Intelligence and Video Processing can help the blind to use the Walker, not only in a controlled environment, but also across streets, to work, etc. More accurate pulse sensors will manage to measure and send better results with less noise interfering with the original message. Using smaller electronic parts will reduce the overall weight of the Walker, making it easier to use. Another interesting aspect is to provide a Global Positioning System (GPS) for the Smart Walker in order to detect the presence of the elderly and the blind at all times in case assistance is required. The emergency push-button can also be set to relay its call to a nearby hospital to provide fast medical assistance, or to send an ambulance. This would ultimately lead to a decrease in the rate of accidents and morality.

Future researches should improve the safety and stability of walkers, and avoid to inadequately resort to alternative devices such as wheelchairs, that have disabling effects, thus contributing and reinforcing to the maintenance or to the improvement of the physical and cognitive capabilities of the user.

A necessary step is the improvement of a smart walker capable of supporting the weight of the user but that can be used to stably and safely drive him with a high manoeuvrability. For this purpose, different handle bar designs must be addressed and it must be verified the best way to dispose the base support of the upper limbs of the user, in order to improve the manoeuvrability of the walker and to improve the ergonomics. Additionally, it is important to understand and study the dynamic model of the walker, to quantify and ameliorate the stability of the walker, while the user is guiding it through unknown territory.

Additionally, it is necessary to find components that are low consumption and the battery system has to be improved. For safety the electrical system has to be isolated from the environment in an enclosure to prevent damage from liquid-spills, etc. On the one hand, the re-charge time of the batteries should not be longer than eight hours to achieve full charge thus allowing re-charge overnight. On the other hand, the runtime of the system should be of the order of six hours. Further, the re-charge system should be simple to connect and monitor.

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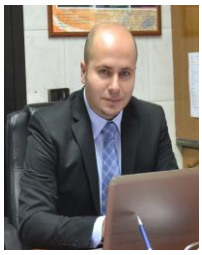

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