Wander Watch

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***Abstract* — The objective of this high level, electrical and computer engineering project, the Wander Watch, is to provide a product that can track Alzheimer's and dementia patients when they wander from the safety of their homes. In order to compete with similar products on the market, the watch must be affordable and wearable. The solution should allow for real-time GPS tracking through a phone application, as well as SMS capabilities to alert the user that the wearer is out of certain range. The product implements GPS/GSM devices with Bluetooth, all used in conjunction to track a wearer.**

***Index Terms* — Application software, Bluetooth, Global Positioning System, GSM, Microcontrollers**

I. BACKGROUND

There are many products on the market that are geared toward tracking Alzheimer's and dementia patients once they have begun to wander from the safety of their homes or care facilities, which are implemented in various ways. A few products require a device to be placed inside of the patient's pockets or shoe, or to be strapped onto a belt, however, it is still possible for the device to be loose and get left behind by the person who needs it. Another implementation utilized Bluetooth to set up a perimeter around the patient's home. Once out of range, a notification will be sent to the caretaker. Unfortunately, this device only tracks indoors at a preset location. If the wearer were to leave the location, the caretaker would not be able to locate them. There are companies that allow people to enroll into a program and provide a device that will track the patients. If the patient gets lost, the caretaker has to contact the company and they will track them. In some instances, the caregiver will need to fill out forms before given access to patient's location; other companies will only communicated directly with local law enforcement. The downside of these systems is that the caregivers is cut out of the search or has to go through a third party, which wastes valuable time.

Outside of implementation, other issues faced are the cost and user-friendliness. Many of these products have high list prices and require additional enrollment and monthly fees, causing the device to be expensive. These products also tend to uncomfortable for most people to wear due to their robustness and often have to be attached to the wearer's ankle.

II. INTRODUCTION

The goal of the Wander Watch was to create a product that be able to compete with the current Alzheimer's and dementia patient trackers on the market. To do so, the group broke the project into four main sections: indoor tracking, outdoor tracking, messaging, and an application. Combined, these sections will form one real-time tracking device.

The indoor tracking is handled by Bluetooth. This allows for easy setup and a long enough range to track the wearer while they are inside the house. The outdoor tracking is of course handled with a GPS component. This device allows for the real-time tracking of the wearer if they decide to wander.

The messaging system is handled with a GSM component. This allows for connection to a mobile network and will give the watch the capability to send an alert message and update the location with GPS coordinates. The last portion of the device is the phone application. This app will allow the users to tailor the notifications and setting to their preferences and will allow for easy setup of the watch when connecting it to their phone.

All of these components are connected to a microcontroller and powered with a Li-Po battery.

Together all of these components work to make a device that is affordable, wearable, light weight, and reliable.

III. SYSTEM REQUIREMENTS AND COMPONENTS

In order to meet the desired objectives, the group set requirements for the Wander Watch. The watch must weigh less than or equal to 75 grams (5 ounces) and cost less than $75. It must also have a GPS accuracy of approximately 3 meters. Within 10 seconds after the patient leaves their home, an alert message must be sent to the caregiver. With these requirements in mind, the group proceeded to find components that met the specifications.

The system can be described by the components inside of the watch. The following gives a brief introduction to the components selected for the watch.

A. Microcontroller

For the main processor, the watch will be using the ATmega1284p chip from Atmel. This is a nice choice for the MCU due to the decent size in memory, the amount of peripherals provided by the MCU for communicating with other devices, and the ability to work with the Arduino platform.

B. Bluetooth

As part of the indoor tracking system, the watch will need to communicate with a centralized hub inside of the home. To achieve this, the watch will use a Bluetooth module that will communicate with another Bluetooth module inside of the home.

C. Global Positioning System and Global System for Mobile Communication

The watch contains the SIM808 GSM + GPRS + GPS cellular module. This component allows the device to connect to any GSM network with a 2G SIM card and also allows for the GPS tracking. It uses AT commands to interface.

D. Display

The tracking device will provide some functionality for the user in the form of a watch. To be able to display the time and date, the watch will be using an OLED display. This is a lightweight and sizeable option for the watch.

E. Power System

The power system begins with the battery that will power this watch. The battery that best fits the needs of the watch is the lithium polymer battery. This battery is not only thin, there is also a healthy capacity at 1200mAh at 3.7V.

What the watch will be using for recharging the battery is the battery charging IC, MCP73831 from Microchip. This battery charging IC provides a nice 500mA charging current for recharging the Li-Po battery. The battery charging IC will receive power from the micro USB.

The battery needs to be monitored to ensure the watch will not power off. For this, the watch has a battery gauge MAX17043 from Maxim Integrated. This battery gauge will be communicating with the microcontroller to provide a calculated value of how much battery capacity remains and then present that onto the display.

Since the watch has several devices that operate on different voltages, the watch will need to have a linear regulator and a buck/boost regulator.

The Bluetooth, display, and microcontroller all need to operate on 3.3V. To accomplish this task, the watch will be using a TPS799 from Texas Instruments.

The GPS/GSM module requires a 4.0V to operate. Due to how the Li-Po battery performs at full capacity, the regulator that is needed is a buck/boost regulator to maintain the 4.0V. The regulator of choice is the TPS63050 from Texas Instruments.

F. Mobile Application

The Android application is where users can log in with their own account so that they can check the status of the watch that they are connected with. It allows them to check alerts, view location of the watch, and change any settings associated with the application.

IV. SYSTEM CONCEPT

A block diagram is helpful to understand how the components are integrated in the device. The following diagram shows each component and what it is connected to in the device.

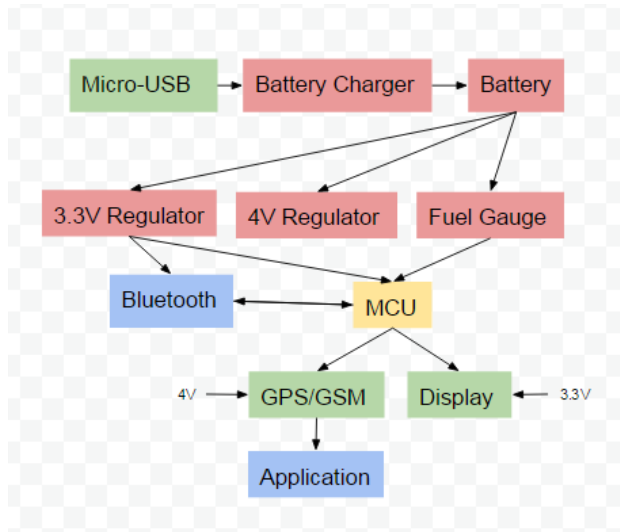

Fig. 1. Wander Watch Block Diagram

As shown in the figure above, power from the wall outlet to the micro USB will provide the power needed for the recharging circuit to recharge the battery. The battery is then sent to the two regulators to regulate the voltages needed for the devices inside of the watch and to the fuel gauge to monitor the battery capacity. The voltage regulated at 3.3V is then powering the microcontroller, the display, and the Bluetooth. The 4.0V being regulated is powering the GPS/GSM module. Data from the fuel gauge is being sent to the microcontroller, which is then sent to display that data onto the display. The fuel gauge is communicating with the microcontroller via TWI (Two Wire Interface) peripheral. The display is communicating with the microcontroller through SPI communication so the display will show the time and date on its face. The microcontroller is also communicating with the Bluetooth. The communication is both ways through a UART peripheral. The GPS/GSM module is communicating both ways also through a UART peripheral.

A phone application user diagram is helpful to understand how the application will be setup.

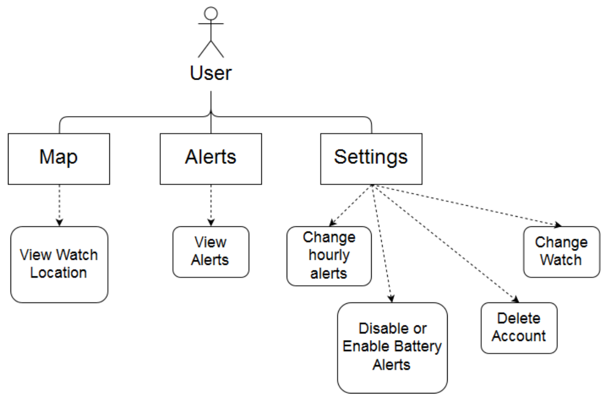

Fig. 2. Application User Flowchart

V. Tracking

A key feature of the Wander Watch is the ability to track the wearer remotely. The group split the tracking into two areas: indoor tracking and outdoor tracking.

A. Indoor Tracking

Indoor tracking was implemented using a hub located in the watch wearer's home and was responsible for keeping track of the patient while they are inside. Bluetooth pairing was used to determine whether or not the watch was in range of the hub. If the Bluetooth modules came unpaired, an alert message was sent to the caretaker's mobile phone via text. Since two Bluetooth modems will be needed (one for the watch and one for the hub), the group decided that the component must be inexpensive. Although the size of the hub is not crucial, it was preferred that the watch and hub had the same Bluetooth component and therefore, in order to fit inside the watch, the module must also be small in size. Lastly, the component must reach a minimum signal distance of 100 meters.

The component used in indoor tracking is the BlueSMiRF Gold. The BlueSMiRF Gold is a Class 1 Bluetooth modem, which means it had a range of 100 meters. [1] Class 1 was vital because it provides the watch with the range need to track inside of a home. The component has an operating voltage range of 3.3V to 6V. It also consumes about 25 mA on average of power. The antenna is built in, which is helpful to conserve space inside of the watch. Uses serial communications between 2400 and 115200 bps.

B. Outdoor Tracking

Due to the limited range of Bluetooth, the group decided to use Global Positioning Systems (GPS) to track the wearer of the watch once they are out of signal distance. As a redundancy to the indoor tracking and a safety measure, a geofence was added to ensure the reliability of the system. A geofence is a virtual perimeter that can be programmed and implemented using GPS. Geofencing allows the user to establish triggers that alert them when a device enters or exits the boundaries defined. [2] In the case of the Wander Watch, the boundaries were set up around the patient's home. Using GPS as a tracking alternative provided both accuracy and high reliability needed to meet the project requirements.

The SIM808 is 24 x 24 x 3 millimeter and weighs approximately 3.2 grams. It provides GPS tracking accurate up to 2.5 meters. It has a hot and cold start time of 1 second and 30 seconds, respectively, which falls within the design specifications. The SIM808 has an update rate of 5 Hertz and has an operating voltage that ranges from 3.4V to 4.4V. Despite the many attractive features of the SIM808, the group selected this component mainly due to the fact that it was actually a GSM model.

VI. Messaging

A GSM device was used to connect the watch to a mobile network in order to send the alert message to the caretaker once the wearer was out of range of the Bluetooth module and no longer within the geofence. The GSM also functioned as message courier, constantly sending the GPS coordinates to the phone application. The main requirement that the GSM module had was that it must connect to a SIM card. A SIM card allows for a phone network to be used on a different device if necessary. This makes the Wander Watch more affordable because the caretaker would only need an extra SIM card from their service provider, whereas other tracking devices on the market require a person to purchase both the device and a new phone.

As stated before, the component used for GPS tracking, the SIM808, was also used for the GSM portion of the project. This decision not only reduced the overall cost of the project, but it also saved space on the PCB. The SIM 808 is compatible with a 2G SIM and with that is able to send and receive text messages. The group came to the conclusion that 2G would be sufficient for this projects and would also help save money since 3G and 4G services are more expensive. The device is programmed with AT commands and this allows for communication with the MCU.

VII. The Application

The phone application developed for this project was created in Android Studio and is designed for Android phones. It was found during research that Android phones make up the largest market share of mobile phones, and thus most users will be more likely to have an Android phone [3]. Developing the app for other mobile phone operating systems could be possible with more time and funds, but for now the application has been focused on the largest base of users.

This application allows users to create an account for their information, connect their account with their watch, track the watch via a map screen, view alerts from the watch, and change settings for their account. It has several screens to handle each of these functions. The application displays alerts on its Alerts screen by capturing the SMS messages from the watch. In turn, the application can send messages to the watch to change certain settings or request an updated location from the watch if it is currently wandering.

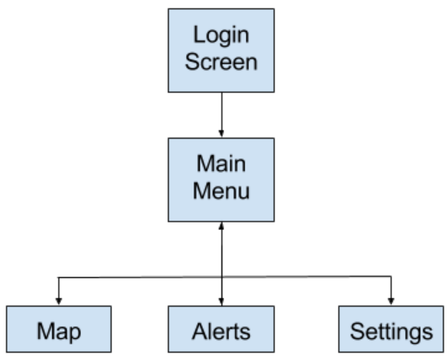

Fig. 3. Application Navigation Chart

If the watch still has a stable connection to the Bluetooth hub, the watch will send an alert to the application that it is safe at home upon the initial connection. This alert is sent only once, as long as it still has the Bluetooth connection. In the application itself, the map screen will show the watch at the home location. If the watch loses its connection to the hub, it will know that it is now wandering. It sends an alert to the hub with coordinates of the watch. The user can then check the map to view the watch's new location, and also refresh the map to keep updated as the watch continues to wander. At this point the user can take the needed measures to return the person wearing the watch back home.

The user can change certain settings via the Settings screen. Namely, they can allow or stop the watch from sending low battery alerts to the application, and can chose to opt-in to regular alerts from the watch. These alerts would be sent at regular intervals while the watch is wandering. Regardless of the option chosen here, the user can still refresh the location manually in the Map screen.

VIII. Board Design

Due to the size constraints given in the design specifications, the board needs to be as small as possible to be a wearable device. The board is 63mm by 37mm, which is also the size of the battery. The board will utilize both sides to minimize the overall size by separating the parts by having one side dedicated to the microcontroller, power, and Bluetooth, and the other side dedicated to the display and the GPS/GSM module. This is due to dealing with the antennas inside of the watch. Not only do the antennas have to be as far apart from each other, there also can't be any traces interfering with the antenna path. The board will be stacked on top of the battery inside of the case and the display will show through a cut out on the top of the case.

The Engineers

Jeffrey Rodriguez is a 23 year old graduating Electrical Engineering student. Jeffrey's career goals lies in the field of digital hardware design, particularly working with FPGAs.

Sarah Rassel is a 25 year old graduating Electrical engineering student who is taking a job with Nelson Engineering Co. in May 2016. Sarah has an interest in power systems and has plans to become a licensed professional engineer.

Alexis Timms is a 23 year old graduating Electrical Engineering student with a minor in Intelligent Robotics Systems. Alexis expresses interest in both autonomous and medical robotics, as well as digital hardware design.

Wendelyn Sanabria is a 23 year old graduating Computer Engineering student with a minor in Digital Media. Wendy has an interest in software engineering overall, and will be starting her Graduate studies at the University of Central Florida in August 2016.

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