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1. Introduction

Objective:

Avalanches, mining collapses and landslides are regular occurrences that often result in loss of life for many of the individuals that are unfortunate enough to become caught up within these natural disasters. One of the major causes of death in these cases is suffocation as the people who get caught in these disasters are usually severely disoriented and do not know which direction to attempt to dig. Time is extremely crucial once buried underneath snow or other debris and any attempt to dig in the incorrect direction can waste this valuable time and cause suffocation. In order to maximize a person's chance of survival in the event that they become buried, they need to quickly and efficiently dig in the correct direction in order to avoid suffocation. Our solution is a wristband device that displays the approximate direction of shortest distance to the surface so that users will be able to know the direction that they need to dig in order to maximize their chances of survival. The survival wristband will be battery powered and correctly display the direction of the normal force of the surface to some degree of accuracy at all times. The survival wristband will help to maximize people's chance of survival in the event that they are buried under snow or other debris and lose their bearings.

Background:

Avalanches are a terrifying natural phenomena that generally causes more than 150 deaths each year. People that are unlucky enough to be buried underneath the snow are taught to thrust their hand or another part of their body above the snow surface as they are beginning to be buried. The issue is often times people are so severely disoriented and see endless white that they are told to guess where the snow surface is and try to get a body part to break the surface in an attempt to be rescued. This is similarly the case with mining collapses and landslides as people that are buried are blocked from the light and almost all of the time have no sense of direction. The survival wristband would be extremely useful in any of these situations as it would display the correct direction of the normal force so that the user is able to stick a body part in the correct direction and have a better chance of being rescued.

In the event that an individual is buried too deeply to be able to reach the surface with a body part, the survival wristband can still significantly increase the chances of survival. Time is extremely essential to avoid suffocation and death. If a person buried in an avalanche can be rescued within the first 18 minutes, the chance of survival is 91% and, in the range of 19 minutes to 35 minutes, the chance of survival drops significantly at about 34%. Suffocation and hypothermia are two of the leading causes of death from avalanches and both causes have the potential of being avoided if time is conserved. The survival wristband can increase the chances of survival for victims buried fairly deeply by pointing them in the correct direction to dig and conserving time. Similarly, suffocation is a cause of death in mining collapses and landslides and the survival

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wristband can also be used to determine the direction of digging by the normal force and thus saving crucial time that is likely critical to the victims survival.

Physical Design:

This is a rough idea of how the survival wristband would function. It would be battery powered and have a 2D LED display similar to the one shown that displays a 3D arrow of the normal force to its wearer.

High-level Requirements List:

- When the device is tilted anywhere from 1 to 90 degrees, the displayed arrow gets updated in its direction to continue to show the direction of the normal force with respect to the device's surface.
- The refresh rate of the displayed arrow is such that it gets recalculated at least once every three seconds.
- The direction of the normal force of the surface is correctly calculated within a margin of error of +/- 15 degrees.

2. Design

Block Diagram: In our block diagram, dashed lines indicate data transfer while full lines represent the power lines.

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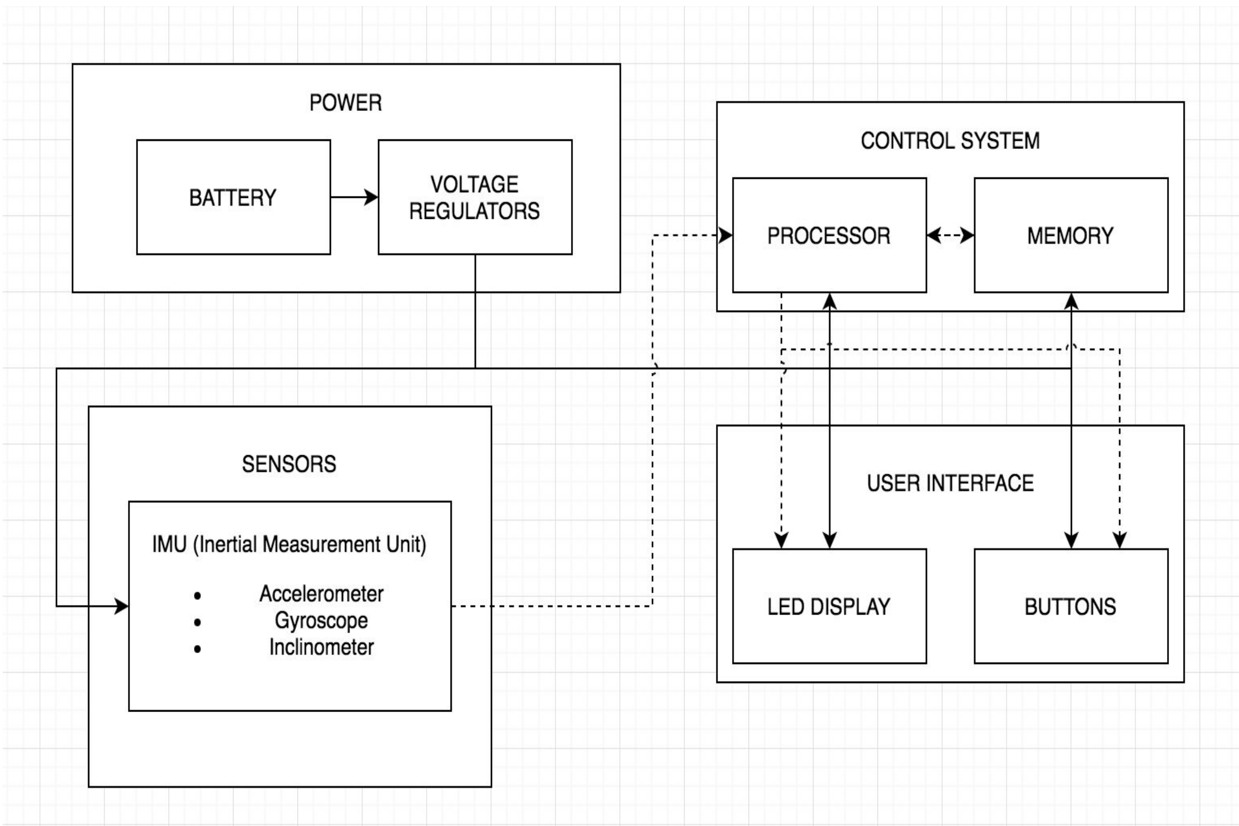

<u>Functional Overview:</u>

Power Subsystem: The power subsystem serves to provide the necessary power to the survival wristband and consists of a Lithium Ion battery as well as multiple voltage regulators.

1. The power subsystem requires a Lithium Ion battery that will be responsible for providing power to the rest of the subsystems and blocks within each subsystem. The battery is crucial to every component of the survival wristband and must be able to provide adequate power to all of the sensors as well as the user interface LEDs and buttons along with the processor and memory
2. Another component of the power subsystem is the voltage regulator. The voltage regulator takes in the power supplied by the Lithium Ion battery and maintains a constant output voltage that is independent from fluctuations in input voltage or the attached loads. Multiple voltage regulators are necessary so that each sensor

is supplied with the correct voltage as well as the microprocessor, user interface and memory.

Sensors Subsystem: The sensor subsystem serves to gather all of the correct information to be able to successfully display the direction of the normal force and thus the direction that the victim needs to dig. The sensor data will be sent to the microprocessor for computation of the direction of the normal force. This subsystem consists of an IMU (inertial measurement unit) that contains an accelerometer, gyroscope, and an inclinometer.

1. The sensor subystem's first sensor is an accelerometer that measures the acceleration of the user. This data can be used to determine the direction of the normal force given that a snowboarder of skier is accelerating down the mountain under the force of gravity. This data is to be sent to the microprocessor to further determine the direction of the normal force.
2. Another sensor in this subsystem is a gyroscope that uses gravity to determine orientation. This sensor can be used to calibrate the wristband and to correctly show the normal force regardless of the user rotating their wrist. This data is also sent to the microprocessor for calculations in determining the normal force direction.
3. The third sensor that we need in this subsystem is an inclinometer. The inclinometer measures the angle of inclination of a surface that the inclinometer is on. This sensor's data is also sent to the microprocessor as the angle of inclination can also be utilized to determine the direction of the normal force.

User Interface Subsystem: The user interface subsystem is where the direction of the normal force is displayed which is the direction that the victim needs to dig. It will contain a 2D LED display as well as a calibration button.

1. This subsystem will consist of a 2D LED display that will display the correct direction. It will be able to display a 3D direction on a 2D display by having a display that shows the plane of the normal force signified by LEFT, RIGHT, UP or DOWN and have a side by side secondary display that shows the relative angle in that particular plane. This will be done using an arrow.
2. There will also be a calibration button that the user will press before they go down the slope if they are a skier or snowboarder. If they are a miner the calibration button will be pressed upon entering the mine. When the button is pressed, the current information that the sensors are reading will be sent to the microprocessor and then stored in memory.

Control Subsystem: The control subsystem is where all the data is collected from the sensors and the correct direction of the normal force is displayed. This subsystem consists of a microprocessor and a memory unit.

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1. The control subsystem will have a microprocessor that performs all of the heavy lifting of the survival wristband. It will take in all of the data from the sensors and will compute the correct direction of the normal force. It will then send the correct data of the direction of the normal force to the LED display. It will also be able to send data from the sensors to be stored in memory when the calibration button is pressed.
2. Another component of the control subsystem is the memory. The memory communicates directly with the microprocessor and stores the current data from the sensors when the calibration button is pressed by the user. This is so that the survival wristband is calibrated correctly to ensure that the normal force is correctly displayed with rotation of the users wrist.

Block Requirements:

1. Accelerometer:

   The accelerometer will measure the acceleration of the user and this will be useful for determining the direction of the normal force when the user is on a slope and accelerating due to the force of gravity.

   Requirement 1: The accelerometer will need to be powered by the power subsystem and will take in a supply voltage of 2 V to 3.6 V.
   Requirement 2: The accelerometer must be continuously supplying data to the microprocessor for analysis in 2 seconds or under. This digital data is in the form of 16 bits, 2’s complement.

2. Gyroscope:

   The gyroscope will measure the orientation of the user’s wrist using the force of gravity. It is used to correctly calculate and display the normal force when the user’s wrist is rotated.

   Requirement 1: The gyroscope will need to be powered by the power subsystem and will take in a supply voltage of 1.95 V to 3.6 V for proper operation.
   Requirement 2: The gyroscope will be interfacing with the microprocessor in the control unit and supplying 16 bit digital data for analysis in 2 seconds or under.

3. Inclinometer:

   The inclinometer will be used to measure the specific incline that the user is currently being exposed to. The data provided by this sensor will be needed to correctly display the normal force direction.

Requirement 1: The gyroscope will be powered from the power subsystem and will need to be powered an input voltage of 3 V to 3.6 V to ensure that it is working successfully.

4. Lithium Ion Battery

    All components in the system require a power source to operate and the system is meant for mobile wear. For this reason, a Lithium-Ion 3.7V battery will suffice to power the system.

    Requirement 1: The battery must supply a voltage between 3.7-5V to the voltage regulator.

    Requirement 2: The battery must never exceed 60 degrees celsius during use.

5. Voltage Regulator

    This component is necessary to provide the correct voltage to certain components. Not all chips are equal. Some chips require more or less voltage than others, so the purpose of a voltage regulator is to take in the power from the battery and measure off a certain voltage range for components like the microcontroller or Accelerometer.

    Requirement 1: The voltage regulator must reduce the voltage of the battery to a range between 2.0-3.6V as input to the accelerometer.

    Requirement 2: The voltage regulator must reduce the voltage of the battery to a range between 1.8-5.0V as input to the microcontroller.

    Requirement 3: The voltage regulator must reduce the voltage of the battery to a range between 1.95-3.6V as input to the gyroscope.

    Requirement 4: The voltage regulator must reduce the voltage of the battery to a range between 3.0-3.6V as input to the inclinometer.

6. Microcontroller

    The microcontroller we will be using is the ATmega328P, which will be taking in the sensor readings from other components such as the inclinometer, logging data such as the the most recently gathered positional data points, calculating the slope of the surface with respect to the device’s surface, and outputting the correct arrow image to the LED display.

    Requirement 1: Provides the data packets that collectively form the arrow graphic to the LED display.

    Requirement 2: The chip must operate at a voltage between 1.8-5V.

    Requirement 3: The chip must not exceed an operating temperature of 85 degrees Celsius.

7. Memory

    The microcontroller has on-chip memory, but it is not sufficiently large

enough to hold logged data and the images of the arrows. For this reason, an additional parallel flash memory chip is necessary.
Requirement 1: All of the graphics used for the LED display are stored and ready to be accessed with at least 256kB left for logging purposes.
Requirement 2: The flash memory must operate at a voltage between 1.65-1.95V.

8. LED Display

    The LED Display will be an OLED display. It will be a monochrome one and will be used to display the direction of the arrow.
    Requirement 1: The display must operate around 3.3V.

9. Calibration Button

    We will have two different buttons. One working as a power on/off button while the other one acting as the calibration button. The calibration button is needed to store the current dimensions of the direction of the arrow.
    Requirement 1: Since these are buttons, the switches must work consistently without any glitch.

Risk Analysis:

Two of the biggest issues we are currently debating as a team to find the most efficient solution is; 1) being able to display our arrow in a very understandable and basic way, but at the same time, we need to make sure the arrow pointing towards the "rescue direction" must tilt accordingly to our position of the wrist, and 2) being able to correctly identify the slope of the surface the user is on and from that, calculating the direction of the normal force within a ±15 degrees error margin.

Since the main aim of our wristband is to display the shortest route out of an avalanche or a landslide, it must be easily understandable. In an emergency situation like that people should not waste time trying to understand which way the direction is showing. Another risk associated with display is to be able to adjust the direction with respect to the wrist's position. We took these risks into consideration while designing the display.

Since the slope of a mountain always changes in different locations we need to have a good estimate that would produce the slope of the current position with a predetermined error margin. We are aware of the non-homogenous slope distribution of the mountain and took this matter into consideration in our design.

3. **Ethics and Safety**

Ethical values were our driving force when we were brainstorming during the idea creation process. Our product aims to find the shortest path out of a snow or debris in the event of an avalanche, landslide or mining collapse which can create the small difference between surviving and dying. A product that's main aim is to help people survive from a natural disaster is highly ethical. We always prioritized the well-being of our users, which made us come up with this idea.

While the main idea behind our product is to accentuate the safety of the user, we also need to think about how reliable and consistent the product will be. A power outage, overheating or a wrong calculation on the microcontroller can have a huge impact. To avoid a situation like this we regulated our battery with a power supply with a voltage regulator connected to it. This will make our battery reliable, eliminating the possible power outage and overheating issues.

We are also aware of the fact that we always need to try to find the shortest path out of the debris/snow/water. So, in our calculations we always need to pinpoint the slope of our current location. We will bear this in mind while producing our software so that a "calculation error" won't be a safety hazard.

The last safety hazard would be the use of a lithium ion battery. There are some cases where a damaged lithium ion battery can cause a problem so having a solid, reliable cover for the battery will protect it from getting damaged in most of the instances. In addition, limiting its temperature up to a certain point to prevent any possible fire will also be a precaution we will take in our design.

4. References

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