Emergency Vitals Monitor

Team 11 - Brandon Noble, Songtao He, Zihong Zeng
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TA - Madison Hedlund

1. Introduction

1.1 Objective

Problem: Administering first aid in disaster situations is an extremely stressful task, that is prone to error if not done by a very well trained professional. Under circumstances with multiple injuries (gunshot, heat/fire related, earthquake, etc.), with limited bystanders available, treatment for these injuries are typically left for emergency response personnel. According to an article by H. K. Bakke et. al. that looked into the role of the bystander in trauma response, only 35% of those bystanders who assisted the injured had first aid training. Furthermore, it is estimated that 6-20% of trauma victims who die prior to making it to the hospital could have been saved if bystanders had acted to assist them.

Solution: A uniquely colored automated blood pressure cuff with extending rod for taking temperature, which doubles as the alignment for the pressure cuff's microphone. This simplifies the use as much as possible so that only a few people can attach them to as large a group as necessary in as little time needed. After activation, the blood pressure cuff will automatically take readings of blood pressure, heart rate, and temperature every thirty seconds. The blood pressure and heart rate can be used to determine an individual's 'shock index', which would set up a triage system automatically. This data is collated on a device for the user so as to see the ranking of each cuff in use in terms of who needs attention first, and gives first aid advice on how to treat the conditions detected. This improves the likelihood of an individual performing effective first aid, as well as ensuring that bystanders are able to perform first aid on those who need it most if first responders are limited.

1.2 Background

There is a similar product named QardioArm[1] that supports blood pressure monitoring for multiple users. This product requires to be paired with other mobile devices before displaying its measurements and it’s mostly used in daily life instead of in emergency situations that it lacks the ability to rank the priority of different patients. Our project ranks the severity of patients depending on MSI (modified shock index)[2] and improves first aid capabilities in untrained bystanders by providing methods to assist injured individuals.

1.3 Physical Design

Figure 1. Physical Design

1.4 High-Level Requirements

- Automatic blood pressure cuffs must operate every one to two minutes, sending vital readings to display device for triage ranking
- Display Device must be able to handle more than one cuff being used at a time
- Display Device doubles as a guide for first aid, with topics prioritized based off of the vital readings of the active blood pressure cuffs.

2. Design

2.1 Block Diagram

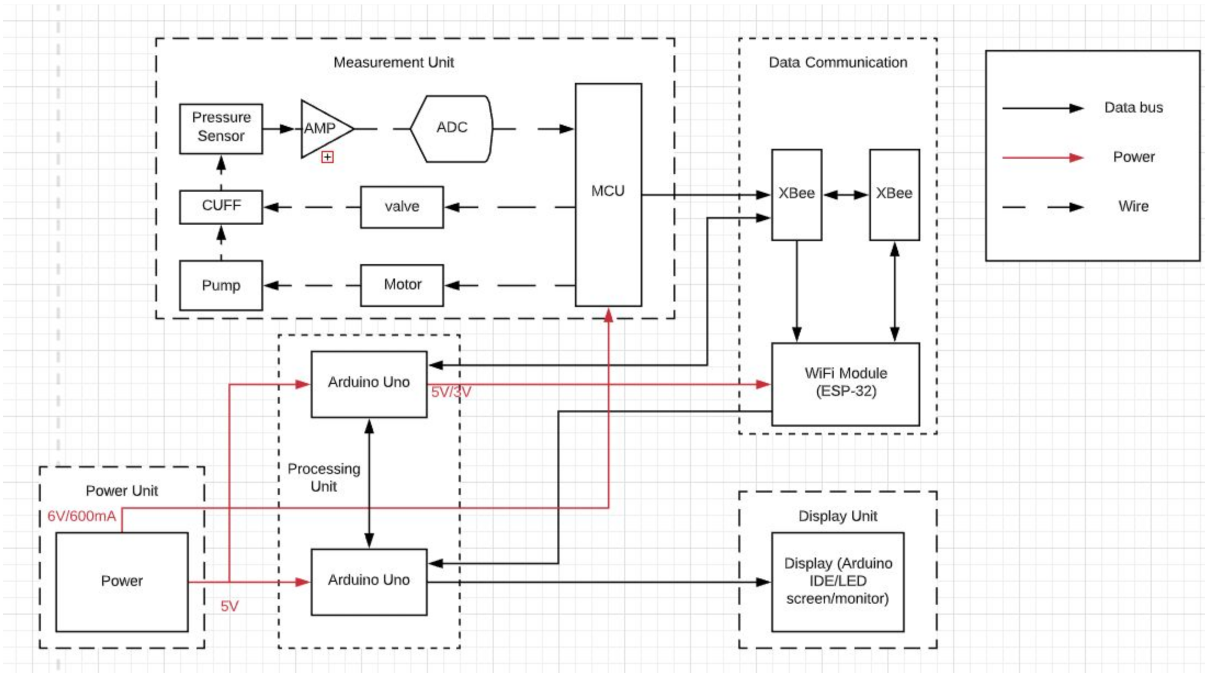

Figure 2. Block Diagram

2.2 Functional Overview and Block Requirements

2.2.1 Power Unit

Using the integrated power supply from our sphygmomanometer, we'll power our cuff and data communication device. Our display device and processing unit will either use a rechargeable lithium-ion battery, or a disposable battery pack.

Requirement: Power supply of 6V +/- 1V is able to power blood pressure cuff for at least 30 minutes.

2.2.2 Measurement Unit

A measurement unit reads the vitals of the individual it's attached to. It measures blood pressure, heart rate, and temperature, sending this data to the processing unit through the wifi module (ESP-32).

Blood Pressure Cuff

A sphygmomanometer, contains an air pump and pressure sensor to determine the Diastolic and Systolic blood pressures, as well as the heart rate through the impulses of pressure that come through.
Requirement1: The cuff must be able to read Diastolic blood pressures as low as 60 mmHg.
Requirement2: Cuff must be able to operate in at least a minimum of 32 degrees Fahrenheit weather.

MCU
Running the signal through an ADC, we then process our readings in order to calculate the MSI. This, along with our base readings, are then sent to the XBee in order to communicate with our display device.
Requirement1: Limit voltage to 6V +/- 1V
Requirement2: MCU can utilize a maximum of 9 bit input/output to connect to XBee.

2.2.3 Data Communication
For our initial prototype, we'll be using wifi modules to send and receive data from our cuff to the display device. The power supply is shared between the blood pressure cuff and the cuff's transmitter.

XBee*2
One XBee RF module receives data from cuff/measurement unit and the other transmits data. Both can communicate with ESP 32 WiFi module. The two XBee modules are set up to talk to each other.
Requirement1: Must be connected to a 5V/3.3V power supply.

ESP-32 WiFi Module
ESP-32 includes both WiFi and bluetooth functions. We will use WiFi for digital display function and bluetooth for devices without network connection.
Requirement1: Must be connected to a 5V/3.3V power supply.

2.2.4 Processing unit

Arduino Uno*2
Upload programs to WiFi/XBee Module and serve as a processing unit for data bus. Connected to a power supply with breadboard to enable WiFi/XBee logic mappings. One for receiving data and one for transmitting data.
Requirement1: Operation voltage is 5V and input voltage is recommended to be 7-12V.

2.2.5 Display Unit

Serial Monitor in Arduino IDE to read data collected from WiFi Module and display on a frontend webpage. LED Screen for display of graphical content. Displays ranking of 'triage priority', based off of calculated MSI.

Requirement1: LED Screen needs to be programmed to read digital data from ADC (analog-to-digital converter).

Requirement2: Device has a button and dial to swap display to first aid recommendations based off of vitals reading of currently selected blood pressure cuff.

2.3 Risk Analysis

Of our blocks, the piece that will pose the greatest problem will be the Data Communication block. Being able to handle a multitude of blood pressure cuffs requires either a set of unique receivers, or for means to 'mute' e ach cuff selectively so that only one cuff transmits data at a time, as one of our goals is to handle at least 6 cuffs, and ideally go past 6 into 16 or more simultaneous cuffs. Furthermore, if the wireless communication is unreliable, then data transferal may result in misconstrued readings, which could either manifest as extremely abnormal blood pressure, and thus inaccurately rank them in the triage list, or prevent it from communicating at all - preventing the individual from being considered in the triage list.

3. Ethics and Safety

Any and all electrical components/wires on the blood pressure cuff must be fully contained inside a box/shell, as the testing will not emulate the hectic nature of the wake of a disaster, and any free wires will pose a safety concern, even if insulated. While assembling the device, the maximum voltage provided will be 6V, and the power supply will only be connected during testing to limit the probability of burning out the batteries on our skin. Working on the electronics in pairs will allow for one individual to provide emergency response if something goes awry. Our testing and debugging techniques follow the IEEE code of ethics, "to avoid injuring others, their property, reputation, or employment by false or malicious action"[1]. Before using the blood pressure cuff, consulting a medical professional about the safety of an automated blood pressure cuff, as there have been reports of side-effects to their use. The delay between each reading will be done based off of this medical advice. By alternating which partner tests the blood pressure cuff on themselves, we'll further limit the chances of damaging our arm through repeated use.

4. References

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- Useful readings on measuring blood pressure (including non-invasive approach in development)
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  H.K Bakke, T. Steinvik, S.I. Eidissen, M. Gilbert, and T. Wisborg. “Bystander first aid in trauma - prevalence and quality: a prospective observational study.” in *Acta Anaesthesiol Scand.,* October 2015. Accessed: Feb. 13, 2020. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4744764/