ECE 445

Spring 2017

Project Proposal

Turning Tracker for Pressure Ulcers

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ABD Tuesday 8:00-10:50 AM

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1 Introduction

1.1) **Objective**

Pressure ulcers, or bedsores, are a huge problem for many overweight and elderly patients, predominantly in low-budget medical institutions. One of the main causes of bedsores is in the inaction of nursing assistants (CNAs) or other medical staff to flip their patients regularly - necessarily, once every two hours. The simple cause of this is bad organization. Our research shows that beyond all other factors, medical staff tend to become overwhelmed with their other duties, and simply forget to flip their patients[3].

The following proposal solves this problem. We propose a device that monitors each patient's two-hour timer using a pressure pad that will keep track of the patient's position on the bed. The pressure pad will send a signal to the nurse's phone, buzzer, or pager when it identifies a patient has been flipped, and this signal will begin the two-hour timer. The CNA or nurse will be notified by their communication device when a turn is necessary.

1.2) **Background**

According to the U.S. Department of Health & Human Services[1], pressure ulcers affect 2.5 million a year, costing $9.1-$11.6 billion a year in the U.S. There are more than 60,000 deaths and more than 17,000 lawsuits filed each year directly relating to pressure ulcers.

As of 2017, there are, not surprisingly, multiple attempted solutions to this problem.

One being the *alternating pressure air mattress* (APAM). According to a belguish study by the Department of Public Health at Ghent University, they found that "there was no significant difference in incidence of pressure ulcers (grade 2–4) between the experimental [group using APAM] (15.6%) and control group (15.3%) [group on a visco-elastic foam mattress (Tempur®), flipped every 4 hours]."[2] Because many nursing homes do not carry Tempurpedic mattresses and patients are flipped every *two* hours in the U.S.[3], this study lead us to believe APAM's simply do not solve the problem.

Another solution includes a *self-turning bed*. According to Christina Paul, an Occupational therapist of five years, self-turing beds are extremely rare to find in many nursing homes and clinics[3]. Our research has shown that they are simply too expensive for widespread use.

With all of this being said, there is just reason that many medical institutions rely solely on their staff to flip patients. The most steadfast, cheap, and simple solution to the bedsore pandemic is simply reminding the nurses and CNAs to flip their patients; medical staff react to 'beeping' and 'buzzing' on a much bigger scale than a mental note, or schedule[3].

1.3) **Requirements**

- The product *must* reliably **measure** if and when a patient is flipped
- The product *must* reliably **communicate** if and when a patient is not flipped within the two-hour window
- The product *must* be **safe** from all harm to users

2 Design

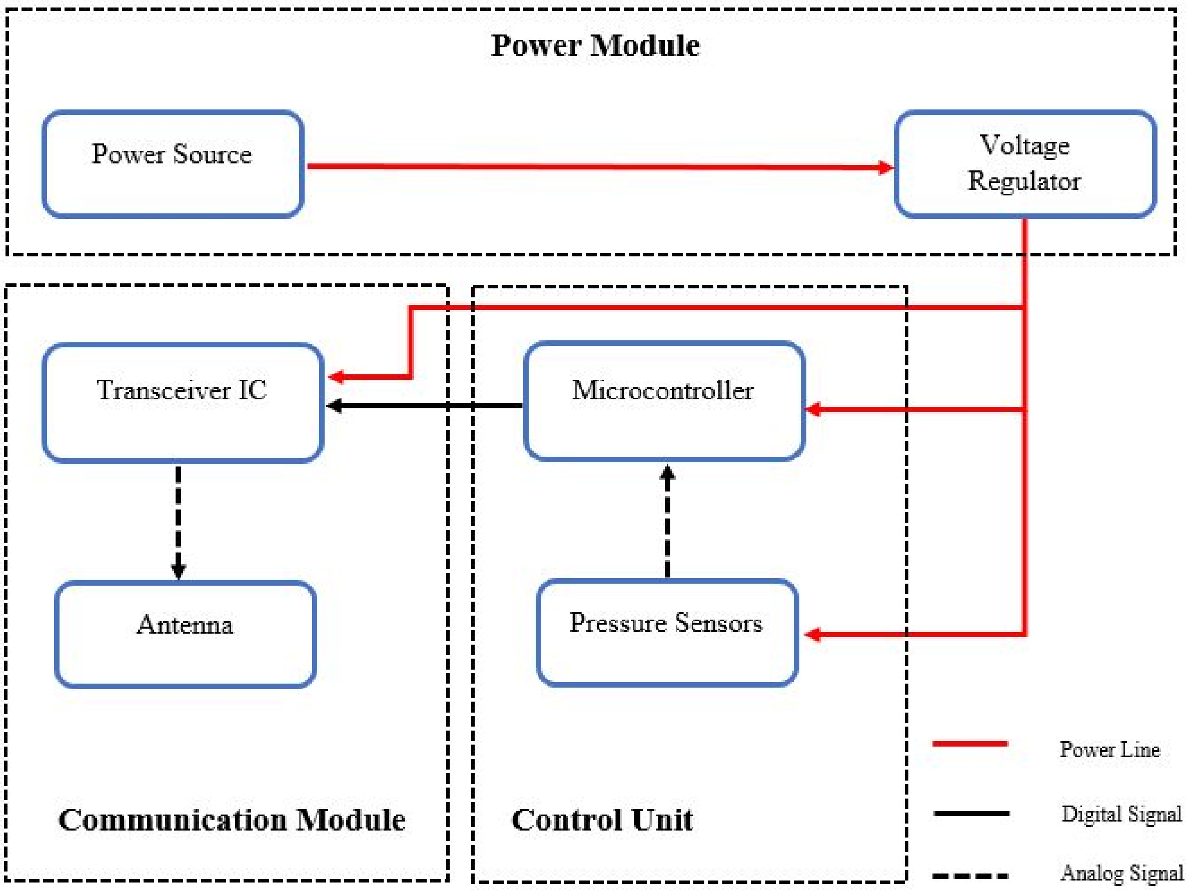

Figure 1. Block Diagram

2.1) **Power Module**

We are considering two different routes when it comes to our power module. Our first option is to use a standard 120V AC wall receptacle as our power source. This route requires us to create an AC to DC power converter as well as a DC to DC power converter to reduce the voltage. The other option is to look into different size batteries so we would only have to create a voltage regulator. Using a battery would be the safer route, but then nurses will have to constantly be changing or charging the battery. Using a wall outlet would provide a constant and reliable power source. Both of these options are currently being considered.

2.1.1) **Power Source**

As mentioned above, the source of power for our system will either come from a 120V AC wall outlet that can be found in any nursing home or hospital or from a battery that could supply enough power for our system.

Requirement for Outlet: Must provide a voltage output of 110-120V AC which is the standard supply in the United States.
Requirement for Battery: Must provide enough power to the system for a full 24 hours on a full charge.

2.1.2) **Voltage Regulator**

Our voltage regulator will be designed to maintain the constant voltage that is needed for all downstream modules.

Requirement: Must maintain a constant voltage with only minor fluctuations that will not affect the control unit and the communication module.

2.2) **Control Unit**

Our control unit will be in charge of deciding when a “patient has been flipped” signal is sent to the communication module, and eventually to a device used by the nurse. The control unit will consist of a microcontroller and multiple pressure sensors.

2.2.1) **Microcontroller**

The microcontroller will be responsible for the logic behind sending a “patient has been flipped” signal by deciding what change in the pressure sensors is necessary to be considered a flipping of the patient .

Requirement 1: Must accurately send a signal when a patient has been flipped.
Requirement 2: Cannot send a signal when a patient has not been flipped. (Family visits and sits on bed)

2.2.2) **Pressure Sensors**

An array of pressure sensors will be used to “map” the pressure distribution of the patient. We have decided to use pressure sensors rather than IR sensors because they can be flat which is important for the comfort of the patient.

Requirement 1: Must accurately sense the weight and location of the patient on the bed.
Requirement 2: Must be able to withstand the force of a 300lb person laying down and sitting in bed.
Requirement 3: Must be comfortable for the patient to lay on for consecutive days.

2.3) **Communication Module**

The communication module will receive the “patient has been flipped” signal from the microcontroller and will send that signal to a communication device used by the nurse. We are hoping to send this signal to the nurse’s cell phone so alarms will be able to be viewed from an app. The app will send a push notification to alert the nurse when a patient needs to be flipped again. It is possible that hospitals restrict nurses from using personal cell phones, so we also might be able to send the alarm to communication devices that they are already using.

2.3.1) **Antenna**

We want our circuitry to be as compact and out-of-the-way as possible. So we are currently exploring antennas that can be directly embedded onto the PCB, yet have the range to reach staff anywhere in the biggest hospital (or outside in case of lunch breaks, etc).

Requirement 1: Must be compact, posing no discomfort for user
Requirement 2: Must reach the communication device’s maximum range

2.3.2) **Transceiver IC**

The transceiver IC will convert the digital signal coming from the control unit and convert it to an analog signal for the antenna. The type of transceiver IC we choose depends on the restrictions that hospitals and nursing homes have for wireless communication, but either way this will be responsible for sending the wireless signal to the nurses.

Requirement: Must abide by restrictions set by nursing homes and hospitals regarding wireless communication.

2.3.3) **Phone Application (if applicable)**

If we find that telephone communication is to industry standard in nursing homes and/or hospitals, we would like a see a user-friendly phone application as the central hub of patient-device interaction. We envision an interface showing all room numbers next to the timers for each device. This would make it easier for nursing staff to visualize and plan their time.

Requirement: Must garner user's attention

2.4) **Physical Design**

Our design consists of flexible, nylon padding, an array of small pressure sensors, a Control Unit/ Communication Module embedded directly into the padding, and a Power Module/ cord on acting on the outside. We plan on positioning the pad underneath the patient's buddox area, where weight distribution is most fluid[5].

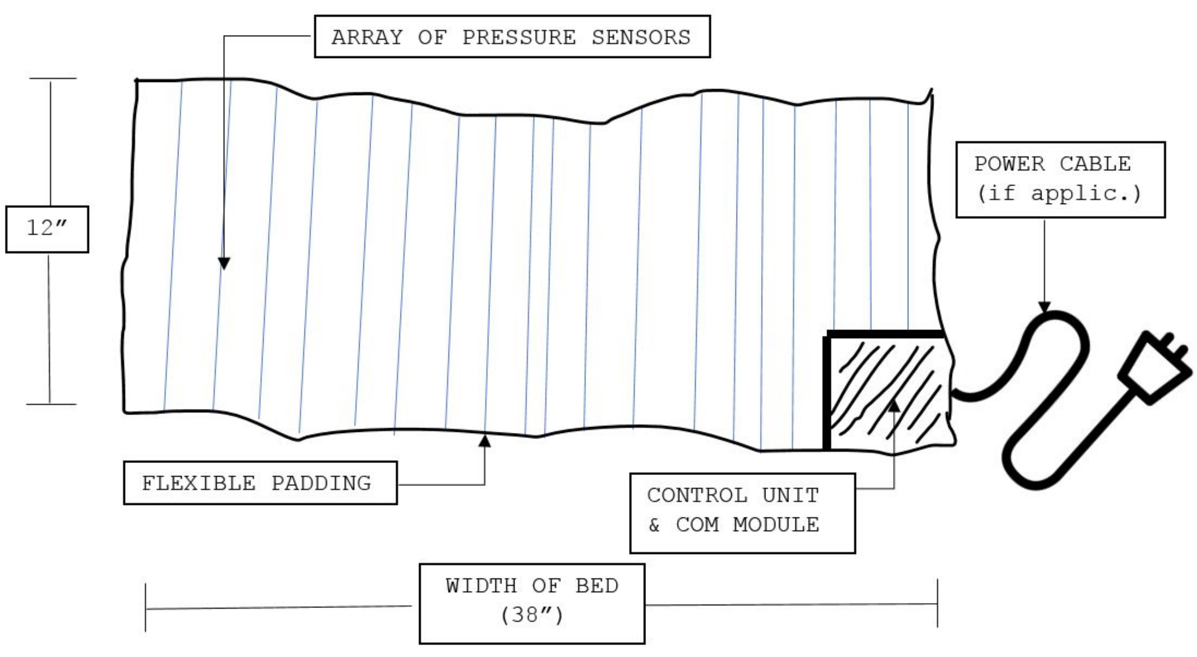

Figure 2. Cutaway schematic of our physical design

2.5) **Risk Analysis**

We are well aware that no one block cannot survive without the others; if the Power Module fails, there is no sensing, and so communication. If the Communication Module fails, there is no communication, lending the Power Module and Control Unit useless. If the Control Unit fails, there is no sensing, lending the Communication Module and Power Module useless.

We have found, though, that while all these modules are equally important in our success, the Control Unit is at the highest risk of failure.

In general, power problems are fairly rare, but can occur. They can usually spark from drainage of battery, or electric shock. If we decide to use a battery, we would have to invoke a “sleep mode” in order to keep the life span as long as possible. We would have to use a buzzer to alert that the battery is low. If we decide to use a standard power cord, we no longer have the maintenance problem, but now we have a higher safety risk. Patients who cannot turn over themselves will be using this product, and having 120V running straight to their behind is a tad daunting. In all, though, through considering implementation as such, we can deem the Power Module relatively *reliable*.

There can definitely be some problems brewing from Communication Module. For instance, a signal simply doesn’t send. This could be from network issues or geographic signal loss. To minimize this problem, we would try to send the signal repeatedly for ~10 minutes and if a signal is still not sent, we would have to use the buzzer explained above. We can think of the chance of failure here as the same as a text message being unable to send. Failure exists, but would be more uncommon and easier to catch than from the Control Unit.

Our research has found that there are colossal amounts of techniques and tricks to flip a patient. Some are rough. Some are gentle. Some are complex. Some are simple. With all of this being said, we understand that to measure the change in weight distribution in a foolproof manner will be quite the difficult task. We would have to find the perfect amount of sensors to accurately measure a flip without using too much power. Any series of problems can occur because the Control Unit depends on the human, which is an unpredictable, mistake-bound entity. For this reason, the Control Unit is the *riskiest* element.

3 Ethics and Safety

3.1) **Development Concerns**

As stated in section 1.3, two of our three main requirements call for our product to be *reliable*. If our product doesn't work, people will simply get hurt. As section 1.2 states, more than 17,000 lawsuits are filed each year regarding bedsores. We would never want to be in the middle of this. As an ex-employer of the bio-instrumental industry, our group is very aware of the rigorous testing procedure that is to come. We need to be within 98% confidence that our product *reliably* senses a flip <u>and</u> *reliably* communicates with the nurse. To not have such confidence would be in violation of IEEE 1st and 9th codes of ethics[6]. The prior obligates decisions to be made in the best health and safety of the public. The latter obligates an avoidance of the injuring of others. We will strive to make the most reliable, well-made device we possibly can, and will be honest with those in the unlikely case of failure.

3.2) **Operational Concerns**

Continuing on with IEEE 1st code of ethics[6], we would have to accurately and promptly inform the public of the reliability of our product, and the risk involved in using it (there is always a failure rate). We would let them use honest data (conforming with the 3rd code of ethics [6]) in their decision to adapt the device.

Because we are designing the sensors to work for those who are qualified at turning patients, we would want to make sure all staff that use this product are certified to flip patients correctly. If not, it is possible that a flip could be misregistered, leading to a fault in a flip cycle. This conforms with the 6th code of IEEE code of ethics[6]; we would have to issue a "disclosure of pertinent limitations[6]" to make sure those who use the device are certified healthcare providers.

We would never want to see our device as a way for medical staff to cheat their way out of work, or "fake a flip". With this in mind, we will make it harder to cheat a flip, then to perform a flip altogether. For this, we will not rely on any accelerometer in our design (to avoid cheating by shaking), and will make sure <u>continuous</u> pressure differential is the main sensing device used to measure a flip.

3.3) **Healthcare Standards and Federal Regulation**

Besides sensing and communicating, power is also a concern. We have to make sure we have a reliable source of power that would never die without warning, or pose any electrical risk to the patient (conforming with the 9th code of ethics[6]). This is why we may chose to use a rechargeable battery with an outside converter, which buzzes when low in power[7].

References

[1] VANDERWEE, KATRIEN, MARIA H.F. GRYPDONCK, and TOM DEFLOOR. *Effectiveness of an Alternating Pressure Air Mattress for the Prevention of Pressure Ulcers*. Nursing Science, Department of Public Health, Ghent University, UZ 2 Blok A, De Pintelaan 185, B 9000 Gent, Belgium, 11 Mar. 2005. Web. 06 Feb. 2017.

[2] Are we ready for this change?. Content last reviewed October 2014. Agency for Healthcare Research and Quality, Rockville, MD. http://www.ahrq.gov/professionals/systems/hospital/pressureulcertoolkit/putool1.html

[3] Paul, Christina H. "Pressure Sore Insights" Telephone interview. 31 Jan. 2017.

[4] Aria, Bobbie. "Problems in the Speech Therapy." Telephone interview. 10 Apr. 2016.

[5] Yassin, Aminah. "Problems in RES." Telephone interview. 11 Apr. 2016.

[6] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 29- Feb- 2016].

[7] United States of America. Office of Statewide Health Planning and Development Facilities. Development Division. *Electrical Requirements for Health Care Facilities*. By Techbriefs Media Group. N.p., 01 Jan. 2015. Web. 07 Feb. 2017.