SMART-Cast

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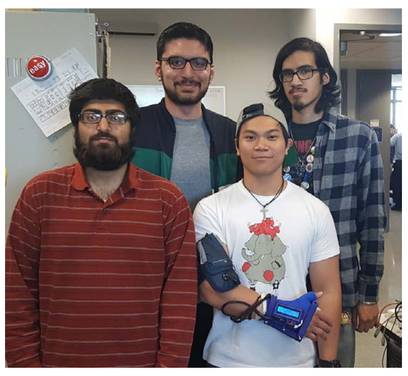
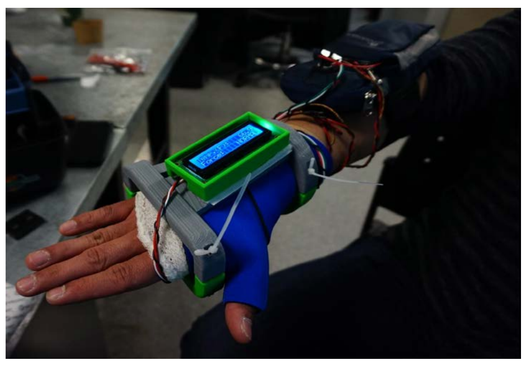


Abstract

Even though a wrist fracture is the most prevalent type of fracture [1], contemporary orthopedic casts do a poor job of keeping the patient aware of how the fracture is healing. The SMART-Cast is an orthopedic device designed to function as a cast for wrist fractures whilst monitoring the healing process. It accomplishes this monitoring by making use of force sensitive and thermocouple sensors to measure vitals that are heightened during inflammation. The FSR sensor will measure the amount of swelling for the affected area, and the thermocouple sensor will measure the temperature at the surface of the skin above the fracture. This device will inform the patient in any deviations of swelling and/or temperature during the healing process. It will help both the patient and orthopedist in being more informed of the progression of the fracture. The device is capable of recording the data to be further analyzed. We have developed a program through MATLAB to perform data analysis.

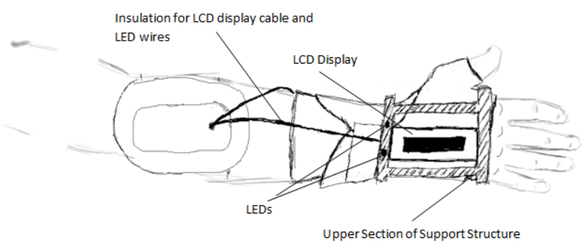


-**Figure 1**: First prototype of the SMART-Cast. This design was our proof of concept.

Customer Needs

- Competitively priced to other casts on the market
- Function as an orthopedic cast
- Incorporate sensors to measure inflammation
- Be able to record data
- Provide data analysis tools
- Does not cause any harm to user

Design Concept



-**Figure 2:** This drawing was our final design concept that agreed upon as a group. From thereon, the first prototype began to materialize, as shown below.

SMART-Cast Components:

- **Gauze Layer #1**: The first part of our design incorporated the Rexall gauze layer to house the ends of the Thermocouple and FSR sensors. These sensors are stitched into the first gauze layer.
- **Gauze Layer #2**: The second layer of gauze wraps around gauze layer #1 to provide extra protection and breathability.
- **Wrist and Thumb Wrap**: This component acted as a brace to insulate the gauze layers as well as provide some extra orthopedic stability around the affected area.
- **Ring and Bridge**: The 3D-printed ring and bridge design was created to ensure the device would function as a cast. It houses an LCD display for the user. The zip-tie locking mechanism ensures stability around the affected area.
- **Armband**: The armband houses the electronics, SD card, and battery involved with sensor measurement and data collection. It was retrofitted to incorporate an external switch.

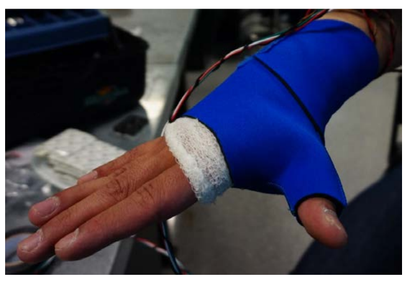


Figure 3: Wrist and Thumb Wrap [2]

Figure 4: Ring and Bridge

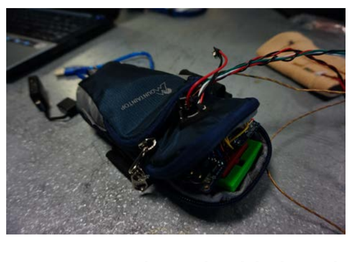


Figure 5: Armband with hardware

Figure 6: SMART-Cast 1.0

The figure above shows the final design of the SMART-Cast. Here are some of the improvements we made from our first prototype:

- LCD display compartment has been incorporated into ring and bridge design
- Wiring is more secure and covered in Texflex
- A switch was implemented for the LCD display unit if the user wants to conserve battery
- The ABS material was printed in high resolution, which provided more mechanical strength for the cast design
- Switch for the entire system has now been secured on the back of the armband

Test Plan

Customer Needs	Requirement	Test Comment
Optimal Rigidity	The ABS material used for the ring and bridge component shall have a Young's Modulus of 2-2.6 GPa and an Impact Strength of 70-370 J/m^2	3D-printed Bridge component does not bend or deform in any direction
Sensors (Force Sensor/Thermocouple)	The thermocouple shall be able to operate at temperatures between -20℃ and +500℃ and the FSR Sensor shall provide accurate readings from -30℃ up to +70℃. The amplifier for the thermocouple shall operate at a voltage of 3V and the FSR Sensor component shall operate at a voltage of 5V.	The Arduino Uno is running off a 9V battery of which powers the sensors, LCD unit, and memory module while following the software script. Thermocouple Test is shown below in figure 7. All components functioning within parameters.
Interface (Built-in display) & Software	The software shall run as one "master code" that can be run on the Arduino unit without being plugged into a computer via USB or other means. User will see data through an LCD display.	The software compiles and successfully runs on the Arduino unit. The LCD unit displays the thermocouple & force sensor reading on two separate lines.
Lightweight	Approximately weighs 2.5 ± 0.15 lbs.	The SMART-Cast resulting weight falls within parameters.
Memory capability	The information on the SD Card shall be readable and interpretable when the SD Card is inserted in a PC using the program Notepad or any other program that can open .txt files.	The reading from the sensors are recorded along with a corresponding timestamp. Data analysis was conducted successfully. Example data graph is shown below in figure 8.

Figure 7: Thermocouple Test

Figure 8: Example Format of Data Graphs

Acknowledgement

We'd like to thank John Hoinowski for printing all of the 3-D components and assisting us in making design decisions. We also thank Dr. Roman for sponsoring our original idea as our capstone advisor.

References

[1] http://www.schwebel.com/userfiles/files/Fractures%281024%29.pdf
[2] "Comfortprene Wrist and Thumb Wrap." *Rehabmart.com*. North Coast, n.d. Web. 29 Apr. 2017.