2015

Non-Invasive Blood Glucose Monitoring System

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Sponsor: VCU School of Engineering Foundation Sternheimer Award

BIOMEDICAL

Non-Invasive Blood Glucose Monitoring System

CAPSTONE DESIGN EXPO 2015

The Problem

- 2013- 382 million worldwide have diabetes → expected to increase by 55% to 592 million by 2035
- 26 million Americans have diabetes → 3 million are type 1 diabetics
- Hypoglycemia is a drop in the blood glucose
- As time progresses, the diabetic cannot feel this drop and is diagnosed with hypoglycemic unawareness
- Hypoglycemic unawareness is a threat to diabetics, side effects of hypoglycemia include: organ damage, convulsions, coma, and especially dangerous while sleeping
- Symptoms & Biological markers of hypoglycemia include: sweating, increased heart rate, cognitive dysfunction, dizziness, and other emotional marker (i.e. anger, tired, irritability, etc.)
- Current solutions fall short:
  - Blood glucose meters and continuous glucose monitors are invasive, cause patient discomfort, and require the patient to self-awaken
  - Current non-invasive glucose detection systems are inaccurate
- How can we solve this problem?

The Solution

- To design a non-invasive solution to nocturnal hypoglycemia, capable of detecting hypoglycemia in type 1 diabetics during sleep that will alert them to wake up.
- Measurements taken to detect this include:
  - Heart Rate
  - Skin Conductance
  - Couple these two measurements together to have a higher accuracy and sensitivity of detecting hypoglycemia during sleep
- Design basics include:
  - Diabetic wears a compressive t-shirt that houses a microcontroller
  - Attached to the microcontroller are:
    - ECG leads (for heart rate detection)
    - Skin conductance sensors (for detecting sweat)
- Implications:
  - Parental and patient peace of mind → better sleeping patterns
  - Decreased risk for hypoglycemic attack → prevents future problems from hypoglycemia
- Other Considerations include:
  - Wearability during sleep → Human Factors
  - Effectiveness
  - Potential Market

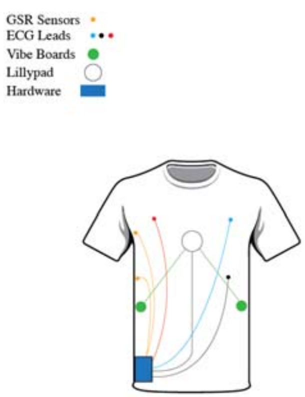

Figure 1. T-shirt sensor layout and design

The Design

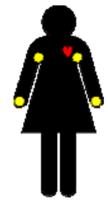

Figure 2. Areas of highest sweat gland concentrations highlighted in yellow in comparison to heart

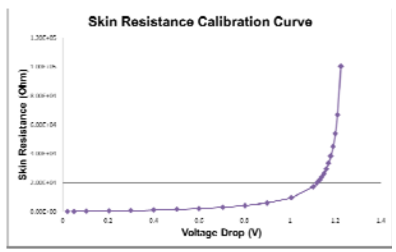

Figure 3. Skin resistance sensor calibration curve

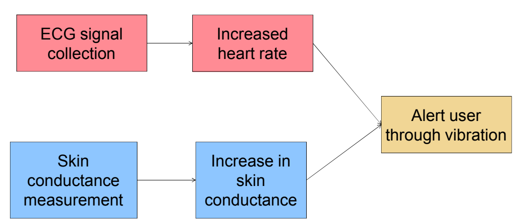

Figure 4. Signal collection, analysis, and user alert flowchart

Figure 6. Finalized prototype on mannequin

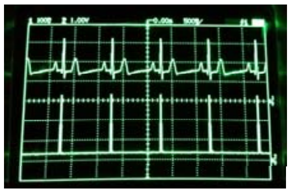

Figure 6. Peak detection circuit at 60 bpm

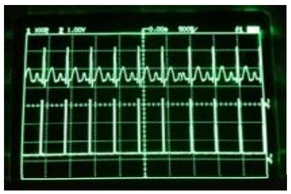

Figure 7. Peak detection circuit at 120 bpm

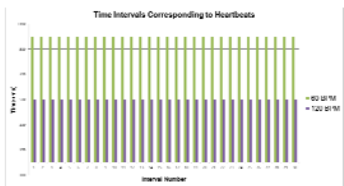

Figure 8. R-R intervals at 60 bpm and 120 bpm

The Future

- Improve upon the design by consolidating hardware components and increase ergonomics for user.
- Empirical testing to determine the accuracy of the system across multiple people of different body types, ages, and severity of diabetes.
- Develop smaller size to accommodate children.
- Develop an app to accompany the shirt to track hypoglycemic episodes over time

Acknowledgements

This project was funded by the Virginia Commonwealth University Biomedical Engineering Department and the Virginia Commonwealth University School of Engineering Foundation Sternheimer Funding. We would like to thank Dr. Paul Wetzel for mentoring us on this project, as well as Dr. Thea Pepperl for her support throughout the year. Other support came from Mr. George Weistroffer, Mr. Tyler Ferro and Mr. David Parker, graduate students in the VCU BME Department.