Pilot Biometrics

ECG Waveform Captures

Team sdmay18-12
https://sdmay18-12.sd.ece.iastate.edu/

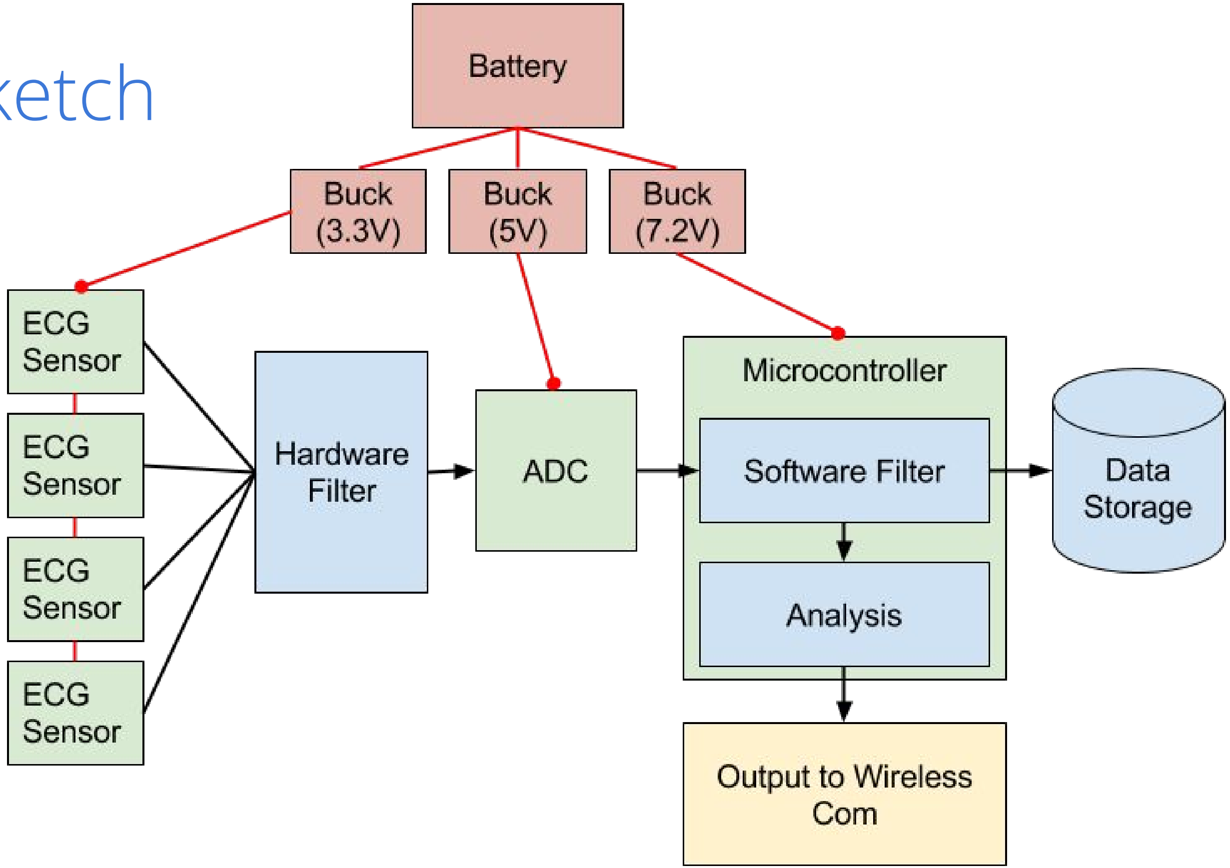
Ryan Gallus (CprE)
Zach Glanz (CprE)
Justin Bader (CprE)
Andrew Jones (SE)
Kory Gray (CprE)
David Kirpes (EE)

Client: Rockwell Collins
Adviser: Akhilesh Tyagi

Problem Statement

- Develop a device that will capture, monitor, and analyze the ECG waveform of a military pilot in flight, to be used during training operations.
- Use four high-fidelity ECG sensors to collect an accurate waveform, then filter out background noise and interference.
- Analyze the waveform data to detect if the pilot is in distress
- Store an encrypted copy of the data and package a copy for real-time transmission to the ground through a component in the cockpit.

Conceptual Sketch



Functional Requirements

- Accurately detect a pilot in distress
  - Capture ECG waveform of pilot in operation
  - Accurately identify distress based on waveform
- 4-5 hours of continuous operation
  - Consistent and reliable power supply
- Notify ground station
  - Communicate danger to pilot without increasing distress
  - Communicate with ground teams
- Store 4-5 hours of operational data
- Operate in real time on an ARM microcontroller

Non-functional Requirements

- Don’t interfere with pilot’s primary tasks
  - Flight operations
  - Emergency ejection
- Don’t interfere with pilot’s safety harness
- Don’t interfere with pilot’s normal communications

Technical/Other Constraints/Considerations

- Filter accuracy and real-time performance - is a software filter too slow?
- How is our system going to be powered?
- Where are we going to store all of our data?
- How do we go about testing our design and simulating flying an aircraft?

Market Survey

Our product is designed to be used in U.S. Navy fighter pilot training programs for monitoring pilot health.

Our product will be unique in its use of ECG sensors in a highly turbulent environment. Any other market potential it has would likely be in monitoring the health of people in such a turbulent environment.

Potential Risks & Mitigation

- Device dying mid flight
    - Connect device to plane electrical system
    - Calculate pull of device and get battery size needed
- Getting inaccurate ECG reading
    - Multileveled software filter for background noise and muscle movement
    - Extensive testing
- Pilot information insecure
    - Encrypt data
- Harness Interfering with piloting
    - Cockpit design
    - Common pilot movements

Resource/Cost Estimate

- Hardware
  - ARM M7 Microcontroller
  - Analog to Digital Converter
  - ECG Sensors
  - Electrical misc.
- Software
  - Micro C Linux

Project Milestones & Schedule

Semester 1

<table>
<tr><th>week 5</th><th>week 6</th><th>week 7</th><th>week 8</th><th>week 9</th><th>week 10</th><th>week 11</th><th>week 12</th><th>week 13</th><th>week 14</th></tr>
<tr><td>Create Website</td><td></td><td colspan="3">Interface ADC with microcontroller</td><td></td><td colspan="4">Develop Alorithm to interpret ECG</td></tr>
<tr><td colspan="2">Project Plan</td><td></td><td colspan="4">Install OS on board</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Test ADC</td><td></td><td></td><td colspan="3">Develop device drivers</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Develop power distribution system</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Test ECG Sensor</td><td></td><td></td><td></td></tr>
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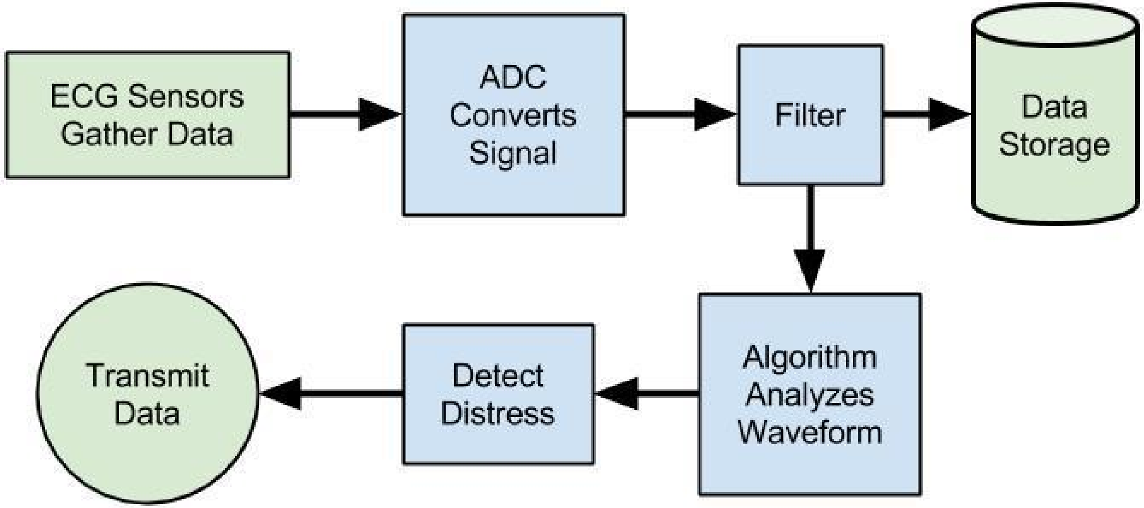
Project Milestones & Schedule

Semester 2

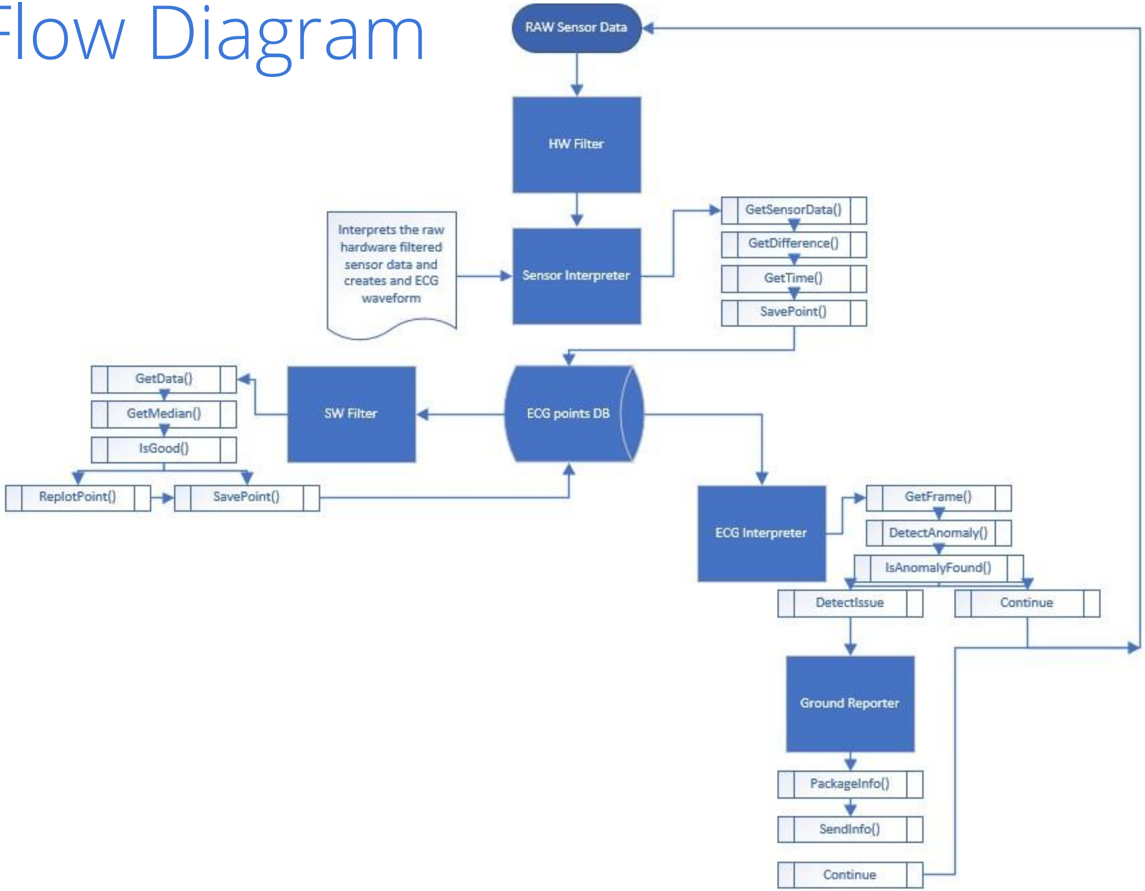
week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	week 13	week 14
Design Harness				Manufacture Harness				Work on Presentation				Present Design	
Design PCB						Test and Refine Harness							
Test and Modify ECG Algorithm													

Functional Decomposition



Detailed Design - Flow Diagram

- 4 major processes
  - Asynchronous
- 1 DB
- Two Filters
  - 1 HW
  - 1 SW

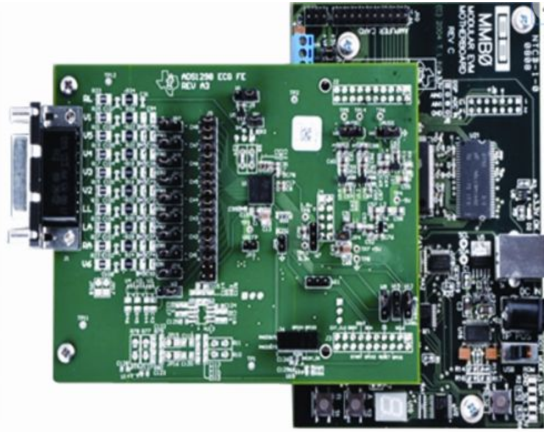


Detailed Design 2 - Database Tables

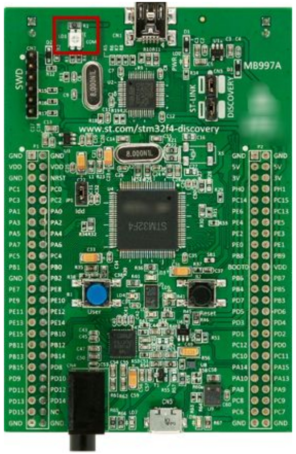
- 3 Tables
  - 1 Unfiltered Data points
  - 1 Filtered Data points
  - 1 Detected Anomalies
- UnfilteredPlot
  - Contains 4 Sensors plots
- FilteredPlot
  - Contains data after SW filter and interpreted data.
- DetectionTable
  - Contains any anomalies detected for investigation later.
  - Contains Start and End times of the anomaly in reference to FilteredPlot table

HW Platforms

- ADS1298
  - 8-Channel, 24 bit ADC
  - 32,000 Samples per Second
- STM34F746G discovery
  - ARM M7 Microcontroller
- Kendall 530 Series Electrode



ADS1298



STM34

Electrode

Platforms

- Micro-c Linux
  - Installed on Microcontroller
- SQL
  - Installed on micro-SD card that is attached to microcontroller
- C/C++
  - Used to enable class usage
  - Easy process creation
  - Easy concurrent program running

Test Plan 1

- First Stage of Testing
  - Check interfacing between all components
  - Software Filters
  - Input from Sensors
  - Response time for Results
  - Accuracy of Results
- Testing
  - Testing on all components must be done periodically
  - To ensure that the product as a whole is still functional
  - Goal is to have quick standard tests in order to verify each component after changes

Test Plan 2

- Final Stage of Testing
  - Will have opportunity to test product in real life scenario
  - Operator Performance Laboratory (OPL)
  - Gain feedback about comfortability
  - Test impact of a High vibration environment
- Goal
  - With this test, we can understand how well our product can perform
  - We may also see opportunities to fix or improve upon the product

Prototype Implementations 1

- ECG sensor prototype
  - All components together
  - Should be able to use sensors to get raw data
  - Process that raw data
  - Test accuracy of that data
- Breadboard
  - Will first use breadboard to test hardware filter
  - Allow use to test the hardware filter
  - Once we are confident with prototype a PCB board can be designed

Prototype Implementations 2

- Prototype for incorporation in harness
  - Must fit comfortably
  - Must hold sensors and product
  - Must be safe and not in the way of pilot
  - Prototype for harness will be made next semester
- Prototype testing will provide much feedback
  - Will be able to use the prototype on a real subject (one of the team members)
  - Will be able to try to induce mild stress and use prototype to detect it
  - Will be able to see product as whole
  - Improve or fix any areas

Current Project Status

- Individually tested hardware components
  - ADC
  - Microcontroller
- Research and assessed previous literature
  - Working with ECG waveforms
  - Storage requirements
  - Medical standards
- Development started
  - Algorithm
  - Software filter

Task Responsibility/Contributions

- Ryan Gallus (CprE) – *Team Lead*
- Zach Glanz (CprE) – *Driver Design Lead*
- Justin Bader (CprE) – *Filter Design Lead*
- Andrew Jones (SE) – *Algorithm Design Lead*
- Kory Gray (CprE) – *Operating Systems Lead*
- David Kirpes (EE) – *Circuit Design Lead*

Plan for Next Semester

- Finish Development
  - Implement ECG sensors into ADC and board
  - Finish writing main algorithm and software filter
- Component Testing
  - Evaluate ECG sensors
  - Evaluate filter
  - Evaluate main algorithm
- Prototype Testing
  - Induced stress test
  - Operator Performance Lab