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Pilot Biometrics - ECG Waveform Captures

Ryan Gallus, Andrew Jones, Justin Bader, David Kirpes, Zach Glanz, Kory Gray

Advisor: Professor Tyagi

Client: Rockwell Collins

Introduction

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.

Solution

- Three high-fidelity sensors collect ECG waveform
- Filter out background noise and interference
- Analyze waveform data to detect if the pilot is in distress
- Store encrypted data and package a copy for real-time transmission via component in cockpit

Relevant Standards

- IEEE 11073-10441 (Cardiovascular Fitness Devices)
- IEEE 11073-10102 (Annotated ECG)

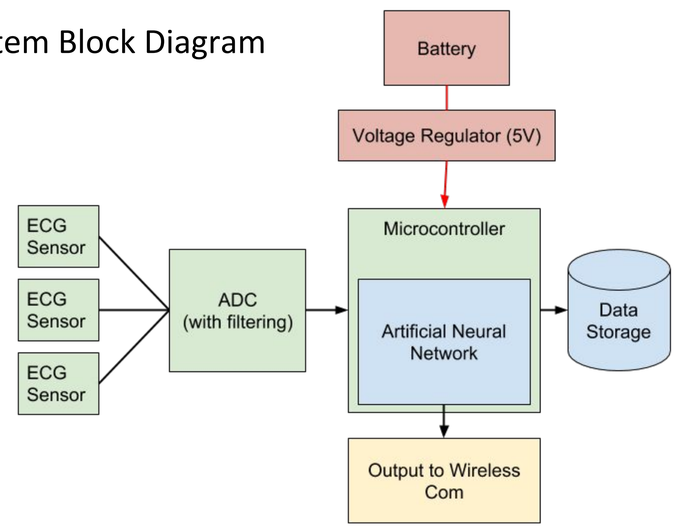
ECG Waveform Output

Design Approach

Functional Modules

- Power Supply
- ECG Sensors
- Analog to Digital Converter
- Hardware Filtering
  - Notch
  - Bandpass
- Software Filtering
- Detection Algorithm
- Data Storage
- Data Transmission

System Block Diagram

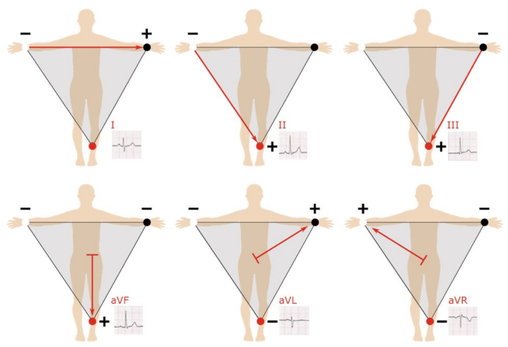


Testing

Strategy

- Gather control data
  - Baseline ECG readings
  - Test different conditions
- Simulate cognitive load on ground
  - Spatial navigation task
  - Increasingly difficult other tasks
- Operator Performance Lab

ECG Sensor Voltage Readings



Design Requirements

Functional

- 4-5 hours of continuous operation
- Store 4-5 hours of operational data
- Communication with ground station
- Operate in real time on an ARM microcontroller

Non-Functional

- No interference with pilot's primary tasks
- No interference with pilot's safety harness
- No interference with normal communication

Operating Environment

- Pilot's cockpit of a jet
- High amounts of vibrations and shaking
- Reasonable range of temperatures

Intended Users

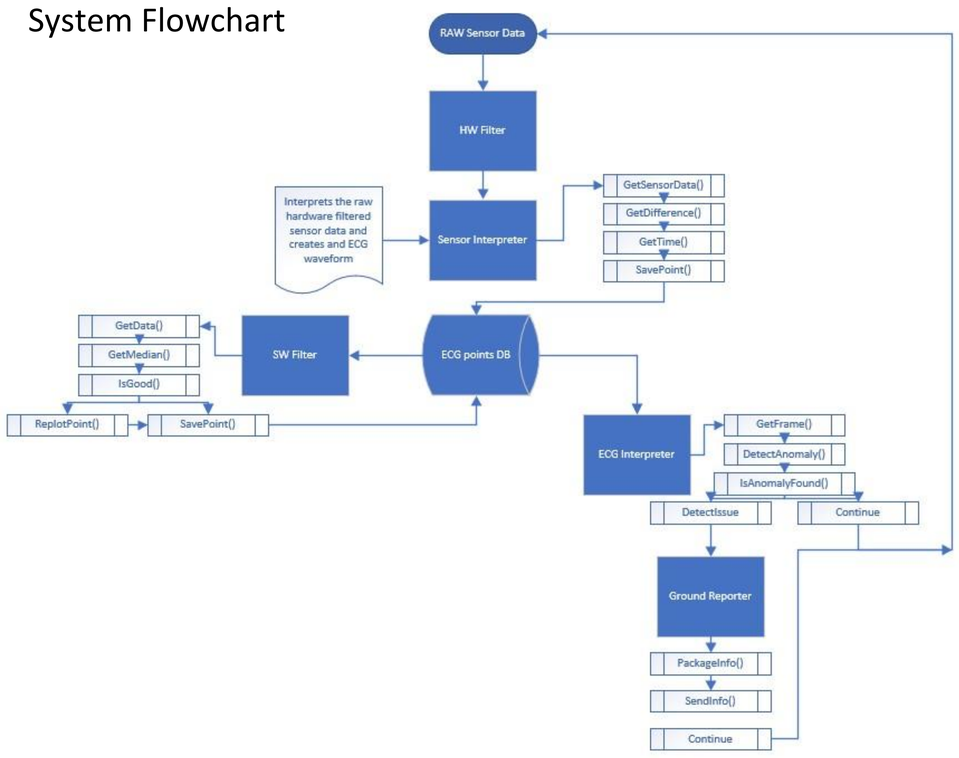
- US Navy Pilots
- Monitor health during training missions

Engineering Constraints

- Multiple hardware components need power
- Securely store large amounts of data
- Difficult operational environment to simulate
- Specific development environment required

System Functions

System Flowchart



Technical Details

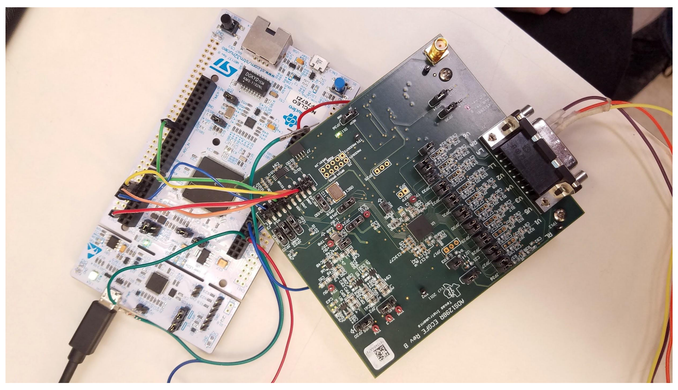
Hardware

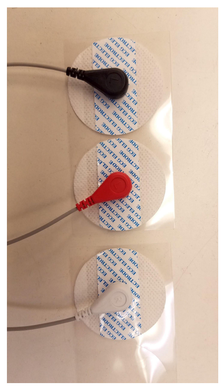
- STM32F767 Microcontroller
- ADS1298RECGFE-PDK analog digital converter
- ECG sensor ADS129R

Microcontroller

- microC linux
- C

Microcontroller, ADC, and ECG Sensors





Software Modules

Artificial Neural Network

- Supervised machine learning algorithm
- Given a labeled training set of data, learns whether an individual is stressed or not
- Uses Heart Rate Variability as metric for detecting cognitive stress
- Can tweek itself over time as an individual changes to improve accuracy and work effectively in a variety of conditions