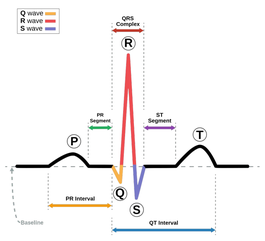
EECS 452 - Winter 2024
Digital Signal Processing

EECS ELECTRICAL ENGINEERING AND COMPUTER SCIENCE UNIVERSITY OF MICHIGAN



Mobile ECG Measurement

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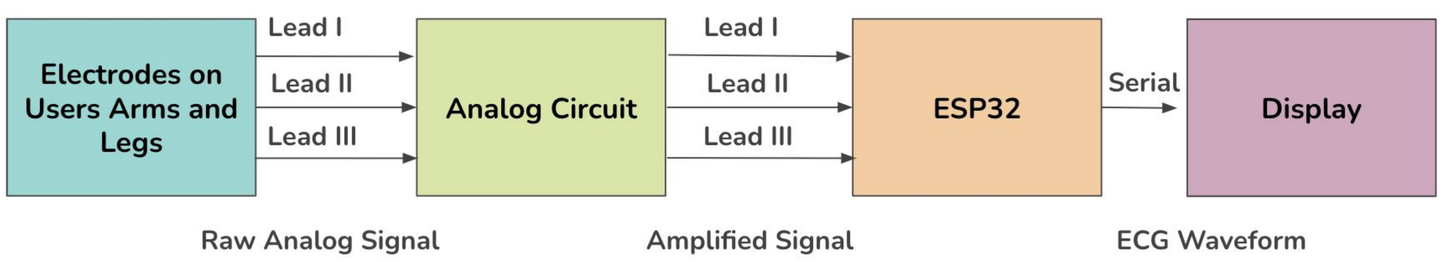
Introduction: Collecting Heart Rate Signal From Electrodes

- **Electrocardiogram (ECG) is a recording of electrical activity from the heart**
- **Three sets of electrode leads capture ECG signals**
- **ECG signals require processing to extract useful information from them**

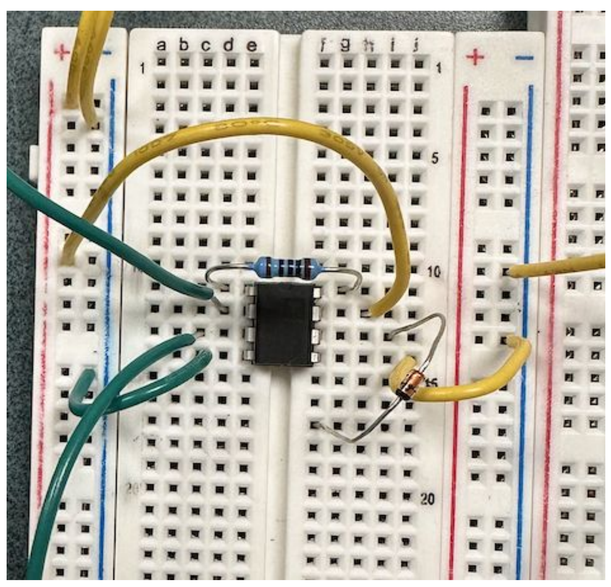
Signal Processing Techniques: Removing Noise From ECG Signal

- **Remove Baseline Wander:**
  - 0.5-150 Hz Bandpass Filter
- **Software Filter:**
  - 60 Hz Notch Filter
- **Peak Detection:**
  - Pan-Tompkins Algorithm
- **Real-time Plotting:**
  - Serial Communication -> Python Script



Implementation: 3-Lead ECG with Analog Circuit and ESP-32

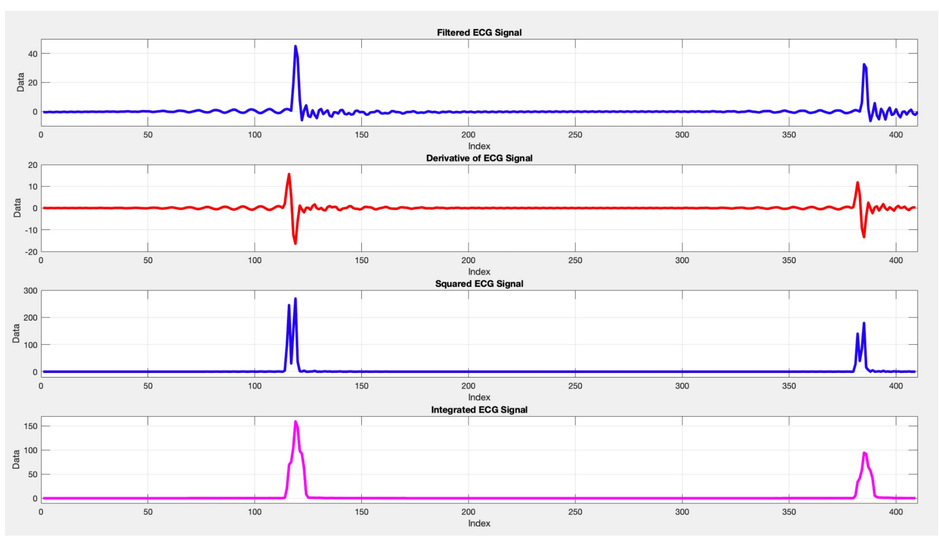
Hardware



Differential amplifier

- **3-Sets of Electrode Leads**
  - Three sets of information
  - Results in positive R-peaks
- **Differential Amplifier**
  - Improves SNR
- **Target Gain - ~500**
  - ECG signal typically 0.5-5mV

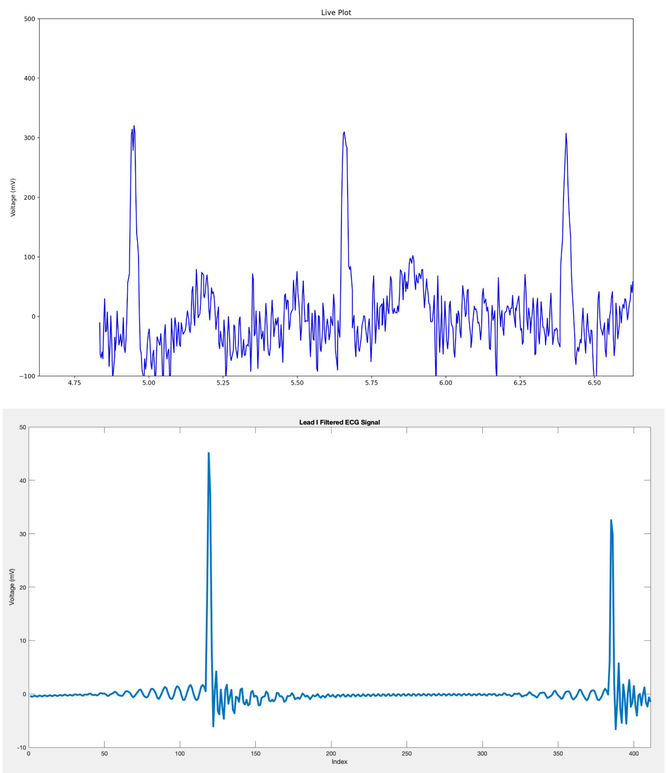
Software



Output of Pan-Tompkins across its stages

- **ESP-32**
  - 300 Hz sample rate
- **Notch Filter**
  - 201 tap FIR filter
- **Bandpass Filter**
  - 0.5-150 Hz passband
- **Pan-Tompkins Algorithm**
  - Differentiation
  - Squaring
  - Moving Window Integration
  - Peak Estimation

Results



Outputs from device

- **Validation of Results**
  - Non-wandering y-axis
  - Clear QRS-complex
  - Obviously Periodic
- **Heart Rate Calculation**
  - Pan-Tompkins output

Acknowledgements: Special thanks to Dr. Shai Revzen and Audrey Cooke