MOBILEDOCTOR

Smartphone
Bioelectric
Body Monitor

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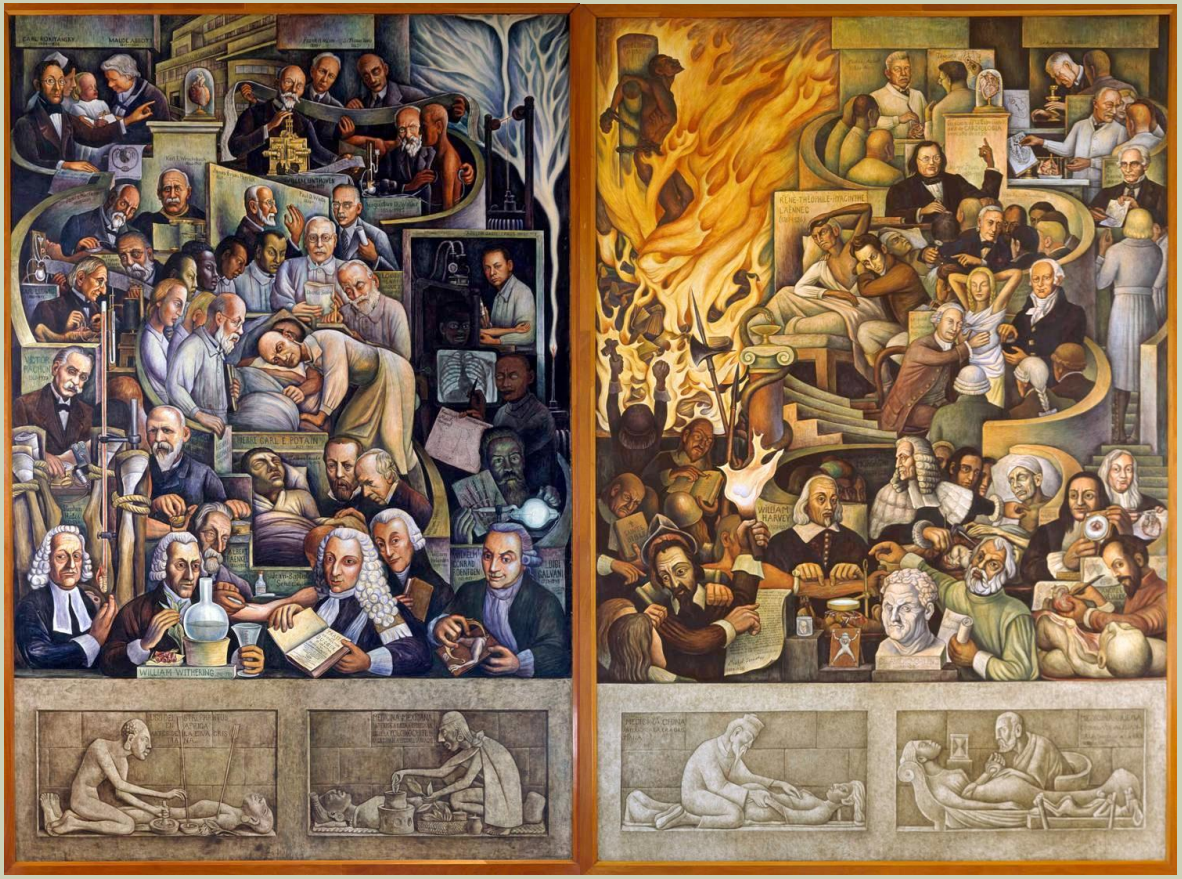
SUMMARY

- Need/requirements
- Design overview
- Analytic Efforts
  - Run time calculations
  - CPU requirements
- Chosen Design
  - Software
  - Algorithms
  - Hardware
- Demo



A History of Cardiology, by Diego Rivera

NEED/REQUIREMENTS

- Who would use MobileDoctor?
  - Demographic shift towards an older population
  - Number of doctors not keeping pace, particularly in rural areas, where there are lot of elderly people
- What does MobileDoctor comprise?
  - Hardware
  - Software – focus of our project

SOFTWARE REQUIREMENTS

- Collect data from patient
- Analyze the data
  - **Algorithms**
- **The focus of this project was the design and implementation of ECG algorithms in a mobile environment**

CHOSEN DESIGN OVERVIEW

- ECG data collection/analysis
- Android smartphone platform
- Wireless data transmission
  - Bluetooth protocol
- Algorithmic analysis

DESIGN ANALYSIS

- Runtime CPU calculations
  - Is it feasible on a smartphone?
- Hardware requirements
- Cost of coding
- Flow diagrams

RUNTIME CPU CALCULATIONS

- Difficult to analytically determine the expected runtime

Disease Present	Runtime (seconds)
No disease	3.5
Ventricular Tachycardia	6.5
Ventricular Bradycardia	5.8
Atrial Fibrillation	4.0

- 60 seconds of data used
- Little effect on regular smartphone usage, particularly when multiple cores are available

CPU REQUIREMENTS

- Testing was done on 2 year old smartphone (Motorola Droid)
  - TI OMAP 3430 processor
  - 550 MHz
- All recent smartphones would have no trouble running the software

COST OF CODING

- Since it runs on Android, MobileDoctor is written in Java
  - $40-$60/hour is the going rate for Java developers

$$20 \text{ hours} * \frac{\$50}{\text{hour}} = \$1000$$

- After release, further expenses will be accrued
  - Maintenance
  - Support
- As these expenses will scale with the number of users, they are not a significant concern

DESIGN DETAILS

- Software Package
- Example Algorithm
- Hardware Requirements
- Flow Diagram

SOFTWARE PACKAGE

- Android files
  - Functionality: Java
  - Layout: XML
- Developed in Eclipse IDE
- Generated .apk file can be installed on any Android device
  - Can also be made available on Android Market or Amazon App Store

EXAMPLE ALGORITHM: VENTRICULAR TACHYCARDIA

- Most common symptom: abnormally high resting heart rate
  - 100+ beats per minute
- Algorithm summary:
  1. Identify location of heartbeats
  2. Use R-R interval to calculate heart rate
  3. Compare to acceptable maximum of 100 beats per minute

IDENTIFYING HEART BEATS FROM ECG

- Look for consistent, repeating artifact
  - QRS complex
- Properties of a QRS complex
  - Very large and unique peak
- Peak finding
  - ECG signal is above a certain value
    - 0.4 mV in this case
  - ECG signal decreases on both sides of the peak
    - Makes sure only one point is selected for each peak

HARDWARE REQUIREMENTS

- CPU already covered
- Storage space

$$0.98\ \frac{MB}{min} * 60\ \frac{min}{hour} = 58.8\ \frac{MB}{hour}$$

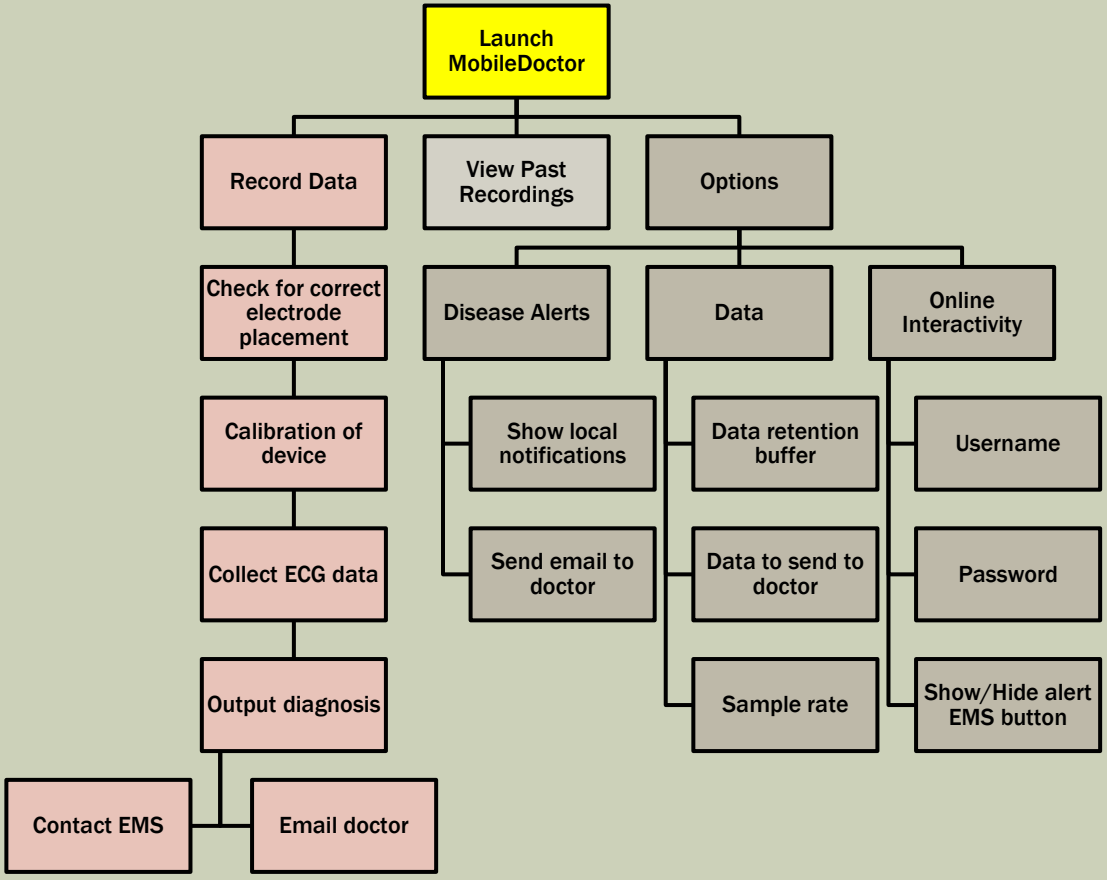
$$58.8\ \frac{MB\ per\ hour}{channel} * 9\ channels = 529.2\ MB\ per\ hour$$

  - Only the last hour of data will be saved, if nothing is wrong
  - Reasonable on modern smartphones

HARDWARE REQUIREMENTS

- Bluetooth support
  - Supported by all Android smartphones
- Cellular internet access
  - Also universally supported

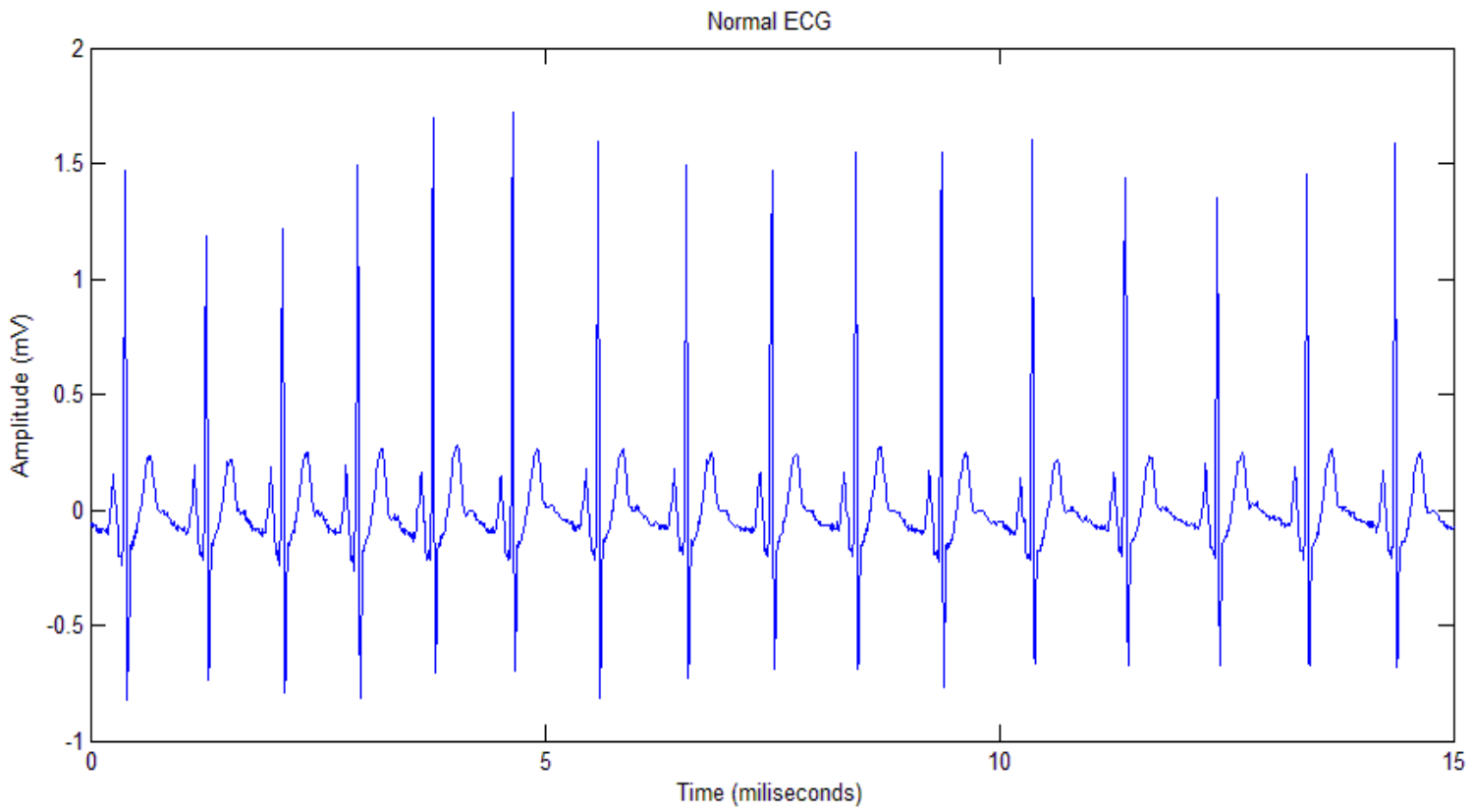
FLOW DIAGRAM



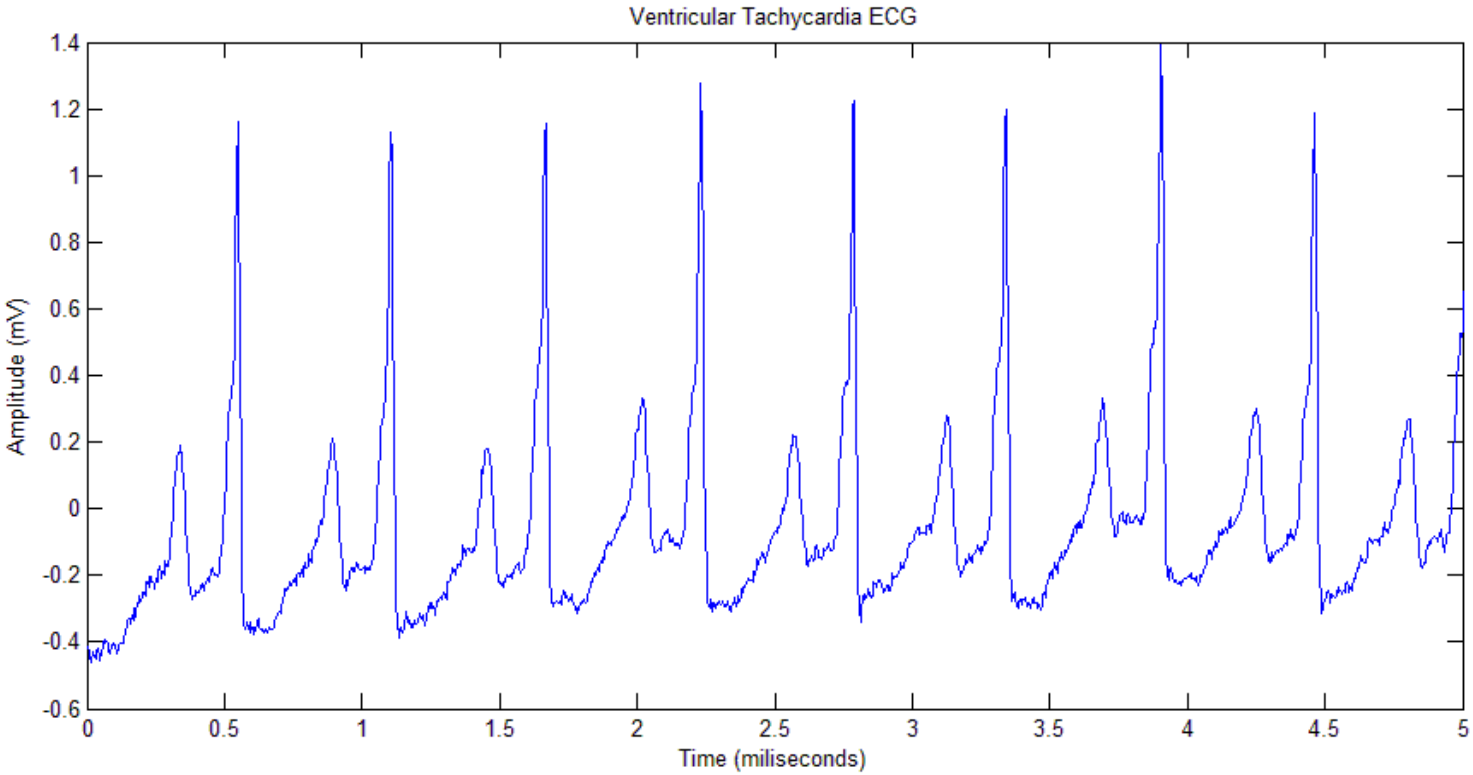
DEMO

Live demonstration using the Android emulator

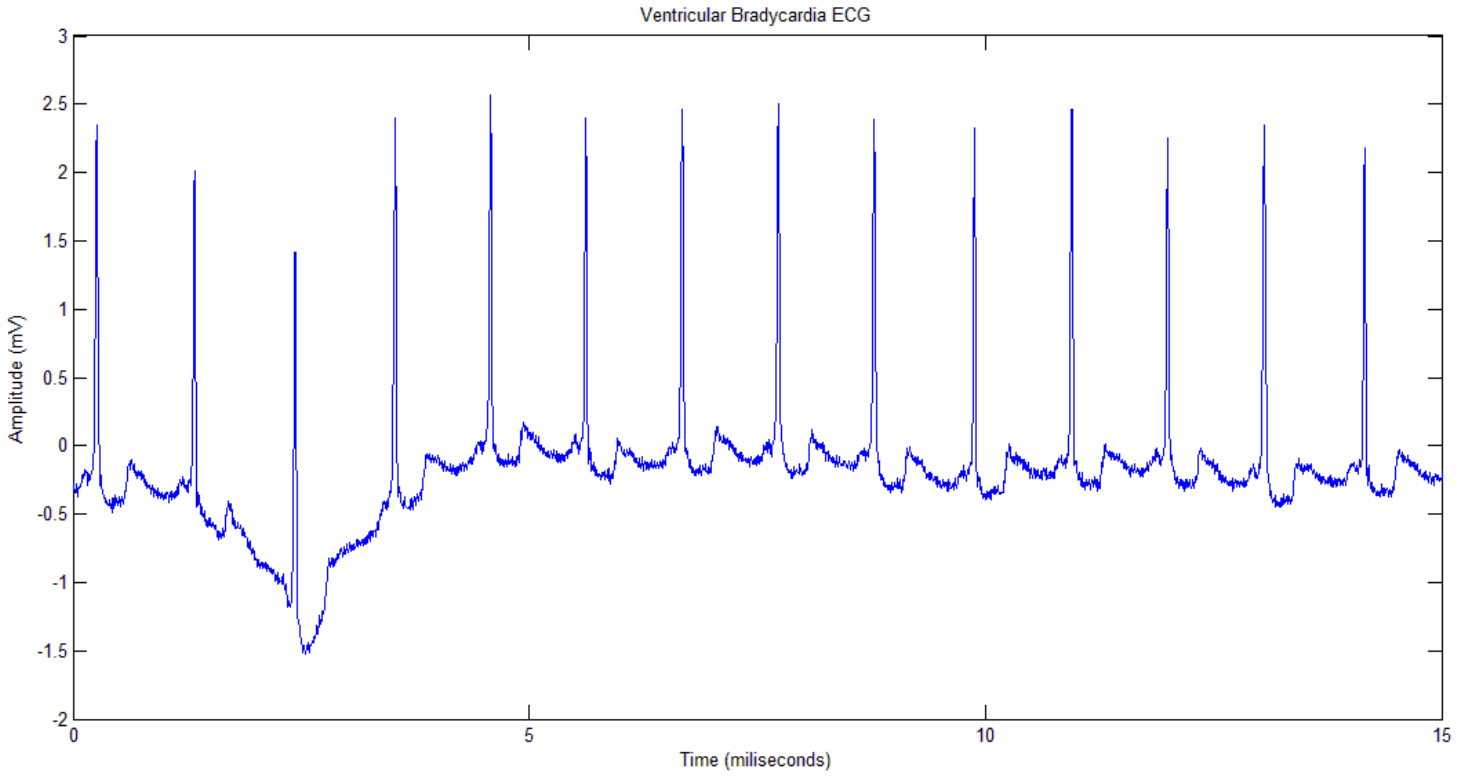
NO DISEASE


Normal ECG
Amplitude (mV)
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
Time (miliseconds)

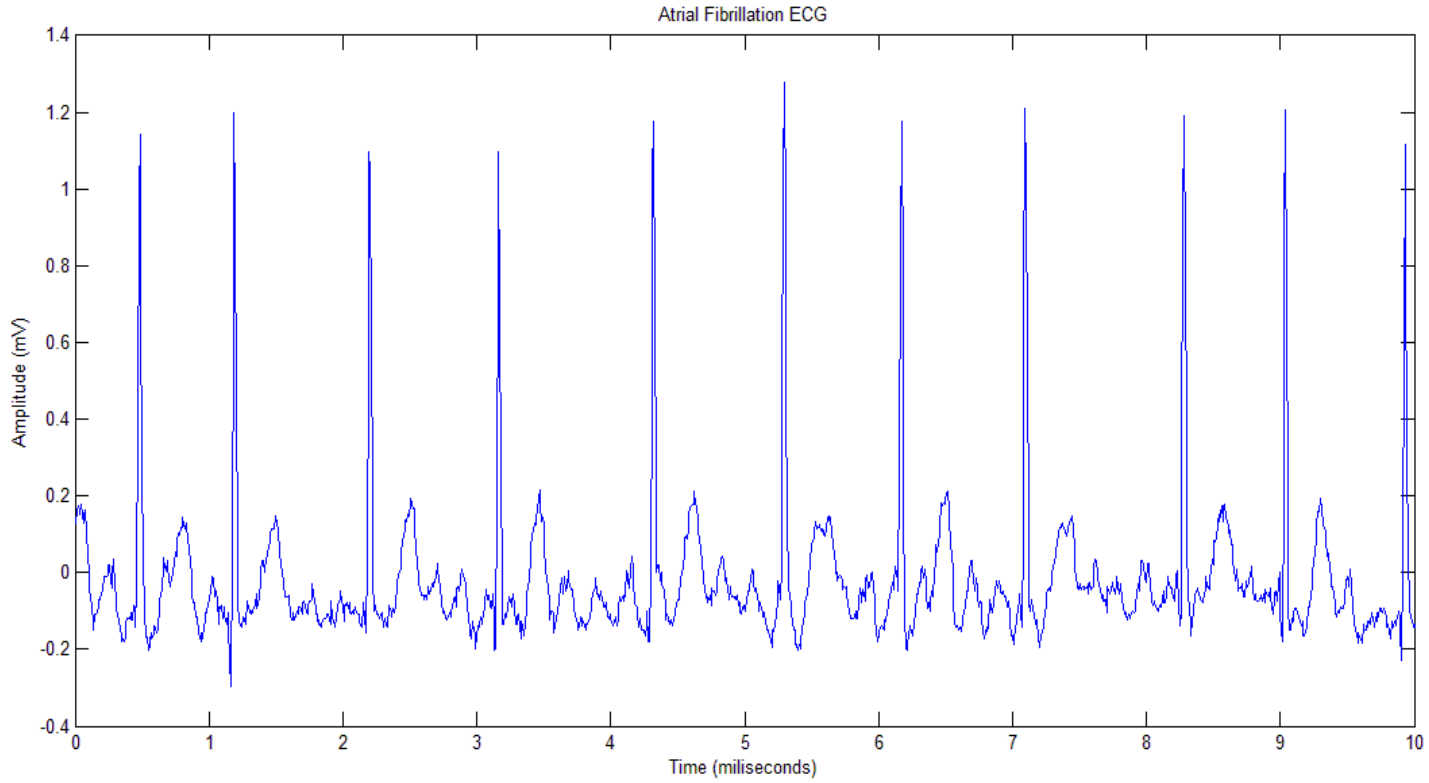
VENTRICULAR TACHYCARDIA



VENTRICULAR BRADYCARDIA



ATRIAL FIBRILLATION



CONCLUSIONS

- Several software problems were solved
  - Algorithmic analysis
  - Mobile platform development
- Future directions
  - Hardware prototype
  - Secure cloud storage of data for doctor-patient interaction

CONCLUSIONS

- Eclectic learning experience
  - Android software development
  - Intricacies of algorithmic analysis
  - Symptoms of cardiac disease
- Changes in hindsight
  - Focus on software only from the start
  - More reliance on 3rd party software

CONCLUSIONS

- Intellectual property: software
  - However, since it is proprietary, competitors would have to rewrite it from scratch
  - Careful security policies regarding the code would be more beneficial than a patent

Thank you for your attention!

Questions?