BIG DATA ANALYTICS FOR SIGNAL PROCESSING IN HEALTHCARE

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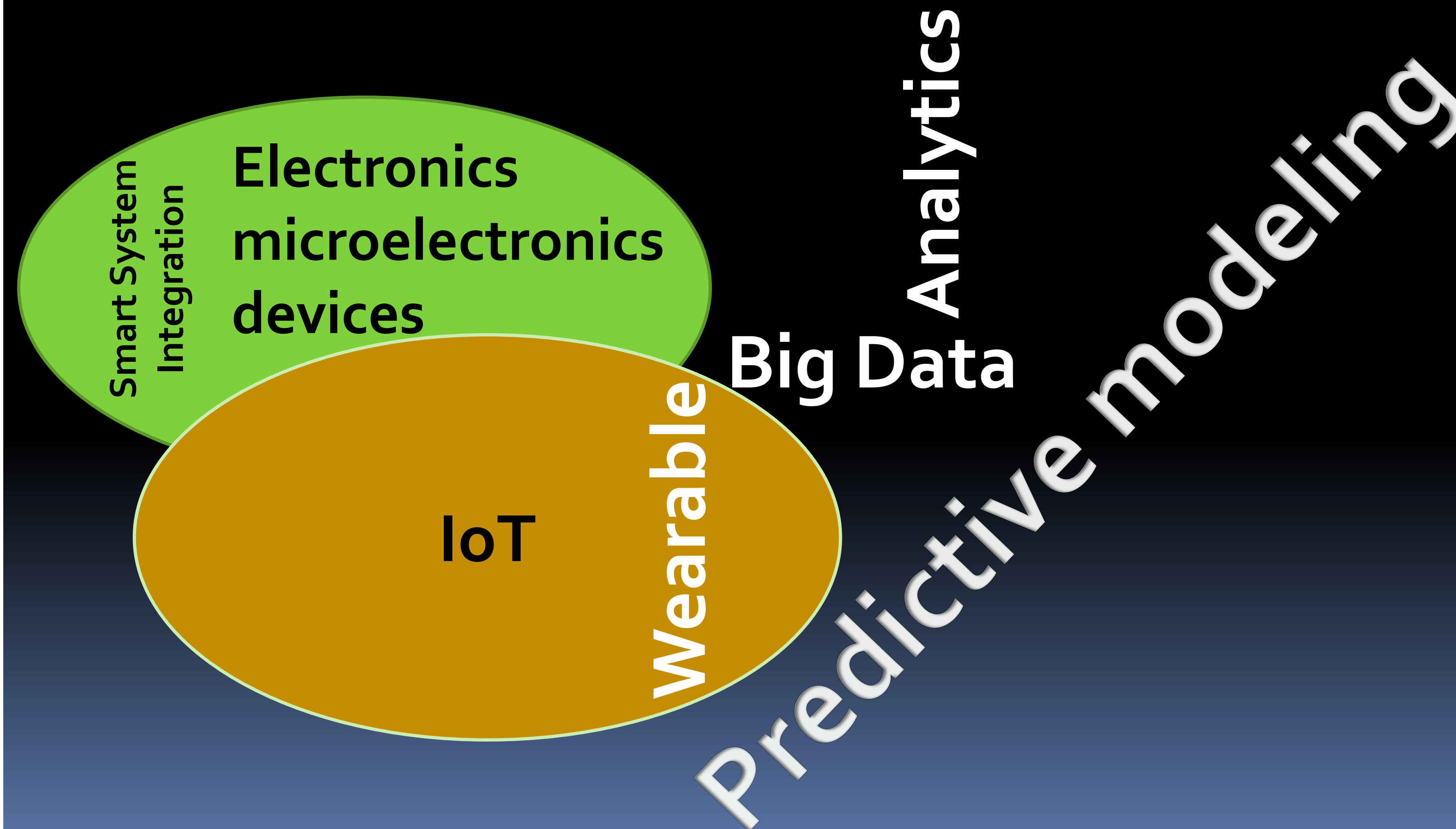
PhD Thesis "Theoretical and experimental contributions to the monitoring of vital parameters using smart control systems based on sensors integrated into textile structures and Cloud Computing services".



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Motivation:

➔ Better medical services and preventive actions based on predictive disease modeling

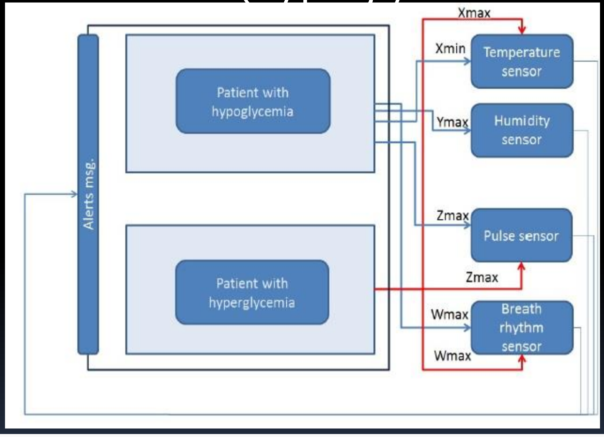
➔ Patients with chronic diseases ➔ better monitoring & hospitalization cost reduction

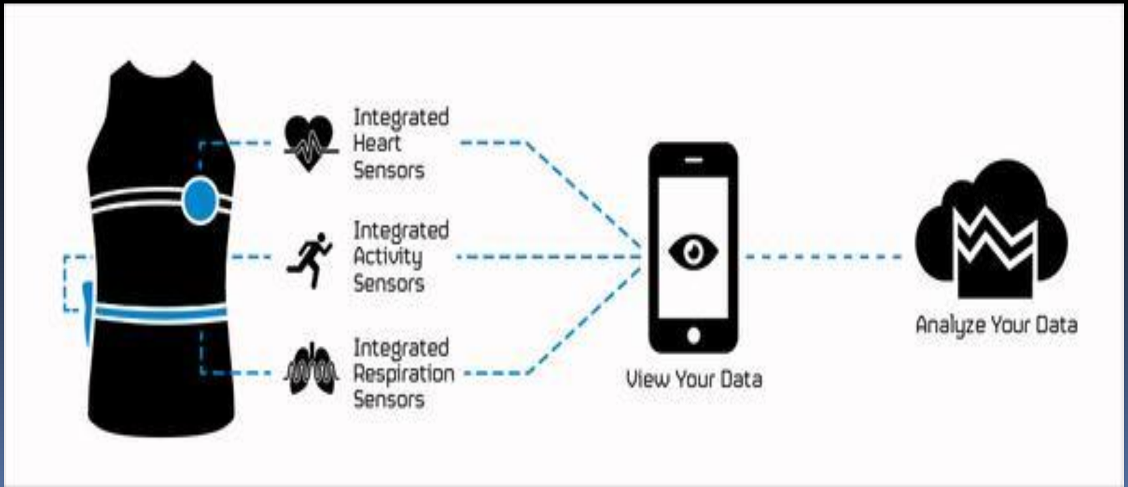
➔ Continuous remote monitoring ➔ Wearable lower power solutions

➔ Sensors integrated in cloths articles & tattoo with microfluidics devices (temperature + skin moisture monitoring + chemical modification at the skin level).

➔ Necessity to find pattern associated with critical events on diabetics (hypoglycemia and hyperglycemia)

➔ Real time monitoring & decission.





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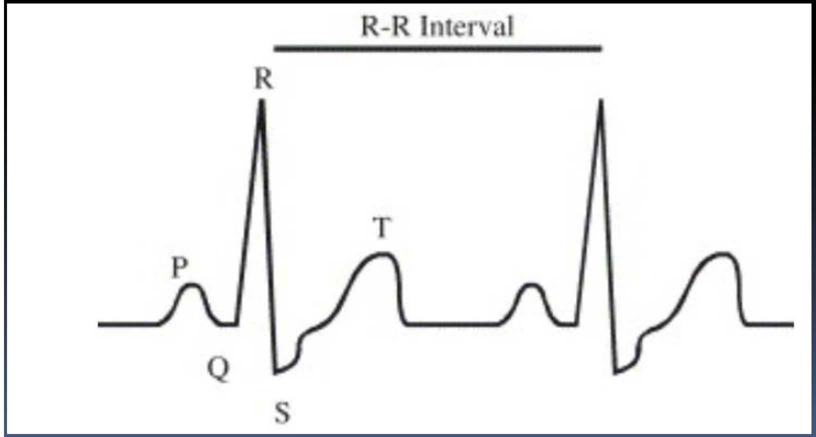
Proposed research methodology:

➔ For several patients (not real time processing and decision support)

- Biomedical datasets (real time data) can be stored locally in private cloud and processed by using Matlab (map/reduce);

➔ For huge populations (approx. 1000 patients or more + real time processing and decision support) ➔ parallel processing.

- Biomedical datasets –stored in public cloud ➔discretization & noise reduction by MapReduce using Hadoop Framework ➔ mapping for obtain the values corresponding to the critical event patterns



Normal values for QRS (ventricular depolarization):

P wave =0.25 V

Q wave =25% R

R wave =1.60 mV

S wave =

T wave =0.1-0.5mV

QRS interval =0.09 seconds

PR=0.12-0.2 seconds

QT=0.35-0.44 seconds

ST=0.05-0.15 seconds

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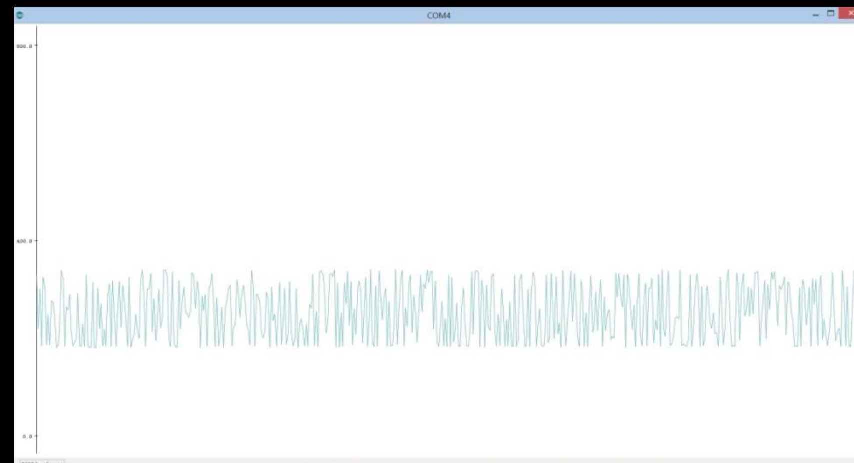
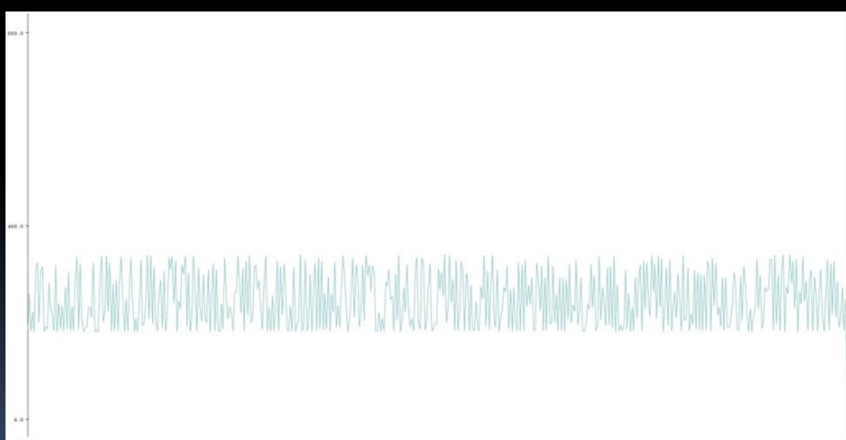
Continuous signal discretization by different time intervals (Data obtained by using Arduino shield and cardio electrodes.



T=10 seconds; f_e=0.1 Hz

In order to avoid noise from the environment the ECG data processing was divides in 4 phases:

- Filtering baseline wander;
- Noise reduction;
- QRS wave detection;
- Post process operations.



T=1 seconds; f_e= 1 Hz

Wearable devices ≈lower power consumption

Increasing the readings frequency ➔power supply minimization➔ low data accuracy

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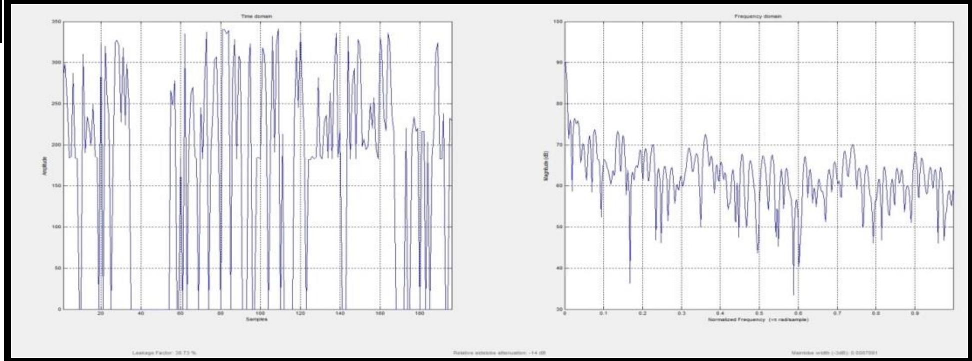
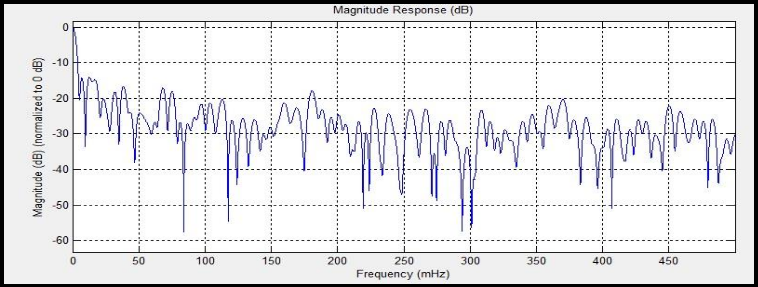
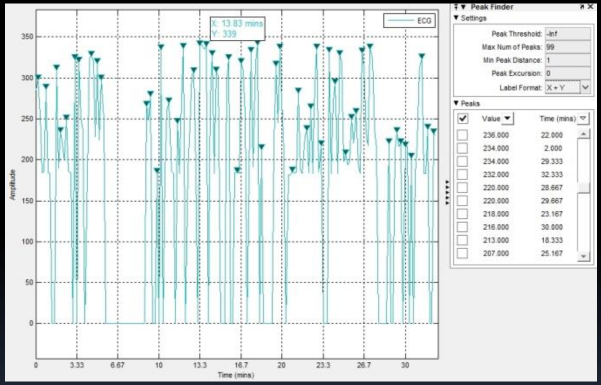
ECG datasets normalization

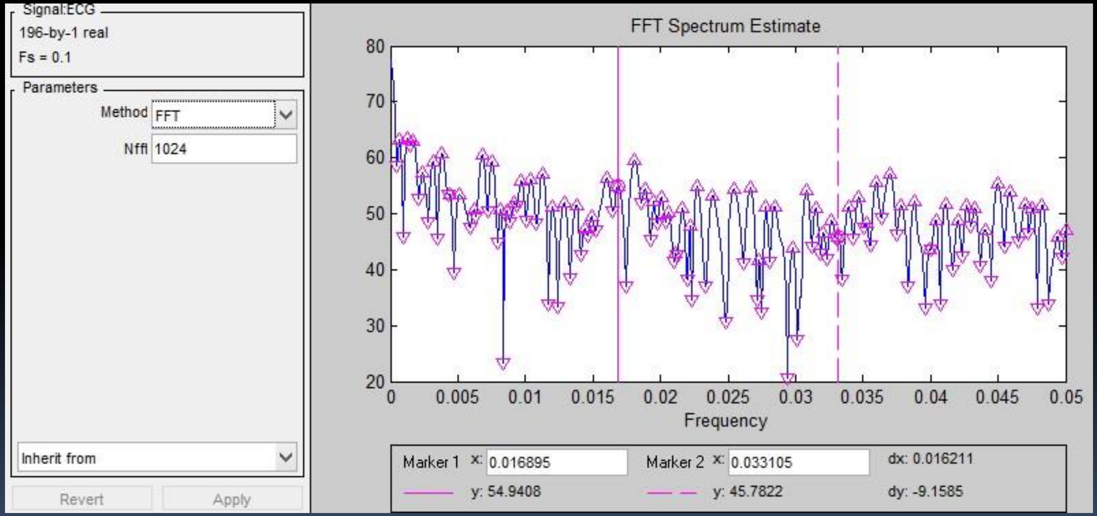




- the frequency domain plot is the magnitude squared of the Fourier transform of the window vector in decibels (dB)

Peaks finding





Signal filter by FFT method; fs=0.1 Hz

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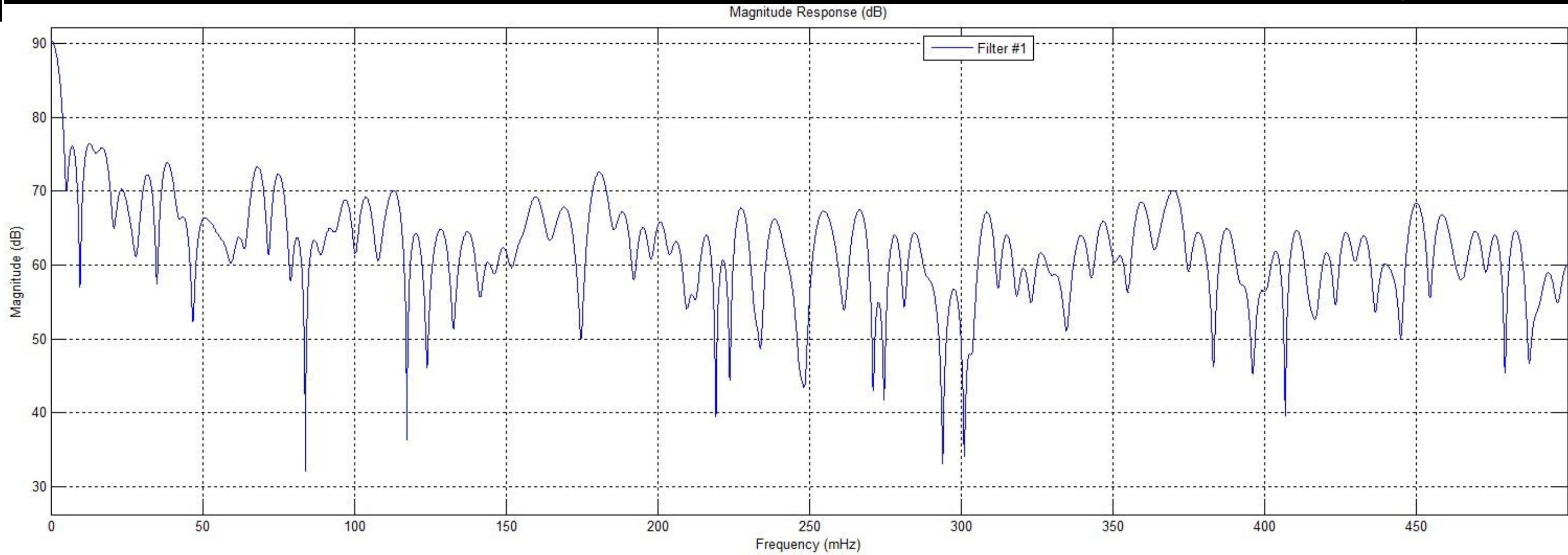
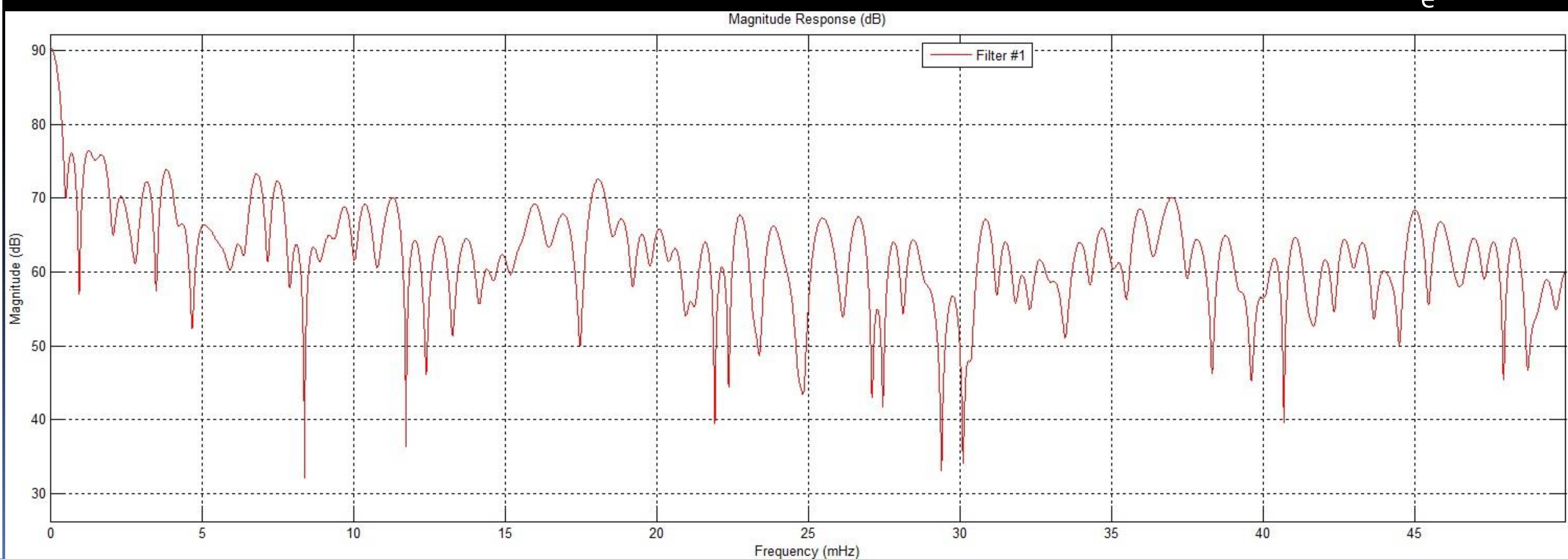
Sampling frequency

f_e=0.1 Hz



f_e=1 Hz



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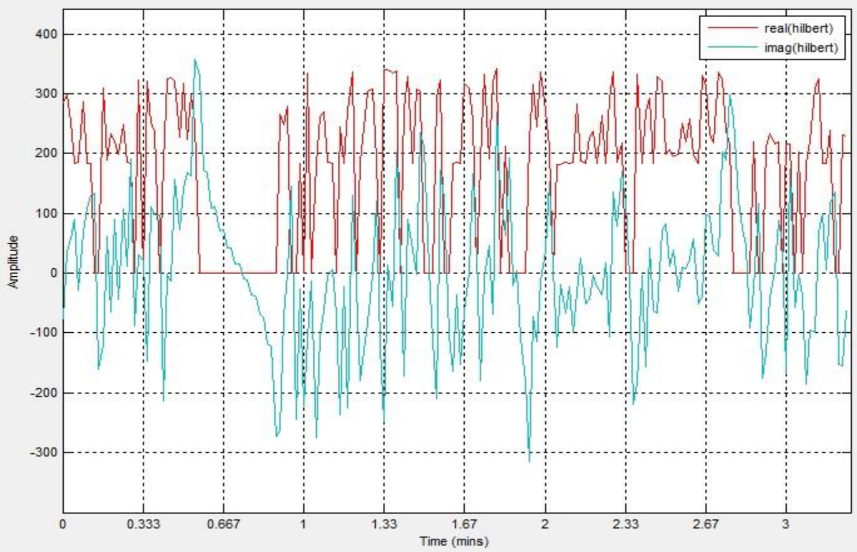
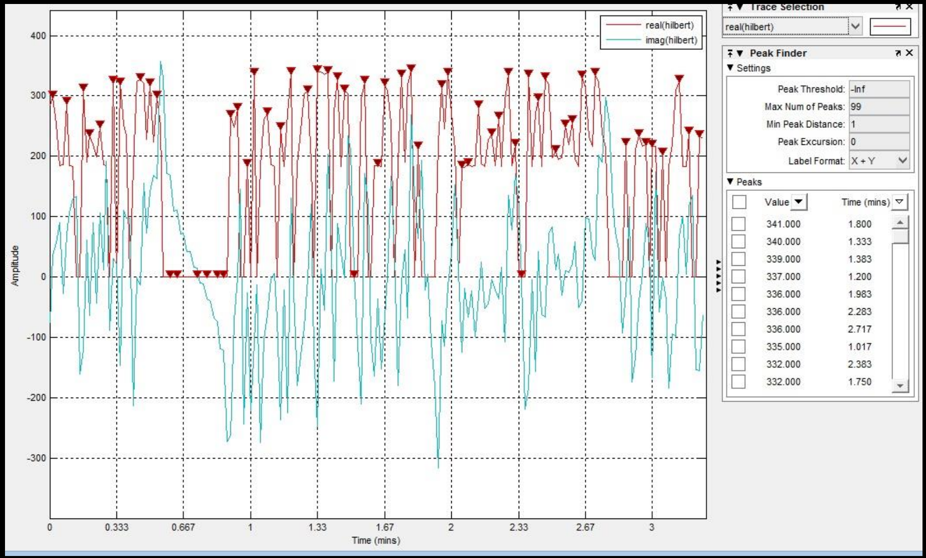
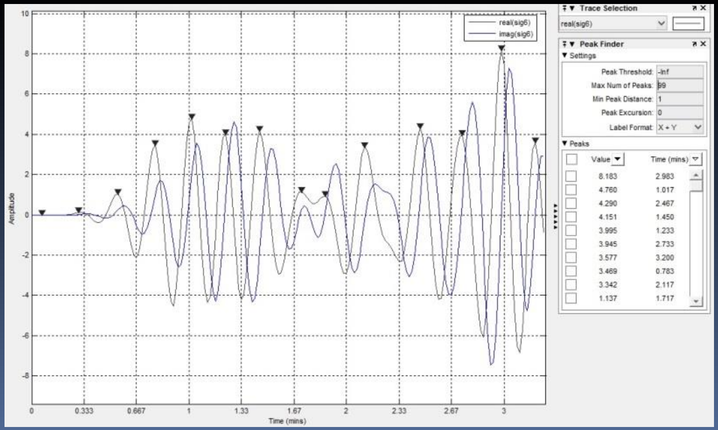
Discrete-time analytic signal using Hilbert transform

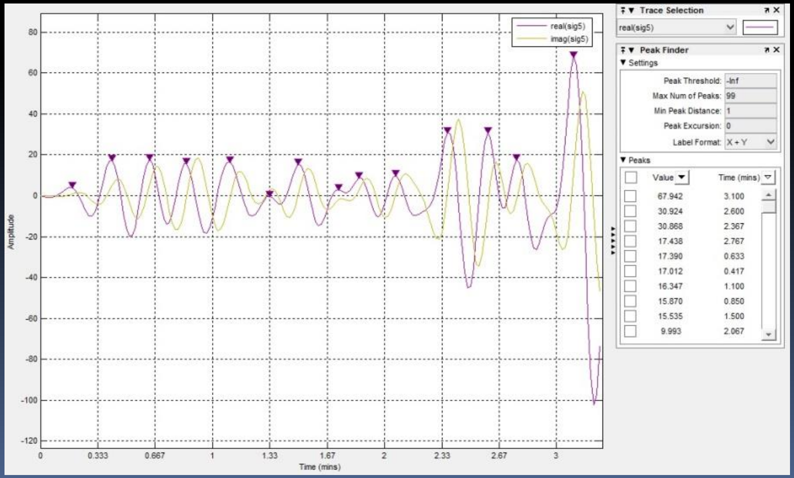
- ECG vector with biomedical datasets;
- Hilbert transformation ➔ Hilbert(ECG)







Filter based on Direct form FIR algorithm



Filter -FFT based FIR algorithm

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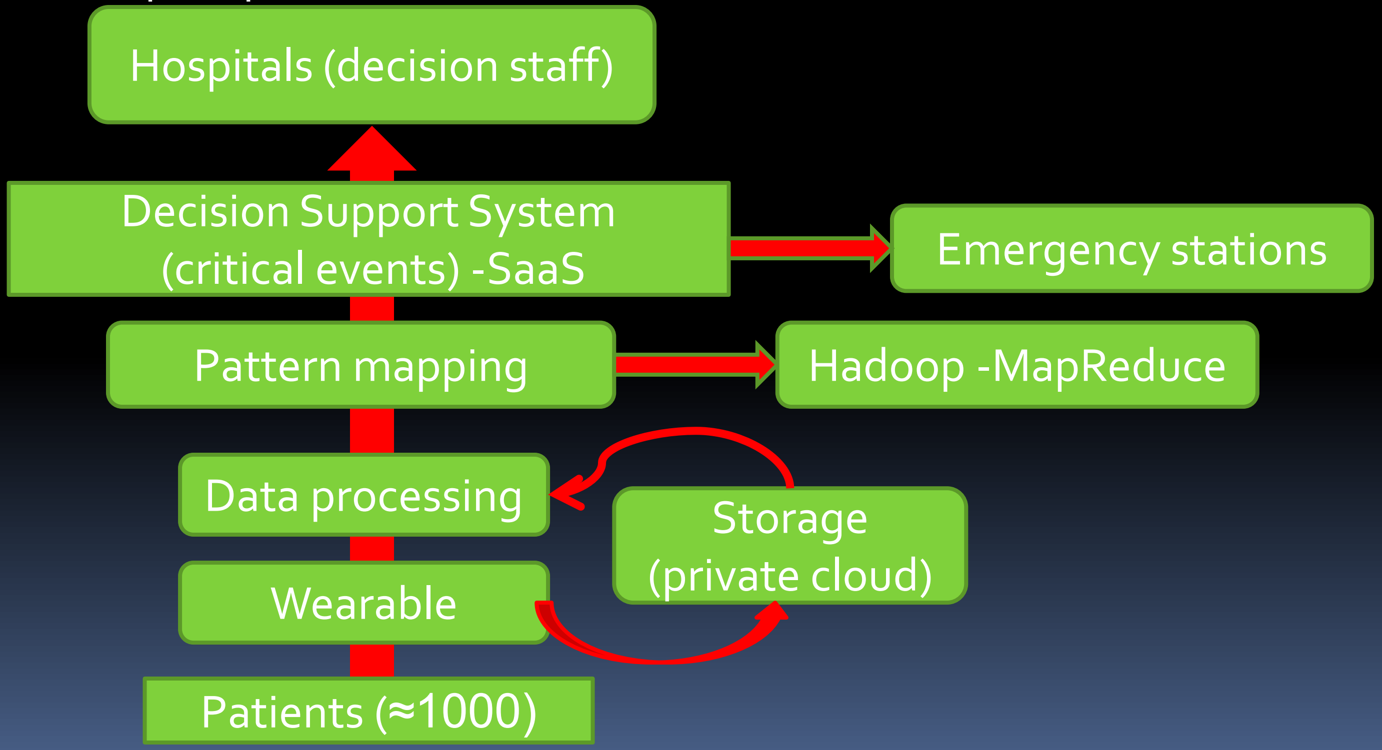
! Inconvenient: sampling frequency doesn't offer significant results regarding physiological parameters variation because many values are repeated;

- Remote monitoring on huge population ➔

Solution: reduction of the solutions interval by removing the repetitive values (Hadoop MapReduce framework)



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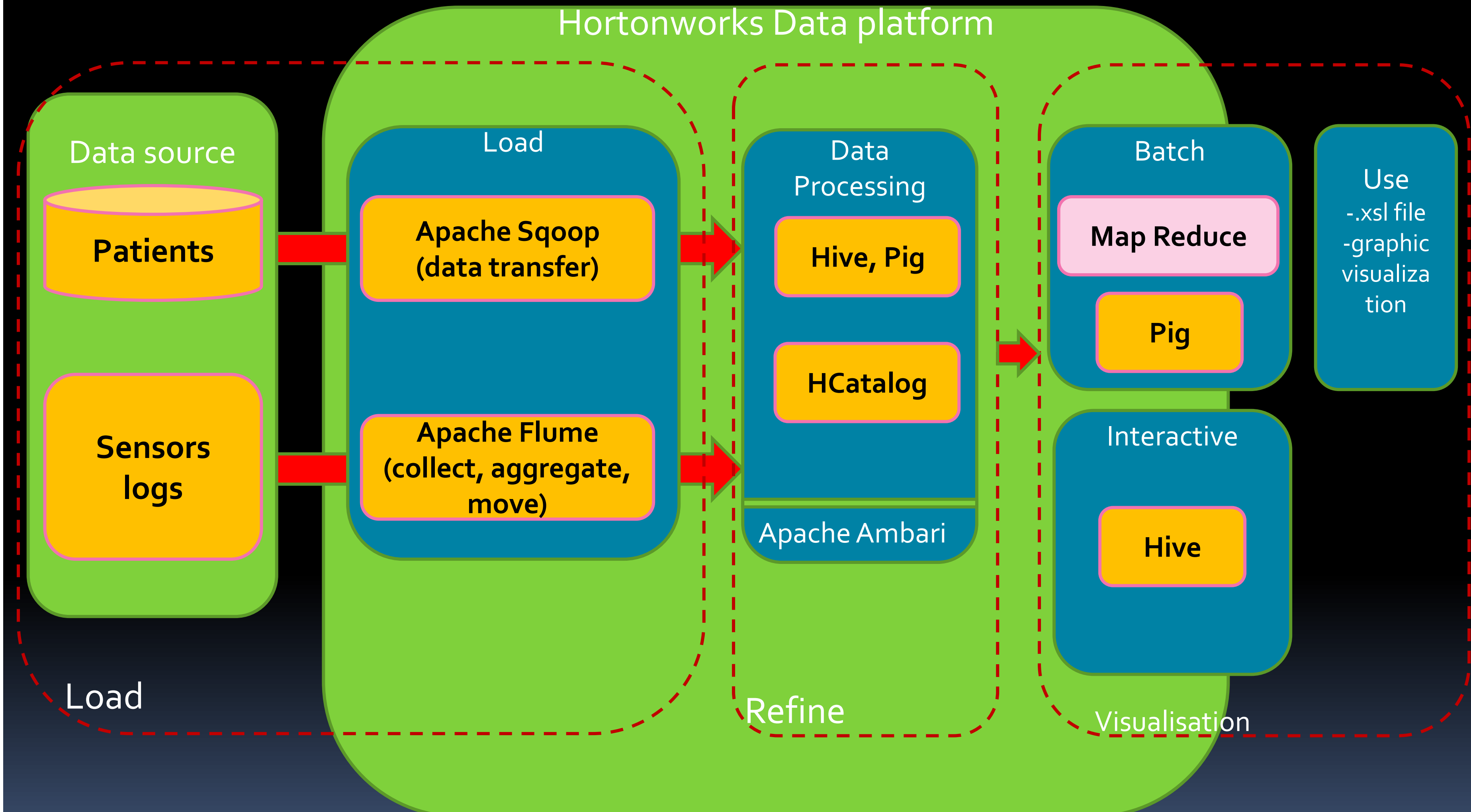

System architecture

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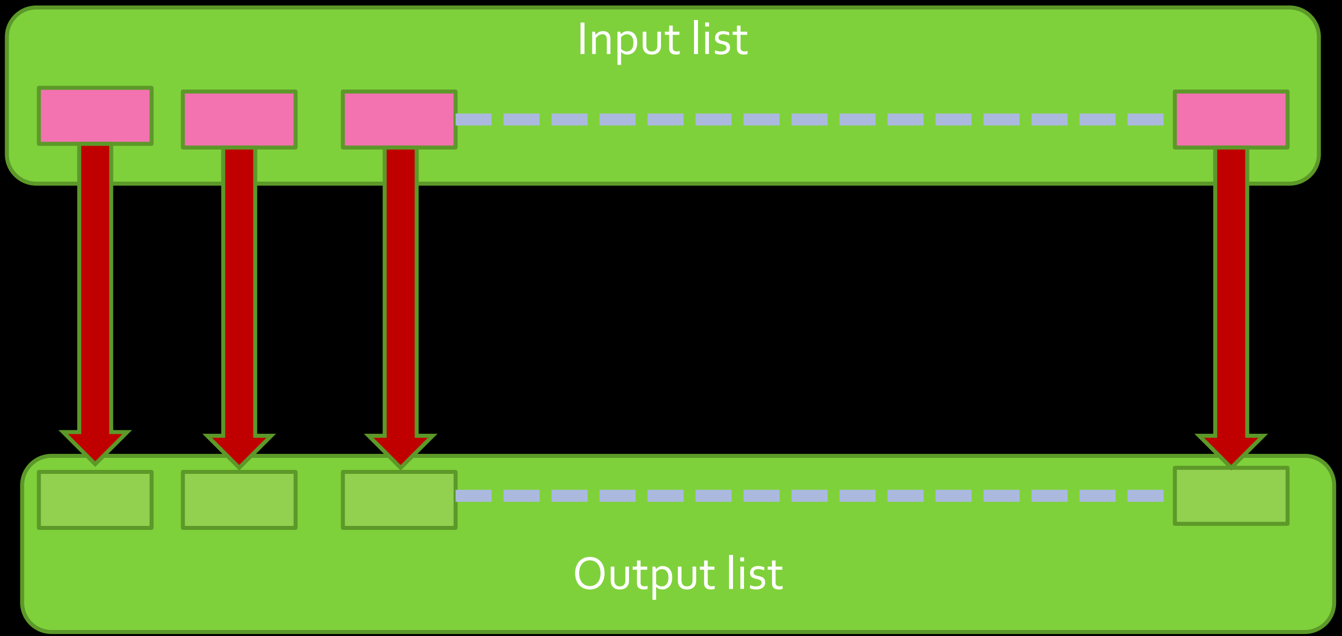
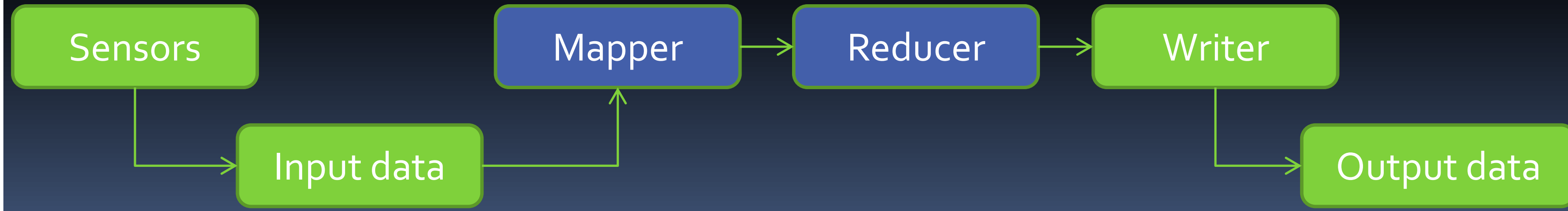


Input list = numerical values from sensors;
Output list = critical numerical value for sensors parameters



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Conclusions:

➔ Temperature and skin moisture must be correlated with cardiovascular monitoring, in order to provide a real insight into the causes and effects arising from certain diseases.
➔Hadoop ➔rapid code programming and testing;
➔virtualization and data analytics for health predictive modeling;
➔possibility to storage data from huge population;
➔possibility to create interactive data visualization;
➔graphical visualization for a patients group.

Thank you for your attention!