INTERNET OF THINGS

SEMINAR CSE 745

PROJECT TITLE: HEATLHCARE MONITORING SYSTEM
UNDER THE GUIDANCE OF PROF. R. SRIDHAR

NAME: PRIYA MURTHY
PERSON NUMBER: 50248887

1. INTRODUCTION:

The aim of the project is to develop a heartbeat monitoring system and extract meaningful information from it.

We can obtain a lot of information from the heartbeat of a person. Not only the beats per minute (BPM), but it also contains information about a person's health, physical fitness, and even mental activity of a person.

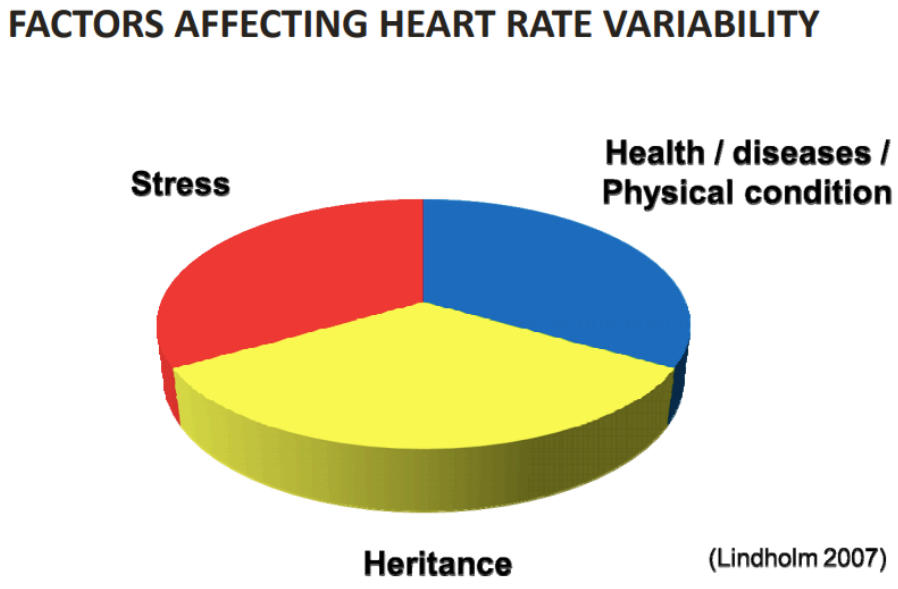
The heart rate signal contains a lot of information, not just about your heart but also about your breathing, short-term blood pressure regulation, body temperature regulation and hormonal blood pressure regulation (long term). It has also (though not always consistently) been linked to mental effort, and not surprisingly so since your brain is a very hungry organ, using up to 25% of your total glucose and 20% of your oxygen consumption. If its activity increases your heart needs to work harder to keep it supplied.

2. LITERATURE SURVEY:

- **Stress Recognition using Wearable Sensors and Mobile Phones - Humaine Association Conference on Affective Computing and Intelligent Interaction:**
  The paper aims to find physiological or behavioral markers for stress based on data obtained from a wrist sensor (accelerometer and skin conductance), mobile phone usage (call, short message service, location and screen on/off) and surveys (stress, mood, sleep, tiredness, general health, alcohol or caffeinated beverage intake and electronics usage). Correlation analysis was performed to find statistically significant features associated with stress and machine learning was used to classify whether the participants were stressed or not.

  Conclusion: The correlation analysis showed that the higher reported stress level was related to activity level, SMS and screen on/off patterns.

- **How to Analyze Stress from Heart Rate & Heart Rate Variability – Firstbeat:**
  Firstbeat utilizes Heart Rate Variability to make a model of the body's physiological states. HRV means the variation in time between consecutive heartbeats.



The picture below describes about various physical states, stress reactions and recovery methods for a person.

Stress reactions	Recovery	Physical activity	Other state
Increased activation level in the body caused by stress reactions. The reaction can be positive or negative. Sympathetic dominance. High heart rate, increased respiration frequency, low heart rate variability, oxygen uptake <20% of maximal capacity (VO2max).	Lowered activation level & calming down of the body. Nighttime sleep and relaxing breaks are important recovery periods. Parasympathetic dominance. Low heart rate, low respiration frequency, high heart rate variability, oxygen uptake <20% VO2max.	Physical stress / activity during which the intensity is > 30% of maximal capacity. **Daily physical activity** Low-level physical stress/activity during which the intensity is 20-30% of maximal performance.	Other state (white) is typically recovery from exercise, short awakenings during sleep or missing data periods (for example during a shower).

Conclusion: We can categorize if a person is stressed or not using the firstbeat analysis but we cannot differentiate between positive and negative stress using this analysis.

- **Classification of caesarean section and normal vaginal deliveries using fetal heart rate signals and advanced machine learning algorithms**

  The primary aim in this paper was to evaluate a proof-of-concept approach to separating caesarean section and normal vaginal deliveries using FHR signals and machine learning. The results show that using a deep learning classifier it is possible to achieve 94% for Sensitivity, 91% for Specificity, 99% for AUC, 100% for F-score, and 1% for Mean Square Error.

  Conclusion:

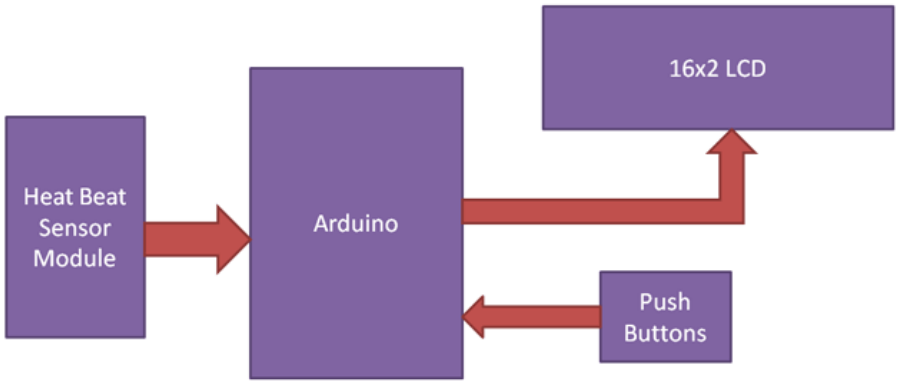
  The results demonstrate that machine learning significantly improves the efficiency for the detection of caesarean section and normal vaginal deliveries using fetal heart rate signals compared with obstetrician and midwife predictions and systems reported in previous studies.

3. THE HARDWARE PART!

COMPONENTS USED:

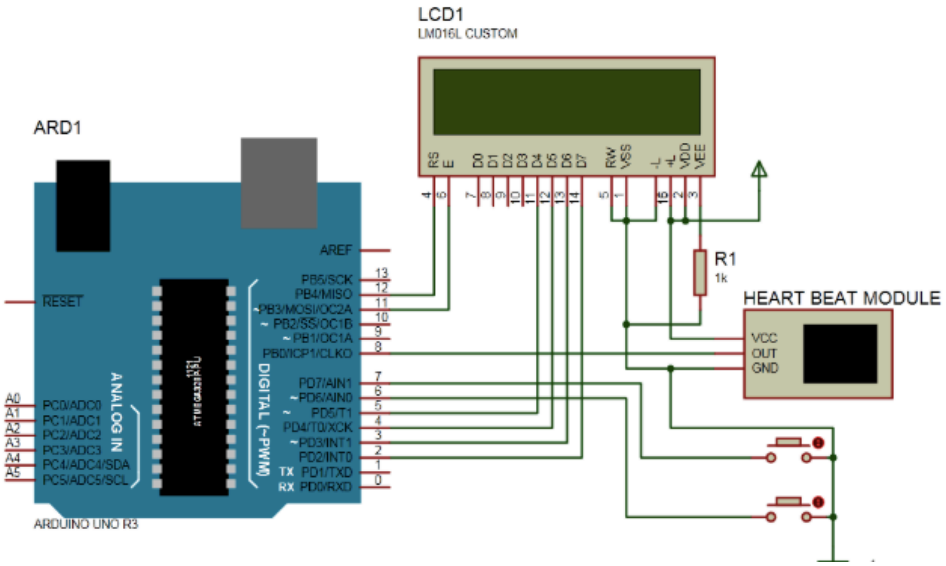
1. Arduino
2. Heart Beat sensor module
3. 16x2 LCD
4. Push button
5. Bread board
6. Power
7. Connecting wires

The diagram below represents the Heartbeat sensor module created for the purpose of this project.



The sensor module contains an IR pair which actually detect heart beat from blood. Heart pumps the blood in body which is called heart beat, when it happens the blood concentration in body changes which is to make a voltage or pulse electrically.

The figure below shows the circuit diagram made by using the components mentioned above.

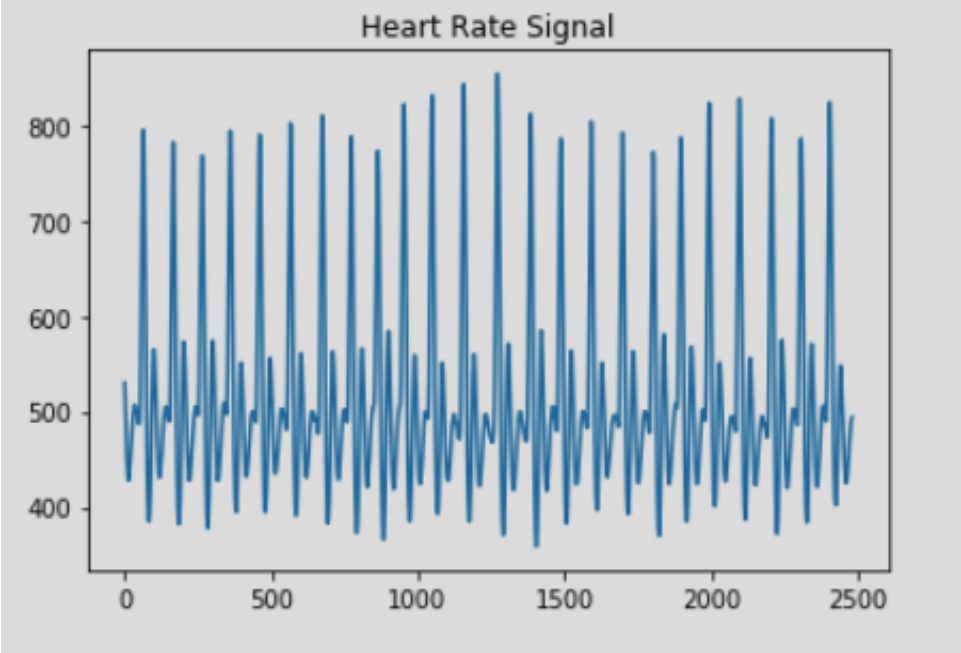


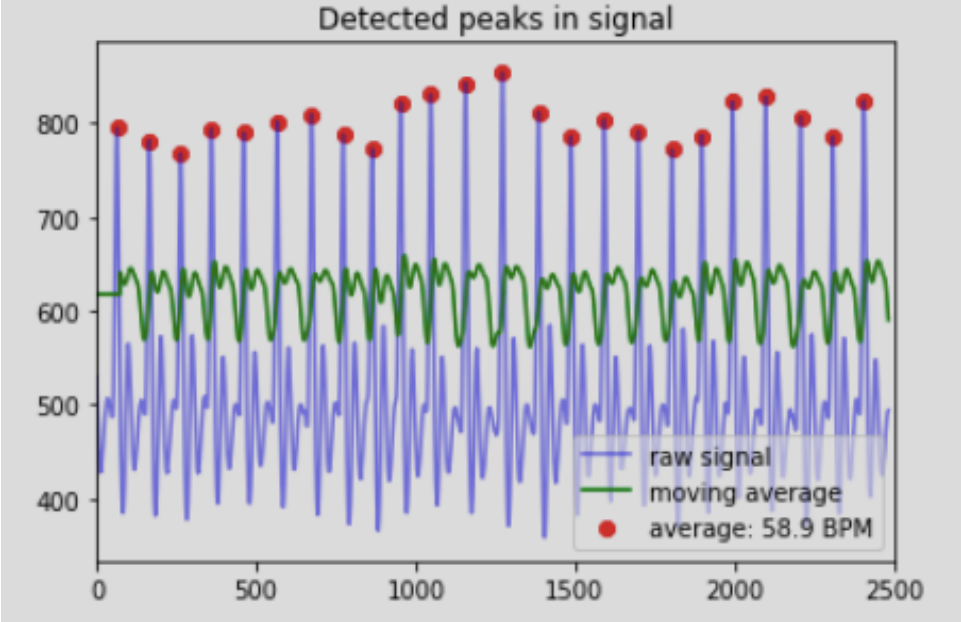
4. EXPLORING THE SENSOR DATA

Once the data is obtained form the Hardware, data was explored and various data analysis methods were tried to observe the stress patterns.

The analysis of data shown below was performed on: Physiological data taken in driving and cycling experiments

- **DETECTING THE FIRST PEAKS AND CALCULATING THE BPM:**
  We can obtain a wide variety of information from the heart rate. Some of which includes: Health of a person, physical fitness, mental activity, Classification of caesarean or normal delivery using fetal heart rate signals.
  From the data used, peaks of the data was obtained using python.





- **EXTRACTING COMPLEX MEASURES FROM DATA:**
  The basic idea is that you take a signal that repeats over time (such as the heart rate signal), and determine what frequencies make up the signal.
  The heart rate signal can be transformed to either time domain or frequency domain,

  From the time series data, we can obtain:
  - BPM
  - Inter beat interval
  - Heart rate variability

  The time series measures often found in the scientific literature are:
  - BPM, the amount of heart beats per minute,
  - IBI (inter-beat interval), the mean distance of intervals between heartbeats
  - SDNN, the standard deviation of intervals between heartbeats:
  - SDSD, the standard deviation of successive differences between adjacent R-R intervals:
  - RMSSD, the root mean square of successive differences between adjacent R-R intervals:
  - pNN50/pNN20, the proportion of differences greater than 50ms / 20ms.

  The IBI, SDNN, SDSD, RMSSD en pNNx (and also frequency domain measures) are often grouped under “Heart Rate Variability” (HRV) measures, because they give information about how the heart rate varies over time.

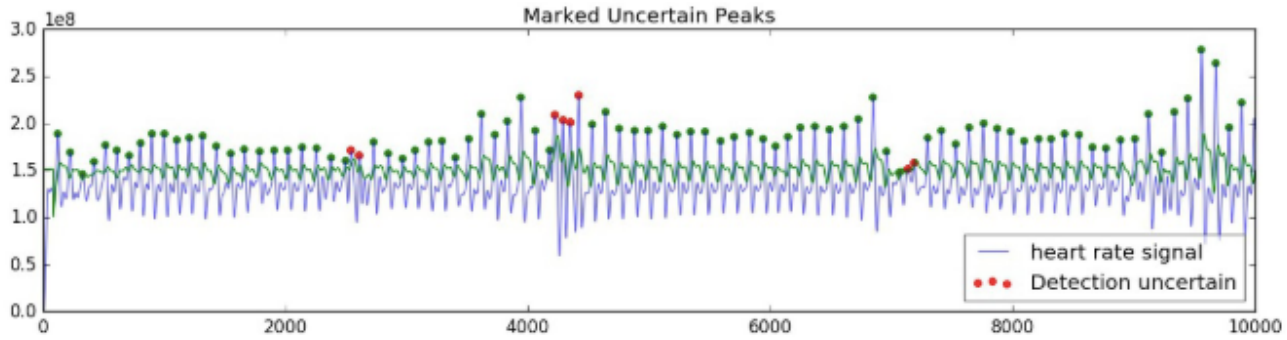
From frequency domain data, we can obtain:

- HF band (breathing rate)
- LF (short term blood pressure)

The frequency spectrum is calculated performing a Fast Fourier Transform over the R-R interval dataseries.

- **WORKING WITH NOISY SIGNALS:**

When the input signal is noisy, detection of peaks becomes difficult.
Thus, I performed Dynamic detection of peaks for the data using python.



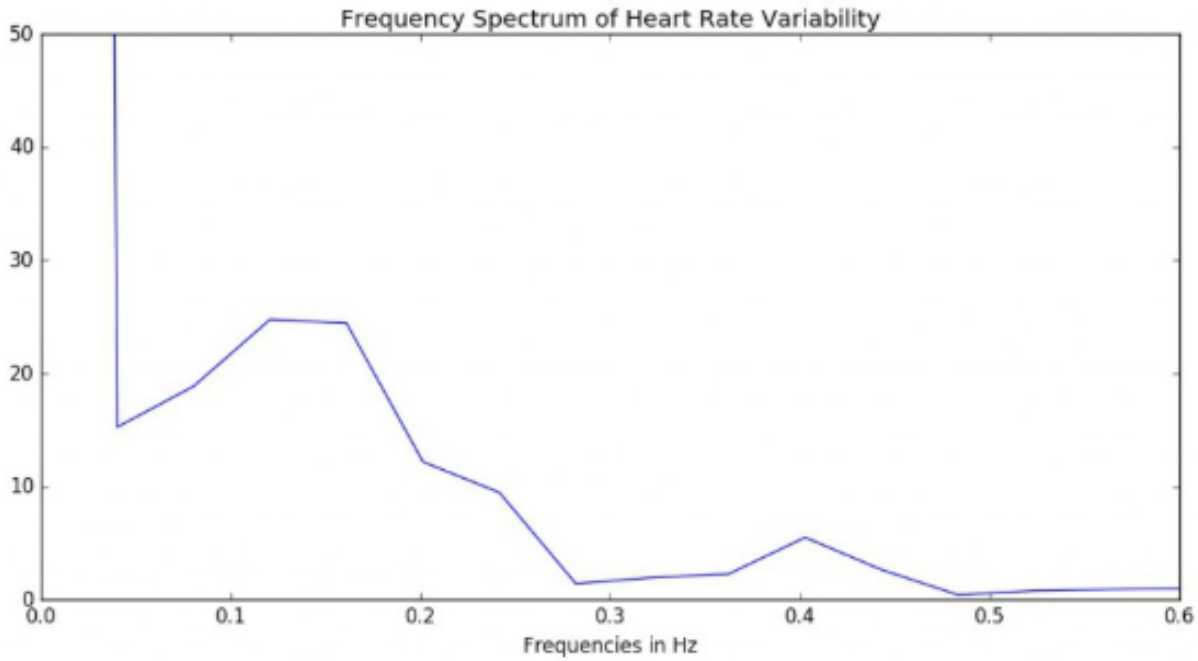
In the figure above, the red points represent the places in the signal where heart rate detection becomes uncertain. Thus, these red points are ignored when performing calculations on the signal.

5. OBSERVATIONS:

Snapshot of the data used:

Heart rate signal
530
518
506
494
483
472
462
454
446
440
434
430
428
430
430
432
436
439
444
450
454
459
465

On calculating the time domain and frequency domain measures on the data.
I obtained the following frequency spectrum of Heart Rate variability.



The data used for this graph was not noisy, and thus we can clearly see the LF and HF frequency peaks in the signal.
This is connected to the physical activity, thermal regulation and hormonal blood pressure regulations of a person.

We also know that:

- If Heart rate increases and Heart Rate Variability decreases. => Stress reactions, bodily functions speed up.
- If Heart rate decreases and Heart Rate Variability increases. => Recovery, Calms down bodily functions.

6. FUTURE SCOPE:

This project aims to determine stress based on the heart rate signals as discussed above.
As we know that the heart rate signals can be used to determine a lot of other useful information as well, we can extend the project to:

- Detect the diseases like Heart rate arrhythmias
- Classify normal vs cesarean delivery based on heart rate signals of the fetus.

7. REFERENCES:

- Analyzing Stress: https://goo.gl/3iAMZc
- Information that can be extracted from heart rate signals of fetus: https://goo.gl/U6yjwp
- Statistical analysis of heart rate and heart rate variability monitoring through the use of smart phone cameras : https://goo.gl/C2cBVz
- Heart beat monitoring system hardware: https://goo.gl/tckjtZ
- Stress Recognition: https://goo.gl/VcvXAS
- Detecting heart arrhythmias : https://goo.gl/iEKLK6