

#### A Comparative Study between ECG-based and PPG-based Heart Rate Monitors for Stress Detection

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- Wearable devices monitor Heart rate,
   Step Count, Sleep, Oxygen level of an individual.
- Heart rate is an interesting feature.
- Heart rate can be collected using two methods:
  - Electrocardiogram (ECG)
  - Photoplethysmogram (PPG)



### Electrocardiogram (ECG)





### Photoplethysmogram (PPG)





## Background

Prior work compared Polar H7 with clinical-grade sensors.

- It measured stress in lab as well as free-living conditions.
- Features computed were used here.

### Motivation



 $RR_1$  $RR_2$  $RR_3$ ECG Signal RR<sub>2</sub>  $RR_3$ RR<sub>1</sub> **PPG Signal** 

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Our study aims at finding

• Whether wrist worn device can provide similar performance to chest-worn devices?

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• Can the data collected from different devices be used to detect stress under same circumstances?

## Methodology

- The entire process is divided in four major steps:
  - 1. Data Collection
  - 2. Data Cleaning and Processing
  - 3. Feature Extraction and Ground Truth Labelling
  - 4. Model Construction

## Data Collection [1/4]

• Device Setup



#### **Devices Used**

- Polar H10
  - Gives one reading per second
- Garmin HRM Dual
  - Gives two readings per second
- Garmin Vivosmart 4 Fitness Band
  - Gives one reading per 15 seconds.

# Data Collection [1/4]

#### Laboratory Study Protocol



- 5 participants (3 males, 2 females).
- 25 years to 35 years.
- Duration: 45 minutes
- Android app over BLE.

- 1. V. Mishra, G. Pope, S. Lord, S. Lewia, B. Lowens, K. Caine, S. Sen, R. Halter, and D. Kotz, "Continuous detection of physiological stress with commodity hardware," ACM Trans. Comput. Healthcare, vol. 1, no. 2, apr 2020. [Online].
- 21-01-2022 2. B. Egilmez, E. Poyraz, W. Zhou, G. Memik, P. Dinda, and N. Alshurafa, "Ustress: Understanding college student subjective stress using wrist-based passive sensing," in IEEE International Conference on Pervasive Computing and Communications Workshops, 2017.

## Data Cleaning and Processing [2/4]



# Feature Extraction and Ground Truth Labelling [3/4]

- Window Size=60 seconds & 50% overlap
- Features are computed using Heart rate data and R-R intervals.
- Windows extracted are labelled as
  - Rest Period => Not Stressed
  - Stressed Period => Stressed

Heart Rate Features	<b>R-R Interval Features</b>	
<ul> <li>Maximum Heart Rate</li> <li>Minimum Heart Rate</li> <li>Mean Heart Rate</li> <li>Median Heart Rate</li> <li>Standard deviation</li> <li>80<sup>th</sup> Percentile</li> <li>20<sup>th</sup> Percentile</li> </ul>	<ul> <li>Maximum R-R Interval</li> <li>Minimum R-R Interval</li> <li>Mean R-R Interval</li> <li>Median R-R Interval</li> <li>Standard deviation</li> <li>80<sup>th</sup> Percentile</li> <li>20<sup>th</sup> Percentile</li> <li>RMSSD</li> </ul>	

1. V. Mishra, G. Pope, S. Lord, S. Lewia, B. Lowens, K. Caine, S. Sen, R. Halter, and D. Kotz, "Continuous detection of physiological stress with commodity hardware," ACM Trans. Comput. Healthcare, vol. 1, no. 2, apr 2020. [Online].

[1]

## Model Construction [4/4]

- Random-Forest Classifier is used to train the model for stress detection.
- The data from each device is trained separately with person independent data.

### Evaluation

Our study aims at finding

- Whether wrist worn device can provide similar performance to chest-worn devices?
- Can the data collected from different devices be used to detect stress under same circumstances?
- Heart Rate Comparison
  - Heart rate readings are compared at granularity of 1 reading per second.
  - RMSE is calculated between the Polar H10 and other two devices.

Device	RMSE (bpm)		
Garmin HRM Dual	5.2		
Garmin Vivosmart 4	10.23		

### Evaluation

- Stress Detection
  - Leave One Person Out Cross Validation is used.
  - Precision, Recall, Accuracy and F1-Score are noted.

Device	Accuracy	Precision	Recall	F1-Score
Polar H10	0.85	0.85	0.84	0.85
Garmin HRM DUAL	0.81	0.88	0.76	0.82
Garmin Fitness Band	0.83	0.87	0.74	0.80

### Formalism

• **Rule** :  $avg(HeartRate) > 0.35 \land stdev(HeartRate) > 0.05 \Rightarrow Stressed$ 



### Future Work

1.Adaptive Sampling for ECG Detection Based on Compression Dictionary - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Adaptive-sampling-principle-of-the-ECG-signal\_fig2\_264144471 [accessed 25 Dec, 2021]





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### Conclusion

- Here three devices that use different technologies for capturing Heart rate are compared.
- RMSE of Garmin HRM Dual and Garmin Vivosmart 4 was 5.2 and 10.23 respectively.
- Also stress detection ability of each device was evaluated.
- It is observed that the difference in F1-score of detecting stress by the three devices is within 5% .
- We provide formal verification of our trained model.

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