SBES466

Biomedical Data Analytics

Final Project Report

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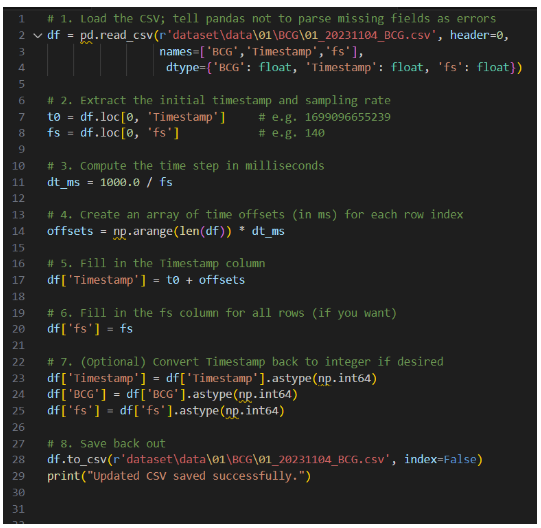
Heart rate detection from bed-embedded Ballistocardiogram sensors

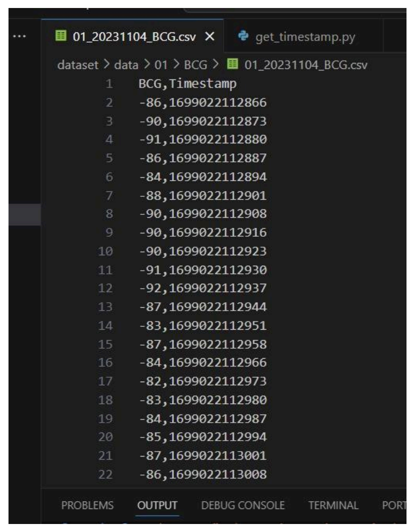
A- Objective:

The aim of this project was to process Ballistocardiogram (BCG) signals and RR intervals to extract heart rate (HR) information, synchronize both signals, and compute the error between the two derived HR measurements.

B- Steps Undertaken:

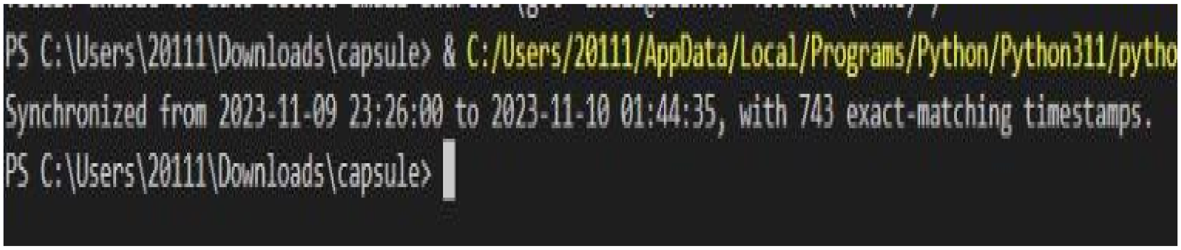
1. **Timestamp Acquisition for BCG:**
   We began by extracting **timestamps** for the BCG signal to establish a temporal reference for subsequent **synchronization** and processing.





2. **Resampling BCG Signal to 50 Hz:**
   The original BCG signal, recorded at 140 Hz, was resampled to 50 Hz to standardize the data and reduce computational load, resulting in a more manageable dataset for windowing and HR analysis.
3. **Heart Rate Estimation via J-Peak Detection:**
   A provided script (Dr code) was utilized to detect **J-peaks** within the BCG signal. These peaks were then used to calculate heart rate values based on the RR intervals between successive **J-peaks**.
4. **RR and BCG Synchronization:**
   To ensure **accurate comparison** between the BCG-derived HR and RR intervals, the RR timestamps were either transformed to align with the BCG timeline or vice versa. This synchronization was essential for consistent time-based analysis.

5. **Identifying Start and End Points:**
The synchronized RR and BCG signals were scanned to locate corresponding start and end points. This ensured both datasets covered the same time segments for fair comparison.

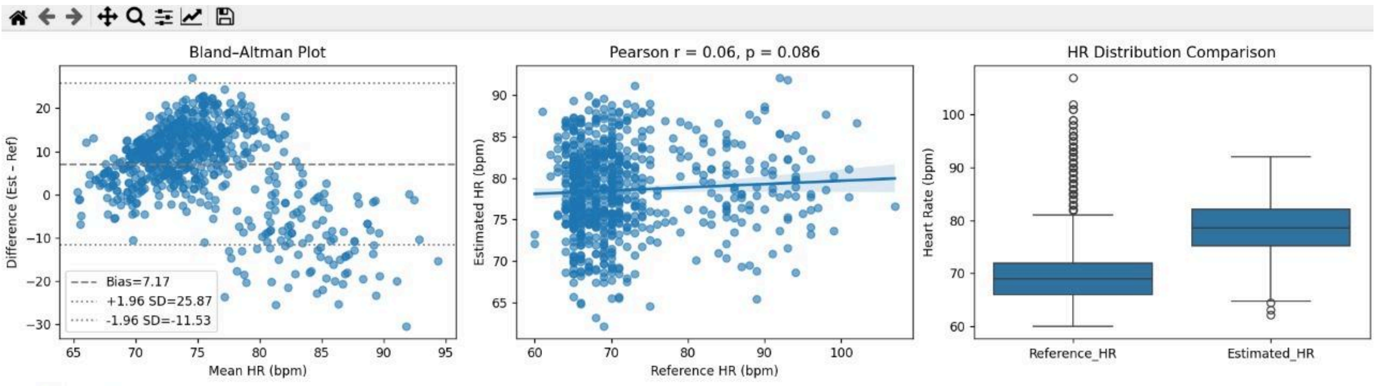


```
PS C:\Users\20111\Downloads\capsule> & C:/Users/20111/AppData/Local/Programs/Python/Python311/pytho
Synchronized from 2023-11-09 23:26:00 to 2023-11-10 01:44:35, with 743 exact-matching timestamps.
PS C:\Users\20111\Downloads\capsule>
```

6. **10-Second Window Extraction:**
From the synchronized data, 10-second windows were extracted for analysis. Given the **50 Hz** BCG sampling rate, each BCG window consisted of **500 samples**. RR interval data, being event-based, varied in the number of samples per window.
7. **Error Calculation:**
The final step involved computing the error between the heart rate values derived from the BCG and those from the RR intervals. This helped evaluate the accuracy of the BCG-based heart rate estimation in comparison to the RR-based reference.
   - **MAE** gives you the average error in bpm(easy to interpret.
   - **RMSE** highlights larger deviations more strongly; if **RMSE** ≫ **MAE**, you have **outliers**.
   - **MAPE** puts errors in context of true **HR**; a **MAPE** of 5% means your estimates are, on average, within 5% of the reference ibf.org
   - **Note** on zeros: If your reference HR array ever contains zeros (unlikely for HR but common in other bio-signals), handle or remove them before computing **MAPE** to avoid division errors.

```
PS C:\Users\20111\Downloads\capsule> &
MAE:  5.91 bpm
RMSE: 7.69 bpm
MAPE: 7.23%
PS C:\Users\20111\Downloads\capsule>
```

C- Conclusion output:



D- Github Link

- https://github.com/AhmedGehad1/Data_analytics.git