Image Based Contactless Blood Pressure Assessment using Pulse Transit Time

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Outline

- Motivation
- Methods
- Experimental Results
- Conclusion
Motivation

- Observation: Funny Phenomenon

Mechanism

Measuring BP with WebCam

• Limitations of using wearable devices:
  • Skin Irritation after a long usage.
  • Not suitable for new-born.
• Previous non-contact methods
  • E.g. Radar, Thermal imaging → Expensive.
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Operation Principle
HR & BP measurement

Stage I: iPPG Signal Recovery
- Camera
- ROI from face
- G-trace Calculation
- Band Pass Filter
- ROI from palm
- G-trace Calculation
- Band Pass Filter

Stage II: Feature Point Detection and IBI/iPTT Calculation
- Feature Points Detection
- iPTT Calculation
- HR Estimation
- KNN Model

Stage III: BP estimation using Transfer Learning
- SBP/DBP Estimation
- MIMIC II
- Transfer Learning
First Stage: IPPG Signal Recovery

Stage I: IPPG Signal Recovery

- **Camera**
- **ROI from face**
- **G-trace Calculation**
- **Band Pass Filter**

- **ROI from palm**
- **G-trace Calculation**
- **Band Pass Filter**

**iPPG_{face}(n)**

**iPPG_{palm}(n)**
Second Stage: HR & BP measurement

Stage II: Feature Point Detection and IBI/iPTT Calculation

- Feature Points Detection
- iPTT Calculation
- HR Estimation

**Features (n)**

**iPPG_{face} (n)**

**iPPG_{palm} (n)**

**Stage II**

- Feature Points Detection
- iPTT Calculation
- HR Estimation

**HR (bpm)**

\[ HR (bpm) = \frac{60 \times fps}{IBI} \]
Third Stage: BP Estimation using Transfer Learning

1. Unify using MSE:

2. Adaptation using Z-score.

\[ iPTT_N = \frac{iPTT - E[iPTT]}{\sqrt{Var[iPTT]}} \]
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Experimental Setup

• Assessed Material:
  – RGB webcam with VGA resolution.
  – 8-bit depth, 75 fps.
  – fluorescent lamp: around 400 Lux.
  – Ground-truth: Blood pressure cuff belt
  – FFT order: 512
  – 13 subjects (10 male and 3 female)
Experimental Setup

• Benchmark Algorithms: CHROM, CDM, POS.

![Timeline of a set of experiment](image)

Table 3. Statistic of Subjects

<table>
<thead>
<tr>
<th>Properties</th>
<th>Statistic</th>
<th>Max</th>
<th>Min</th>
<th>Avg.</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td>33</td>
<td>21</td>
<td>23.5</td>
<td>2.7</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td>29.1</td>
<td>18.7</td>
<td>22</td>
<td>2.6</td>
</tr>
<tr>
<td>SBP(mmHg)</td>
<td></td>
<td>135.00</td>
<td>84.00</td>
<td>110.03</td>
<td>11.05</td>
</tr>
<tr>
<td>DBP(mmHg)</td>
<td></td>
<td>91.00</td>
<td>57.00</td>
<td>72.78</td>
<td>7.50</td>
</tr>
<tr>
<td>HR(bpm)</td>
<td></td>
<td>89.00</td>
<td>53.00</td>
<td>70.55</td>
<td>7.75</td>
</tr>
</tbody>
</table>

*S.D. = Standard Deviation, BMI = Body Mass Index*

![Distribution of collected data](image)
## Benchmark Methods

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>FPS</strong></td>
<td>75</td>
<td>420</td>
</tr>
<tr>
<td><strong>Measure Position</strong></td>
<td>Face, Palm</td>
<td>Face, Palm</td>
</tr>
<tr>
<td><strong>BP Type</strong></td>
<td>SBP, DBP</td>
<td>SBP only</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>KNN</td>
<td>LSM</td>
</tr>
<tr>
<td><strong>Personalize/Generalize</strong></td>
<td>Generalize</td>
<td>Personalize</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>General model using transfer learning with MIMIC II and self-built DB</td>
<td>Personalized model for each individual subject</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>MIMIC II data comes from ICU patients.</td>
<td>Tedious process is essential before building model.</td>
</tr>
</tbody>
</table>

# Experimental Results

## Table 5. Performance Compare of BP Measurement

<table>
<thead>
<tr>
<th>Training Set</th>
<th>Signal</th>
<th># of Data</th>
<th>Method</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SBP</td>
<td>DBP</td>
</tr>
<tr>
<td>Camera</td>
<td>iPPG</td>
<td>1,300</td>
<td>Proposed</td>
<td>16.50</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Benchmark</td>
<td>15.08</td>
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<tr>
<td></td>
<td>PPG</td>
<td>15,551</td>
<td>Proposed</td>
<td>14.19</td>
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<tr>
<td></td>
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<td></td>
<td>Benchmark</td>
<td>16.18</td>
</tr>
<tr>
<td>Camera+MIMIC</td>
<td>iPPG+PPG</td>
<td>16,851</td>
<td>Proposed</td>
<td>14.02</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Benchmark</td>
<td>16.17</td>
</tr>
</tbody>
</table>

*unit = mmHg*
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Conclusion

• First, we integrated the iPTT and remote PPG to estimate Blood Pressure with relative low frame rate.
• Then, we proposed a new type of iPTT which is suitable for image based PPG.
• To increase the valid training data, we trained model with the aid of MIMIC 2 database.
• Root mean square error is successfully reduced to 14.02 mmHg.
Thank you for listening