Systolic blood pressure estimation using PPG during physical exercise
Sun, S.; Bezemer, R.; Long, X.; Muehlsteff, J.; Aarts, R.M.

Published in:
38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, August 17-20, 2016, Orlando, Florida

Published: 01/08/2016

Document Version
Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:
- A submitted manuscript is the author's version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 29. Dec. 2018
Systolic blood pressure estimation using PPG during physical exercise
Shaoxiong Sun\textsuperscript{1,2}, Rick Bezemer\textsuperscript{1,2}, Xi Long\textsuperscript{1,2}, Jens Muehlsteff\textsuperscript{3}, Ronald M. Aarts\textsuperscript{1,2}
\textsuperscript{1}Department of Electrical Engineering, Eindhoven University of Technology, The Netherlands
\textsuperscript{2}Philips Research, Eindhoven, The Netherlands.
Email: s.sun@tue.nl

Conclusions

\begin{itemize}
  \item The estimated SBP had high correlations with the measured SBP, while the RMSE still warrants further attention.
  \item The features we proposed such as \(d_{\text{mean}}\) and \(s_{\text{var}}\) played important roles as indicated by the larger normalized weights.
\end{itemize}

Materials and Methods

\begin{itemize}
  \item N = 19 healthy subjects doing 30-minute cycling exercise
  \item We initialized the model for each subject at rest.
  \item We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
  \item We evaluated model performance using leave one subject out cross validation (LOSOCV).
\end{itemize}

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.

Materials and Methods

N = 19 healthy subjects doing 30-minute cycling exercise
We initialized the model for each subject at rest.
We derived 18 features (including 4 proposed features), combined these features using linear regression and quantified their contribution by means of normalized weights.
We evaluated model performance using leave one subject out cross validation (LOSOCV).

Results

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Bias & -0.04 mmHg \\
Standard deviation & 14.07 mmHg \\
Median intra-subject correlation coefficient & 0.85 \\
\hline
\end{tabular}
\caption{Model performance}
\end{table}

Fig. 1. Finger photoplethymography

Materials and Methods

Continuous monitoring of blood pressure not only provides immediate physiological parameters for patient care and monitoring, but also reveals health risks that might eventually lead to hypertension or arteriosclerosis.

Measurements using brachial cuff can be only obtained intermittently. Measurements using finger cuff is not suitable for long-term use. Measurements using an invasive arterial catheter expose patients to infection risks.

Photoplethysmography (PPG) has been considered as a method to estimate blood pressure.

We designed a model using multiple PPG-derived features to estimate systolic blood pressure (SBP) for healthy people during physical exercise.