Methods of Blood Pressure Predictions for Noninvasive Sensors

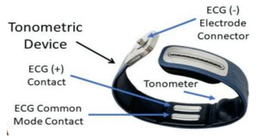
Morayo Adeyemi*†, Parker Ruth†
*Howard University, †Stanford Department of Computer Science

Howard University | Karsh STEM Scholars Program

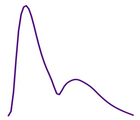
Stanford University

Introduction

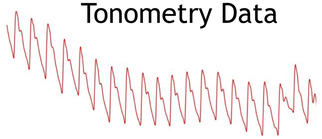
Over 580 million people worldwide have hypertension but are undiagnosed.[1] Hypertension is preventable and curable if identified. 24 hour BP cuff sensing is better than your once a year office BP test.[2] However, there is no existing sensor for practical continuous BP sensing. The Microsoft tonometer device continuously measures pulse pressure.[3] Can a simulated pulse wave database[4] be reflective of real data?



Simulated Data



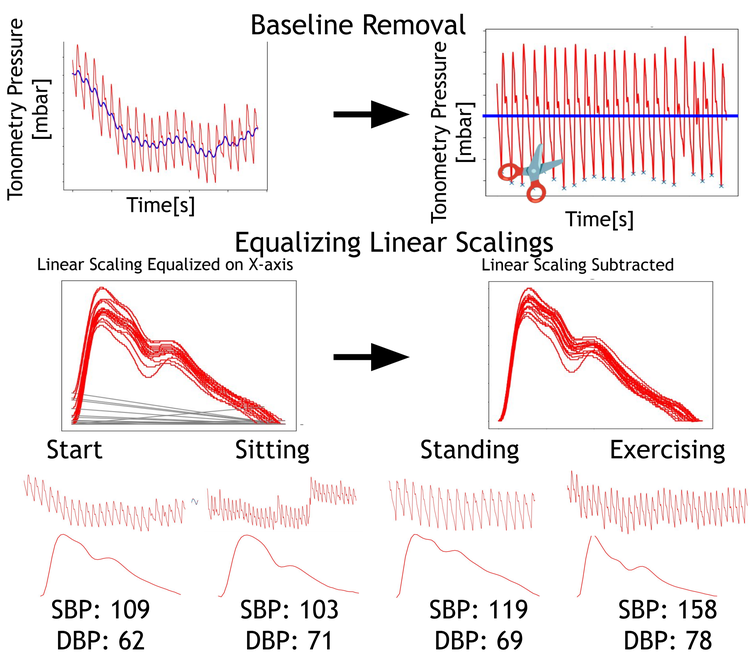
Tonometry Data



Goal

Compare similar 1D pulse shapes to predict blood pressure from real and simulated pulse waveform data using learning models.

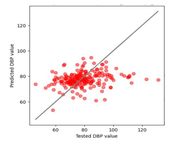
Methods



1 Linear Regression

Benefits:
- Is a great baseline

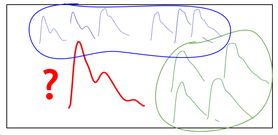
Cons:
- Pulse waves are non-linear



2 K-nearest neighbors

Benefits:
- Compares pulse shape

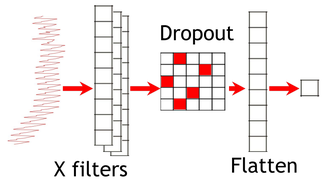
Cons:
- Same shaped pulses have different BP values



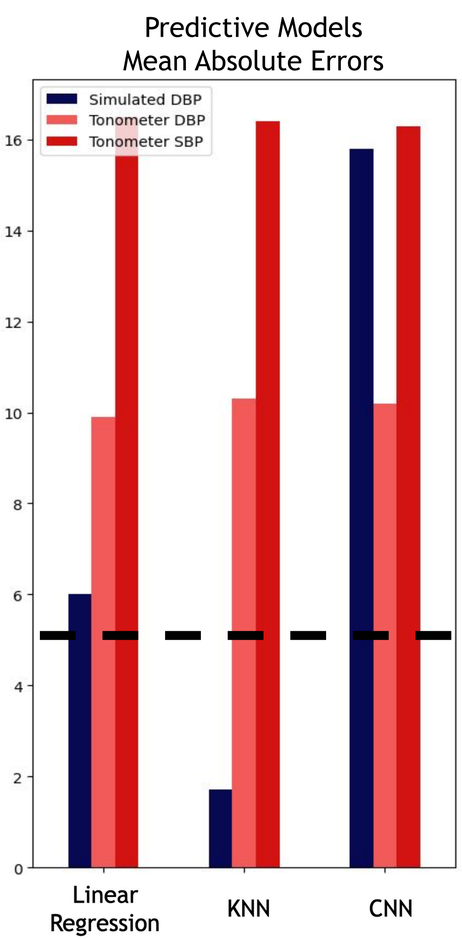
3 Convolutional Neural Network

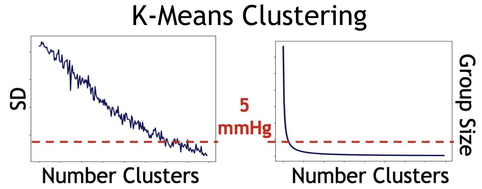
Benefits:
- Can learn complex connections

Cons:
- Risk of overfitting

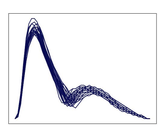


Results

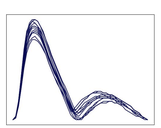




Simulated Data
15 unique simulated pulse shapes



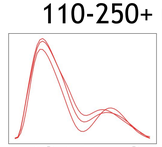
DBP: 77.3 ± 1.5



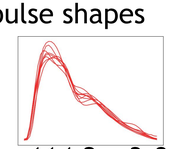
DBP: 77.4 ± 1.5

VS

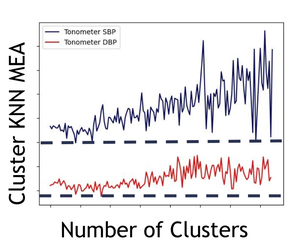
Tonometry Data
110-250+ unique pulse shapes



SBP: 134.5 ± 34.0
DBP: 85.8 ± 20.8



SBP: 114.2 ± 3.8
DBP: 57.5 ± 6.0



KNN with clusters

15%

improvement compared to CNNs

Discussion

- There are groups of similar tonometer pulses; however, achieving low BP variation within a group requires an average of only 5-10 pulses per group, which is insufficient for predictive model testing.
- The gap in simulated and real predictions arises from the simulated dataset being over simplified compared to human body
- Sampling the pulse in even split did not capture important features

Future Work

Explore more advanced CNN architectures to better capture complex patterns in pulse waveforms. Additionally, optimizing segmentation techniques to retain critical pulse features will enhance the models' performance.

Conclusion

This project compares the performance of blood pressure inference models across 1D simulated and real-world data. CNNs perform best on real-world data, while KNN performs best on simulated data. Grouping pulses by 1D similarity and using a KNN model can improve real-world BP prediction by 15% compared to CNNs.

References

[1] World Health Organization. More than 700 million people with untreated hypertension, 2021
[2] Giuseppe Mancia, Paolo Verdecchia. "Clinical Value of Ambulatory Blood Pressure: Evidence and Limits." Ahajournals, 2015
[3] R.J. Mieloszyk et al. "A Comparison of Wearable Tonometry, Photoplethysmography, and Electrocardiography for Cuffless Measurement of Blood Pressure in an Ambulatory Setting," IEEE Journal of Biomedical and Health Informatics, vol. 26, no. 7, pp. 2864-2875, 2022
[4] Charlton P.H., Mariscal Harana, J., Vennin, S., Li, Y., Chowienczyk, P. & Alastruey, J., "Modelling arterial pulse waves in healthy ageing: a database for in silico evaluation of haemodynamics and pulse wave indices," AJP Heart. Circ. Physiol., [in press], 2019.