Please cite the Published Version

Ray, Daniel, Collins, Tim and Ponnapalli, Prasad (2021) Deep Neural Network Architecture Search for Wearable Heart Rate Estimations. Studies in health technology and informatics, 281. pp. 1106-1107. ISSN 0926-9630

DOI: https://doi.org/10.3233/shti210366

Publisher: IOP Press

Version: Published Version

Public Health and Informatics
J. Mantas et al. (Eds.)

doi:10.3233/SHTI210366

Deep Neural Network Architecture Search for Wearable Heart Rate Estimations

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Abstract. Extracting accurate heart rate estimations from wrist-worn photoplethysmography (PPG) devices is challenging due to the signal containing artifacts from several sources. Deep Learning approaches have shown very promising results outperforming classical methods with improvements of 21% and 31% on two state-of-the-art datasets. This paper provides an analysis of several data-driven methods for creating deep neural network architectures with hopes of further improvements.

Keywords. wearables, heart rate, photoplethysmography, deep neural networks, network architecture search.

1. Introduction

Wrist-worn PPG heart rate monitors provide an unobtrusive and low-cost method for continuous heart rate measurements, widely adopted in both commercial and clinical settings [1,2]. Researchers have identified several factors, such as motion, skin characteristics and ambient light, that cause the acquired signal to contain artifacts making the extraction of accurate heart rate estimations challenging [2]. Deep Neural Networks (DNN) have seen promising results as a method to accurately estimate heart rate from signals that contain artifacts [1]. However, applying a data-driven approach may improve on state-of-the-art deep learning methods by creating elaborate and complex network architectures that would be un-achievable for machine learning engineers to create due to the enormous search space of compounded architectural components.

2. Methods

Several Network Architecture Search strategies will be applied to the current state-of-the-art PPG datasets [1,3,4] to establish an architecture that improves upon the accuracy achieved in [1]. These strategies include Reinforcement Learning [5], NeuroEvolution of Augmenting Typologies [6] and a Bayesian Optimization Network Morphing method [7]. The current standard is to use both PPG and 3-axis accelerometer, as a motion reference, signals which are segmented into overlapping sliding windows [1]. The 'truth' values of each window are recorded using a chest-

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worn Electrocardiography device. Each window is then transformed into the frequency domain using a Fourier Transform, then inputted into the network during the training process using Mean Absolute Error (MAE) as comparable metric.

3. Results

Preliminary results show the method of Network Morphing [7] created an architecture that achieved a MAE of 18.2 BPM after 10 iterations. These results would be expected to dramatically improve as more iterations are carried out, allowing for more complex and elaborate architectures to be created as well as exploring ensemble learning.

4. Discussion

Establishing accurate methods for heart rate extraction from wrist-worn PPG devices is becoming increasingly important due to an expanded use in clinical settings [2] as they provide an unobtrusive and low-cost method for continuous heart rate measurements. Classical methods using statistical and signal processing techniques have much smaller computational footprints compared to DNN techniques. However, in periods of intense activities the DNN method outperformed the classical methods by a MAE of 8.91 BPM [1].

5. Conclusion

Preliminary results show that network architecture search is a viable method for creating architectures that would be un-achievable for machine learning engineers to create due to the enormous search space. With more search iterations and analysis of differing strategies, improvements on MAE are likely to be achieved.

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