PCovNet+: A CNN-VAE anomaly detection framework with LSTM embeddings for smartwatch-based COVID-19 detection

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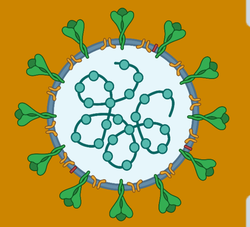
SCAN ME



INTRODUCTION

The COVID-19 pandemic has highlighted the lack of preparedness in healthcare systems worldwide. Smartwatches and fitness trackers can be used for passive COVID-19 monitoring. Wearable devices can monitor heart rate, heart rate variability, and other health metrics to detect COVID-19. Artificial intelligence (AI) has played a significant role in wearables-based early COVID-19 detection.

Dataset distribution. The left donut chart denotes the phase-1 dataset and the left one represents the phase-2 dataset

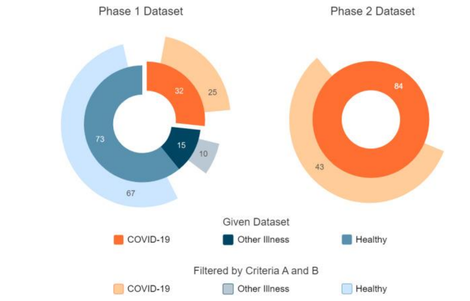
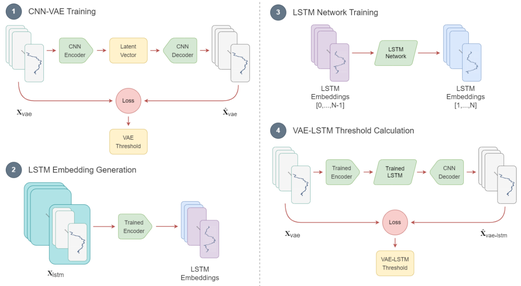


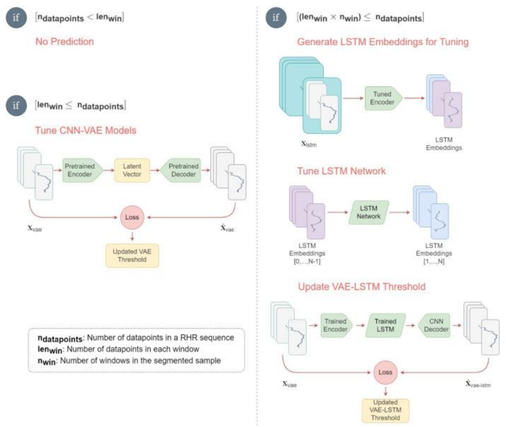
Diagram of training sequence of PCovNet+ framework



METHODOLOGY

Researchers from Stanford University collected data on COVID-19 patients' vitals using smartwatches and a survey platform. The first phase included 32 COVID-19 patients, and the second phase included 84 patients with wearable data. The combined dataset consisted of 68 COVID-19 patients, 10 patients with other illnesses, and 67 healthy individuals. The wearables data needed to contain heart rate and steps during the same timestamps and range from at least 20 days before the symptom onset to 21 days afterward. The PCovNet+ framework was developed and validated on this combined data. The study aimed to detect anomalies in the data to identify COVID-19 infections.

Implementation steps of PCovNet+ framework for online learning. Different steps are shown in the diagram based on the availability of data during real-time implementation.

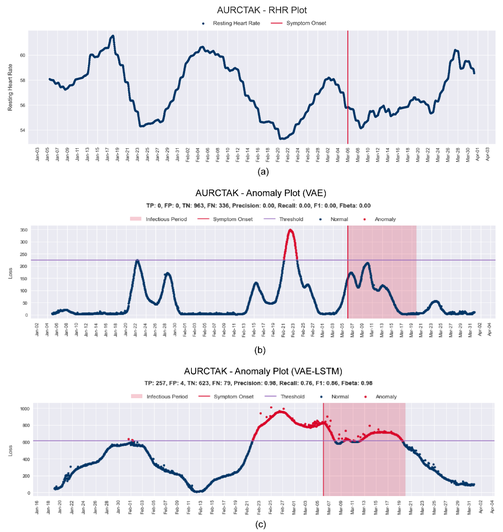


Different test sets from the infection periods, where the test set contains (a) all the data after the baseline region, (b) non-infectious period and Day 0 to Day 14, (c) only Day 0 to Day 14 and the recovery period, (d) Day 0 to Day 14, and (d) only Day 0 to Day 7.

CONCLUSION

- The study presents the PCovNet+ framework for anomalous RHR detection using smartwatch data, which is an improvement over the previous work. The framework is based on an anomaly detection model.
- The experiments show a significant improvement in the statistical metrics, and the lack of ground truth issue is addressed. This study explores the COVID-19 prediction using smartwatch data further and improves the robustness of the previous work.
- Although this system cannot replace laboratory-based active detection systems, it can be used as a secondary diagnostic tool and can be useful in regular human life to combat respiratory diseases.

(a) RHR Plot and the difference between anomaly plots (b) before and (c) after LSTM embeddings for subject id AURCTAK from the Phase-1 dataset.



DISCUSSION

This work developed a framework to detect anomalous RHR using smartwatch data. The framework used a combination of CNN-VAE and LSTM networks. The CNN-VAE network was used to generate latent vectors, and the LSTM network was used to generate temporal-aware embeddings. These embeddings were then used to generate a reconstructed signal by the CNN-VAE decoder. The framework was trained using only normal RHR data.

Abir, F. F., Chowdhury, M. E., Tapotee, M. I., Mushtak, A., Khandakar, A., Mahmud, S., & Hasan, A. (2023). PCovNet+: A CNN-VAE anomaly detection framework with LSTM embeddings for smartwatch-based COVID-19 detection. *Engineering Applications of Artificial Intelligence, 122*, 106130. doi:10.1016/j.engappai.2023.106130

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