PulMon-C: A Real-time Monitoring Framework of Pulmonary Function

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BACKGROUND:

This project will develop **PulMon-C**, a real-time monitoring framework of pulmonary function to diagnose COVID-19 patients who are being self-quarantined at home. The tool will identify anomalies in breathe rate and predict pulmonary deterioration to raise alert for immediate actions. The uniqueness of the tool is using non-invasive sensors placed under-mattress that are able to communicate data about the respiratory signal. The customer segment of PulMon-C will be the diagnosed COVID-19 patients and healthcare providers. PulMon-C will assist with the remote monitoring of COVID-19 patients as an urgent need in the USA and will bring larger impact in delivering medical care for worsening conditions of COVID-19 patients timely without overwhelming hospital systems that have otherwise limited capacity and resources. The goal of the research is to perform the needed R&D for real-time monitoring of COVID-19 patients, develop and test signal processing techniques, and preliminary evaluation through end users and healthcare professionals.

METHODS:

PulMon-C consists of an under-mattress pressure sensor that senses and communicates data about the respiratory signal of the person lying on a bed. Using intrinsic mode functions (IMF) and principal component analysis (PCA) as signal processing techniques, PulMon-C is able to extract the respiration rate of a person without using other kinds of apparatus. The extracted signal is sent to a Cloud (PulMon-C Cloud) directly connected with the healthcare provider in real-time using a powerful stream-data database (Influx DB). The system provides real-time monitoring of the patient's respiratory rate by showing up-to-date stream data of the breath that is refreshed every five or less seconds. When the patient presents a rapid deterioration of the pulmonary function, the system triggers an alert to the healthcare provider, who can check the status in the system. The rapid deterioration is measured by the analysis of shortness of breath indicators in the time and frequency domain and the alerts are configured in a powerful visualization tool (Grafana).

RESULTS:

With our initial prototype, we were able to collect pressure data into the cloud service. The prototype consists on a Raspberry Pi 4 that is connected to a BPM180 pressure sensor that transfers the data using a 12C Shield digitizer. The Raspberry Pi incorporates a local database that is accessed via Wireless by the Cloud that contains a powerful data visualization tool. The

data is collected continuously by a service that reads the digital data and save it into the database. Because the access is done in real-time, the user can see the pressure data every second. We expect that the tool will be a unique addition for affordable care of tracking the pulmonary function and monitoring respiration rate from the comfort of their home; the device can provide real-time transferring of information to the healthcare provider too. The long-term impact includes a real-time report of the diagnosed patients by hospitals and clinics and getting alerts when a patient is in rapid pulmonary deterioration. Healthcare providers can plan in advance their available resources as PulMon-C will provide a prediction of future patient's condition (using machine learning) based on the current and past hours/days of monitoring. PulMon-C analyzes the data and provides real-time information directly to the hospital, which is convenient and useful for both the healthcare provider and the patient. This technology will have a major social impact on diagnosed individuals.

CONCLUSIONS:

Incorporating a real-time and easy-to-use system for monitoring COVID-19 patient's pulmonary function from home is a life-changing technology for patients and healthcare providers. **PulMon-C** will be the first real-time monitoring framework of COVID-19 patients who are being self-quarantined from home.