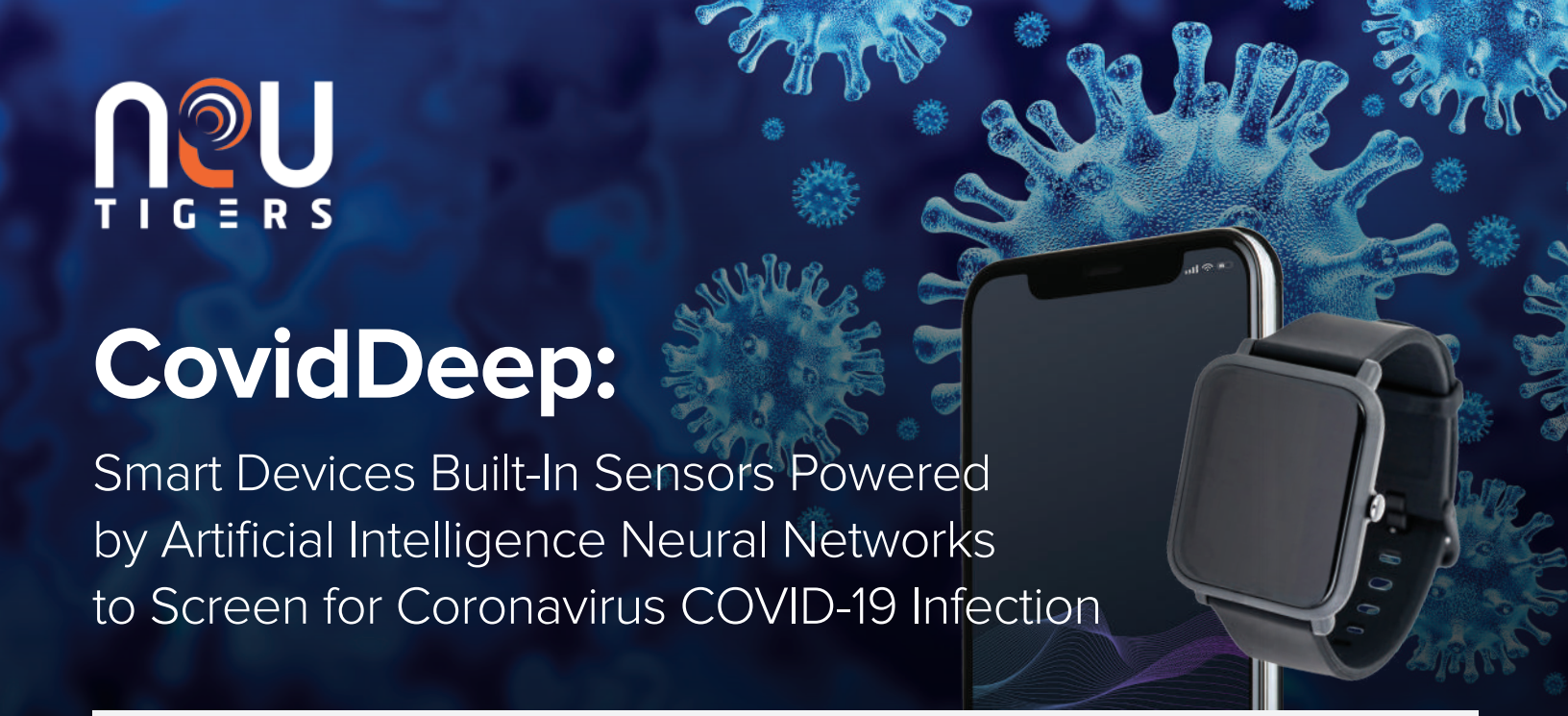


CovidDeep:

Smart Devices Built-In Sensors Powered by Artificial Intelligence Neural Networks to Screen for Coronavirus COVID-19 Infection

The COVID-19 pandemic poses a major threat to all countries around the world. The world has needed to largely shut down the global economy due to our current inability to test everyone every day.

The existing bottlenecks in biological testing capacity are likely to continue in the coming months or possibly years until a vaccine is developed and deployed globally. The challenge is to isolate confirmed cases and their contacts in a way that is compatible with our shared understanding of privacy in western democracies. To bring COVID-19 under control, we must act in the same manner; speed and cooperation are essential to protect health, privacy, and the global economy.

THE REASON

Even with close to $4T in annual healthcare expenditure, the world has been caught by surprise by the coronavirus. The resultant respiratory illness, COVID-19, has created havoc around the world. Coronaviruses are a family of viruses that cause illness in humans or animals. The novel coronavirus, COVID-19, was first discovered in Wuhan-China in December 2019. During the last six months, the virus has spread widely worldwide, and was classified as a pandemic by the WHO on January 30th, 2020. Furthermore, all countries are striving to control the coronavirus disease COVID-19. As of June 30th, 2020, this deadly virus has led to 10 million cases and 0.5 million deaths worldwide, with the US unfortunately leading the pack with respectively 2.5 million and 125 thousand followed by Brazil, Italy, Spain, and China. The confirmed COVID-19 patient's symptoms manifesting in the early phase include fever, tiredness, and dry cough, before reaching a possible lethal phase because of respiratory distress. Less common symptoms include nasal congestion, sore throat, temporary loss of taste or smell, muscle and body aches, and gastrointestinal symptoms.

There is a pressing need for any and all solutions that can help mitigate this crisis. While there are many mechanisms for detecting the coronavirus disease, COVID-19, including clinical analysis of chest CT scan images and blood test results, these are costly and take time to obtain. One novel approach is to deploy machine learning models as physician aides to expedite data-driven decision-making. The solution combines efficient Artificial Intelligence (AI) neural networks with off-the-shelf built-in wearable medical sensors (WMSs) for pervasive diagnosis of the coronavirus disease, COVID-19. WMSs enable a longitudinal, yet user-transparent, mechanism to collect and analyze physiological signals. Such an approach bridges the gap between temporal clinical checkup and continuous daily monitoring. The proposal provides a low-cost solution since most of the healthcare professionals and individuals have already adopted smartphones and apps for different everyday purposes. Capturing physiological and behavioral data and embedding intelligent diagnosis services into a growing number of wearable device users globally could significantly improve the timeliness and precision of public health responses.

THE SOLUTION

In recent years, computer-based clinical decision support (CDS) has significantly improved the quality of general healthcare, thanks to the rapid advancement of data science and electronic health records. The emerging biomedical wearable sensors (WMSs) have further changed the landscape of conventional healthcare by enabling personalized, continuous monitoring, making predictive health monitoring not only a rising trend for smart health but also a potent tool for physicians.

We are currently partnering with two hospitals (San Matteo, Pavia, Italy, and Jefferson Health, Philadelphia) to obtain WMS based physiological data and some other data from COVID-19 patients as well as healthy individuals. In collaboration with San Matteo Hospital in Italy, we have collected this digital physiological data with a paired mobile device, Empatica E4 smartwatch and a Samsung Galaxy S8 smartphone. All data collection has been done in a HIPAA/GPDR compliant manner.

A proprietary AI algorithm enabled framework reads the smartphone/ smartwatch sensor signal measurements to support the prediction of the grade of severity of the COVID-19 disease. The collected data will be preprocessed and denoised, after which we will extract useful inferences and make predictions/decisions by leveraging state-of-the-art machine learning algorithms. The functionality and feasibility of both continuous monitoring and diagnosis decision support will be intensively studied and verified.

Our solution, called CovidDeep, is an AI-powered monitoring and screening tool that can detect the different phases of the COVID-19 infection, from healthy (tested Covid-) versus asymptomatic (tested Covid+ that can stay home) versus symptomatic (Covid+ that needs hospitalization). CovidDeep is wearables-based, noninvasive, and non-obtrusive (no wires, no needles, no pain), designed to be worn for continuous physiological monitoring and detection. CovidDeep is scalable and deployable everywhere at the point of care (private and public urgent care clinics, retail drug stores, local medical doctors), and beyond at sport events, public transportation (airports, trains, buses), corporate businesses, in brief in everyday's life of a person.

The outcome is an enterprise-grade solution deployable for masses that will provide early warning signs of infection from mild cases to critical illness, help people self-quarantine preventively, get treatment sooner and, importantly, put the country back to work and save our economy.

THE RESULTS

In this study, we have designed and developed a framework called CovidDeep. It combines off-the-shelf wearable-based sensors (WMSs) with efficient AI Neural Networks for real-time monitoring and screening of COVID-19 even when the individual is not in a clinic or hospital and is going on with his/her daily life.

We evaluated CovidDeep based on data collected from 87 participants in a controlled clinical trial. Our system achieves 98% accuracy in distinguishing among healthy, versus asymptomatic, and symptomatic COVID-19 subjects. We have demonstrated that CovidDeep can be employed in a pervasive fashion across a diverse set of mobiles and wearable devices while offering high efficiency and accuracy.

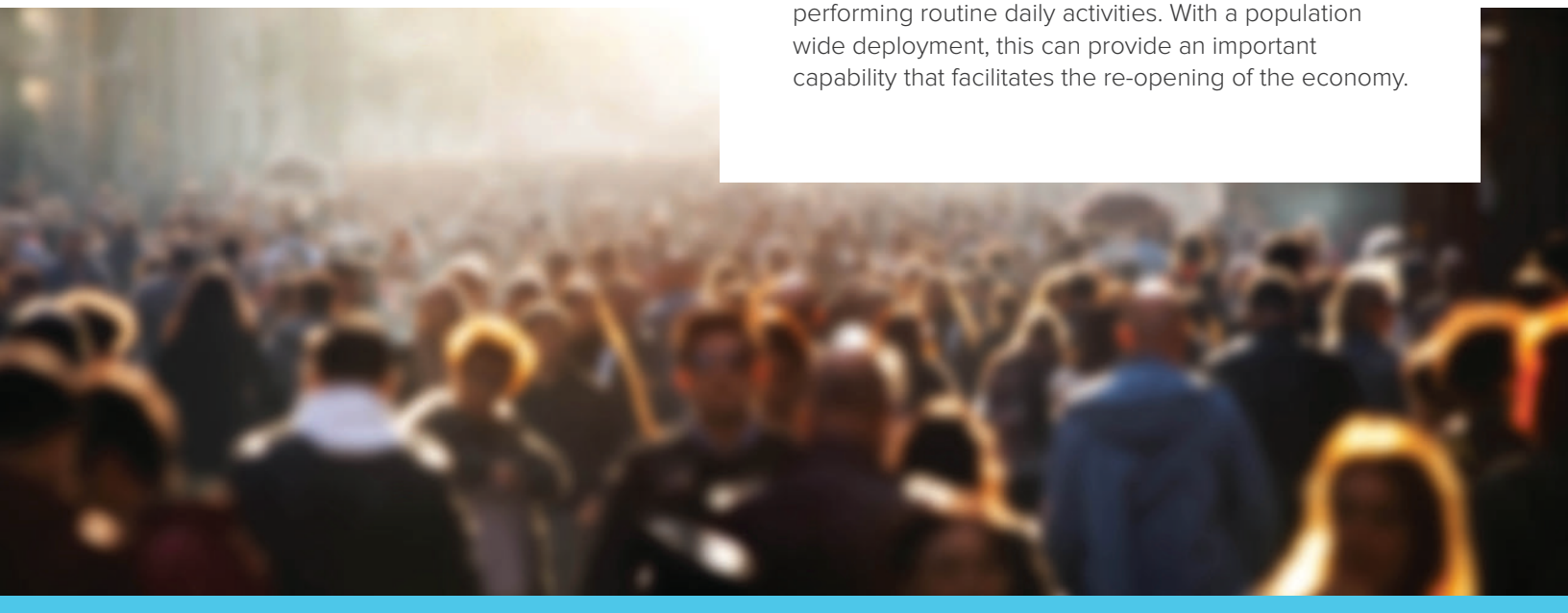
The anticipated outcome is a suite of energy/memory/latency-efficient neural networks that provide accurate COVID-19 screening based on data collected from a given subset of devices through an app on the smartphone. The software platform features a secure, scalable, and HIPAA/GDPR compliant infrastructure to capture, transport, and process the data. The capture is done using a smartphone app connected to sensor devices. The app captures and transports data over a secure channel without any intervention from the staff to ensure the security and integrity of the data. The data has been anonymized at capture to preclude the possibility of transporting personal health information. In addition, the captured data will be encrypted, and controls will be in place to make sure only authorized personnel can access them. The software developed uses agile methodology with an emphasis on testing to ensure quality.

The product consists of three parts—data capture smartphone app, data processing and machine learning platform, and the inference/validation smartphone app. The final deliverable is an inference/prediction smartphone app that embeds the neural network developed using the captured data. This app can be used to classify an individual into one of the three COVID-19 cohorts. This capability is anticipated to provide a COVID-19 symptom detection rate with greater than 95% accuracy.

CovidDeep opens the potential for future WMS-based disease diagnosis studies, given that more than 69,000 diseases exist.

We hope that this study will encourage clinics/hospitals/researchers to start collecting WMS data from individuals across more challenging diagnostic tasks, e.g., for managing long-term chronic conditions such as diabetes, hypertension, mental health disorders, cancers, and others.

NeuTigers innovative technology, grow-and-prune synthesis paradigm may even support continuous disease trend forecasting capability, given its continuous learning capability. As more data becomes available and is analyzed with the proposed methodology, its effectiveness as a scalable approach for future pervasive diagnosis and medication level determination will continue to improve. This capability will allow individuals to self-monitor for the virus while performing routine daily activities. With a population wide deployment, this can provide an important capability that facilitates the re-opening of the economy.



"When we think about an AI-powered future, CovidDeep, a COVID-19 screening solution is just the beginning. Our work enables state-of-the-art AI applications to advance smarter healthcare at the point of care," says Adel Laoui, CEO & Founder of NeuTigers. "But our work doesn't stop there, we have a responsibility to apply our technology in ways that support the greater global good, and we're poised to tackle and strategically address issues across many IoT verticals, edge computing, cybersecurity, and others."

— Adel Laoui, CEO NeuTigers, Inc.

Name of Facility

- San Matteo Hospital, Pavia, Italy
- NeuTigers/Princeton University, Princeton, New Jersey
- Rajant, Malvern, Philadelphia

The Partners

- NeuTigers/Princeton University
- Rajant
- San Matteo Hospital

Solution Components

- HIPAA/GDPR Compliant Data Collection Platform
- Multimodal Hardware Devices System
- AI Energy-Latency Efficient Technologies for the Edge Devices

Outcome and Impact

- Advance Smart Healthcare
- Protect our Healthcare Front Line Workers, and Individuals
- Re-open the Economy

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