COVID-VISION: Covid-19 Real-time Outbreak Detection System

Abstract

The Coronavirus (COVID-19) pandemic has left the Global economy and healthcare infrastructure tattered. The most effeictive way to get the economy back on track is an effective national mitigation effort, and delivering the testing resources and technological capability to test the entire population of nation-states for COVID-19 viral infection, in the hands of front-line healthcare workers. This research initiative is to create customized and optimized outbreak detection DNN models, to be deployed on wearable/desktop embedded systems, for the real-time detection of the COVID-19 virus, which will lead a more robust and effective global response to the virus, through biosurveillance and outbreak detection.

1 Background

It is our purpose to create A.I. solutions that have maximum human impact, using the most leading-edge commercial technologies available to civilians. The nature of our small team, and attention to detail, has allowed our team to outperform larger agencies in the novel nature of our A.I. research, trade secrets, model accuracy, and the ability to adapt and change direction fairly quickly in a post-coronavirus world.

COVID_VISION was created in the backdrop of the worst epidemic in recent history. The number of COVID-19 cases has been increasing since December 2019, which is the driving force behind global demand for COVID-19 testing. The mortality rate for COVID-19 was reported to be up to 30 per thousand people, much higher than the influenza pandemic in 2019. Thus, COVID-19 outbreak detection kit demand will increase with the evolving COVID-19 pandemic.

In the past, our work has involved the detection of diseases using computer vision, such as Autism, with accuracy rates as high as 99.22%. Additionally, the team also has experience with infectious as well as non-infectious diseases. The teams initial experiences with infectious diseases came during the teams participation in the Nvidia Inception Program for A.I. Startups. The team specializes in high-accuracy Deep Neural Networks (DNN's), has achieved 99.99% accuracy rates to detect the common cold and flu. While participating in the Global Hack, in an effort to address the rapidly spreading Corona Virus, the team developed a precursor to the COVID_VISION as it exists today.

The Team gained subsequent support for the project, by partnering with the University of Colorado, Colorado Springs, Oracle for Startups, the COVID Accelerator, and Amazon Web Services. Each entity has provided the on-going project with research resources, human capital, cloud-based infrastructure, access to mentoring, and technical engineers. In particular, Nvidia provided I8I with $110,000 in cloud credits and business services. The Team 's experience with accelerated computing, which is necessary in order to process the complex algorithms and DNN's, is extensive in the cloud and on bare-metal.

We chose to initially focus on ways to mitigate the virus using real-time embedded and/or cloud-based systems. According to data from the Centers for Disease Control and Prevention (CDC), as of April 9, 2020, 9,282 COVID-19 cases were reported among healthcare professionals (HCP), who

reported contact with COVID-19 patients in healthcare, household, and community settings.[1] Globally, according to data compiled by John Hopkins University, 251,718 people have died from the virus, with 70,847 of those deaths occurring in the United States.[2] This research will show the great need for testing, and inefficiencies with current methods.

As of May 16, 2020, many states are beginning to reopen, with more in the coming weeks. The reopening goes against many recommendation within the medical community. For example, according to the CDC, as of May 11, all 12 models forecast an increase in deaths in the coming weeks, and a cumulative total exceeding 100,000 by June 1.[3] The COVID-19 virus has already infected more than 1.4 million Americans, and killed more than 84,700 according to tracking by John Hopkins University.[4] Furthermore, President Donald Trump in late March shared White House projections that the death toll could hit between 100,000 and 240,000 Americans, although he spun the forecast as a success, in contrast to an earlier model that predicted more than 2 million deaths if no effort was made to contain the disease.[5]

According to Paul Romer, a professor of economics at New York University, COVID-19 containment will not only require testing repeatedly, on the order of the entire US population every two weeks...even 35 million tests per day may not be enough.[6] The test themselves must also improve, while the most common RT-PCR genetic tests for the SARS-CoV-2 virus can test dozens of specimens at once but can take hours to run at in-house labs at a hospital or clinic. These tests can take days to get results, if the tests need to be sent to an outside lab.

The Food and Drug Administration recently approved a genetic molecular test from Abbot Laboratories that can deliver positive results in as little as five minutes, but can only deliver negative results in 13 minutes.[7] But the system can only run one sample at a time, and Abbot is currently aiming at running as many as 50,000 tests per day, which is far below the million experts say is needed. The innovation that COVID_VISION provides, is that it allows for instant test results using Artificial Intelligence. This allows not only one person to be tested within 10 seconds, but for multiple patients to be tested at the same time, using object detection and computer vision, which allows for the virus to be detected in a crowded room. While the screen capturing of the current readings of the device take 10 seconds, HCP will know instantly what the status of the patient is. This object detection feature will allow for even more than 2,880 persons per day to be analyzed per

1   Morbidity and Mortality Weekly Report: Characteristics of Healthcare Personnel with COVID-19 2019 (COVID-19). CDC Centers for Disease Control and Prevention. April 17, 2020. Accessed Jun 5, 2020. https://www.cdc.gov/mmwr/volumes/69/wr/mm6915e6.htm.

2   Erin D. Impact of the coronavirus pandemic on the global economy - Statistics & Facts. April 28, 2020. Accessed May 17, 2020. https://www.statista.com/topics/6139/covid-19-impact-on-the-global-economy.

3   Paul L. Why state reopenings have sent projected coronavirus death rates back up. May 11, 2020. Accessed May 20, 2020. https://www.cnn.com/2020/05/11/politics/what-matters-may-10/index.html.

4   Susannah L. U.S. on pace to pass 100,000 Covid-19 deaths by June 1, CDC director says. May 15, 2020. https://www.politico.com/news/2020/05/15/us-on-pace-to-pass-100-000-covid-19-deaths-by-june-1-cdc-director-says-261468.

5   Donald T. Proclamation on Declaring a National Emergency Concerning the Novel Coronavirus Disease (COVID-19) Outbreak. March 13, 2020. https://www.whitehouse.gov/presidential-actions/proclamation-declaring-national-emergency-concerning-novel-coronavirus-disease-covid-19-outbreak.

6   Umair I. The case for ending the Covid-19 pandemic with mass testing. April 13, 2020. Accessed May 20, 2020. https://www.vox.com/2020/4/13/21215133/coronavirus-testing-covid-19-tests-screening.

7   Rachana, P. Abbott's Fast COVID Test Poses Safety Issues, Lab Workers Say. April 23, 2020. Accessed May 20, 2020. https://khn.org/news/abbotts-fast-covid-test-poses-safety-issues-lab-workers-say.

device. Even if the HCP chooses to analyze one person at a time, the total that can be analyzed with our projected release of 100,000 devices, will be 288,000,000 patients per day, more than meeting the requirements of experts. With the spread of near instant analysis of COVID-19 devices, the entire U.S. population of nearly 330 million could be tested every two days. Thus, the first innovation is the ability to instantly test a patient using A.I. accelerated computing, and will look for the following CDC designated COVID-19 symptoms: fever, chills, muscle pain, sore throat, nausea, vomiting, chest pain, confusion, fatigue, runny nose, sneezing, bluish lips or face, cough, and shortness of breath. It is our desire to bring the most advanced technology available to civilian society, to the front lines of the global pandemic.[8]

2 Current Methodologies for Covid-19 Detection

The U.S. Food and Drug Administration has issued the emergency authorization to use three types of detection methods for the COVID-19 virus: PCR test, Antibody test, and Antigen test. The first type of test, uses technology called PCR (polymerase chain reaction).[9] A PCR test may cost as much as $100. These tests generally are the most reliable, but may not identify someone who has recently been infected. Likewise, the swabbing of the throat and nose required a HCP to get within the 6-feet of recommended social distancing, and also require the HCP to swirl the specimen in an open container with liquid chemicals. The latest test, the Abbott ID NOW, has caused complaints to surface from lab personnel who are worried about the safety of the rapid coronavirus tests, particularly, the risk of infection to those handling it.[10] Another manufacturer of rapid tests, Cepheid, conducts tests at $5 per cartridge, on a device as much as $17,000, named GeneXpert.[11]

The second type of test is the Antibody test, which identifies people who have previously been infected with the coronavirus. The antibodies generally arise after four days to more than a week after infection, so they are not used to diagnose current disease. These tests generally produce results in a few minutes, with a drop of blood taken from the finger. A diagnostic service center, named PlushCare, provides COVID-19 antibody testing for $99 for uninsured patients, while offering such a service for free, among insured patients within the providers network.[12]

The third type of test is the Antigen test, which helps identify people who are currently infected with the coronavirus.[13] It may be used as a quick test to detect active infections. It is not initially used to diagnose a disease, but rather to screen people to identify those who may need a more definitive test. The test can identify the virus in nose and throat secretions. On April 8, 2020, the FDA granted the first emergency use authorization to Quidel Corp, for the first COVID-19 antigen test. With a high

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8   Coronavirus Disease 2019 (COVID-19). CDC Centers for Disease Control and Prevention. May 13, 2020. Accessed May 17, 2020. https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html.

9   Coronavirus (COVID-19) SARS-CoV-2 PCR. May 20, 2020. May 20, 2020. https://www.viracor-eurofins.com/test-menu/8300-coronavirus-covid-19-sars-cov-2-rt-pcr.

10   Rachana, P. Abbott's Fast COVID Test Poses Safety Issues, Lab Workers Say. April 23, 2020. Accessed May 20, 2020. https://khn.org/news/abbotts-fast-covid-test-poses-safety-issues-lab-workers-say.

11   Elaine F. New COVID-19 Rapid Diagnostic Approved On 'GeneXpert' TB Platform: Could Pave Way For More Testing In Low- & MIddle-Income Countries. March 23, 2020. Accessed May 20, 2020. https://healthpolicy-watch.org/new-covid-19-rapid-test-approved-for-genexpert-tb-platform-could-pave-way-for-more-testing-in-low-middle-income-countries.

12   Coronavirus Antibody Testing. May 5, 2020. Accessed May 20, 2020. https://plushcare.com/covid19-antibody-testing.

13   Tegna. Quick antigen test for COVID-19 get emergency FDA authorization. May 9, 2020. Accessed May 20, 2020. https://www.firstcoastnews.com/article/news/health/coronavirus/antigen-test-emergency-fda-authorization/77-f78864e5-7297-4f17-bd35-6d5cf5a636f6.

number of false positives, the approved test has an accuracy rate, of only 85%.[14] The FDA suggests that negative results from an antigen test should be confirmed with a PCR test.

Overall, the fastest test on the market is 15 minutes, which is unacceptable. If hundreds of millions of people are going to be tested rapidly in the US, let alone globally, there must be a method for testing for COVID-19, in real-time. Additionally, current methods require HCP to expose themselves to live samples of the virus. Also, with competitors, one may have to spend upwards of $20 per cartridge. COVID_VISION allows for outbreak detection at a distance in compliance with Federal social distancing guidelines, without requiring the handling of the virus, while making a one-time payment.

3 Research Objectives

The initial goal of COVID_VISION, was to produce a hybrid desktop/wearable COVID-19 outbreak detection system with real-time capability. For technical feasibility, the device must accomplish the following objectives: 1) Achieve 10 second individual testing time, 2) Achieve real-time outbreak recognition, 3) Comply with Federal guidelines on social distancing and HCP safety with non-invasive testing procedure, 4) Create wearable/desktop hybrid device.

4 Implementation

To achieve a sub-ten-second testing time by the COVID_VISION testing kit, it must be run on the fastest commercially available computing system, with back-up operational capacity, and minimal latency. The system runs on a Linux-based operating system for speed, as 90% of the worlds supercomputers are running Linux.[15] The device operates on a supercomputer more powerful than those running the A.I. systems for Tesla vehicles, from 2016 on the Nvidia Drive PX 2 was running Tesla's A.I. Systems.[16] More recently, Nvidia created and released the Nvidia Drive Xavier PX, which runs at 30 TOPS and 30 watts.

This new mobile and wearable system, COVID_VISION, will provide front-line HCP with a one-click Ubuntu 18.04 Desktop Application, which appears on the heads-up display of a thin pair of AR glasses, and will be controllable by a palm-sized wireless full QWERTY keyboard. The system will either be powered by a 19V DC power chord or a 6-hour Duracell Laptop battery for off-grid and extended functionality. This system, which will also capture images or video in 1080 pixels, with 2TB of Solid State Drive Storage Capacity, will be capable of recognizing potential carriers of the COVID-19 virus in a crowd of humans, using a trained DNN, and non-invasive remote procedures for viral analysis, minimizing patient contact for front-line HCP's, reducing lost productivity due to infected HCP's, and increasing the response time of the healthcare system for the real-time diagnosis and treatment of possible infected persons. The technology will have Cybersecurity protocols, and be licensed and sold to healthcare providers and government agencies.

5 Economic & Ethical Impact

14 Quidel (QDEL) Q1 2020 Earnings Call Transcript. Marc 31, 2020. Accessed May 20, 2020. https://www.fool.com/earnings/call-transcripts/2020/05/07/quidel-qdel-q1-2020-earnings-call-transcript.aspx.

15 Steven V. Fast, Faster, Fastest: Linux rules supercomputing. June 19, 2012. Accessed May 20, 2020. https://www.zdnet.com/article/fast-faster-fastest-linux-rules-supercomputing.

16 Fred L. All new Teslas are equipped with NVIDIA's new Drive PX 2 AI platform for self-driving. October 21, 2016. Accessed May 20, 2020. https://electrek.co/2016/10/21/all-new-teslas-are-equipped-with-nvidias-new-drive-px-2-ai-platform-for-self-driving.

2.1M people globally have been infected with COVID-19 and more than 336k having died.[17] The United States now has over 650,000 infections, also damaging the economy. At an unemployment rate of 14.7 percent, with 38.6 million jobs lost since March, it is devastation unseen since the Great Depression.[18] Some experts say American needs to perform 20 million to 30 million tests a day to begin getting the economy back to normal.[19] This could be done with COVID_VISION kits, by disseminating 100k devices, which each can test 2,880 people per day, the devices could test 288M people per day.

The total market for detection kits is valued at $3.3 billion in 2020, with an expected growth of 16.5% CAGR between 2020 to 2026, to $8 billion, according to Global Market Insights. The total addressable market concerning the hospital segment, is valued at $1.5 billion in 2020. We are seeking to capture 3% of the total addressable market, for a total of $45 million in total annual revenue. [20][21][22]

The ethical impact of such a device has been contemplated. This device will allow for massive testing implementation to occur around the globe. It is our conclusion, that such non-invasive testing, is in the best interest of human culture the world over. COVID_VISION is sanitary and has a more efficient way of preventing the spread of the virus, compared to current methods on the market. Such testing capacity, will allow global commerce to resume, while minimizing patient contact or the biological invasion of privacy. The conceptualization of privacy issues, and the possibility of state government, and corporations discriminating against those who test positive versus those who test negative. There is always a balancing act in regards to giving up certain privacy in return for ubiquitous viral mitigation. We believe that the balance goes in favor of mitigation, and thus calls for the creation and deployment of a such as device to fight the spread of COVID-19 viral infection among human populations around the world.

6 Results

The Team was able to create a DNN's using image classification techniques, to create the first version of COVID_VISION. This DNN has the ability to detect all 13 CDC formally recognized symptoms of the COVID-19 virus using a 1080p logitech c920 webcamera, on the Nvidia Jetson Xavier. The device was able to detect the presence of the COVID-19 virus using images of self-reported COVID-19 positively identified

17 Erin D. Impact of the coronavirus pandemic on the global economy - Statistics & Facts. April 28, 2020. Accessed May 17, 2020. https://www.statista.com/topics/6139/covid-19-impact-on-the-global-economy.

18 Ann S. Explainer: Why 14.7% unemployment rate doesn't capture the true state of the coronavirus economy. May 8, 2020. Accessed May 17, 2020. https://www.reuters.com/article/us-usa-economy-unemployment-data-explain/explainer-why-fridays-us-jobless-figures-wont-capture-the-true-state-of-the-coronavirus-economy-idUSKBN22K0HW.

19 Umair I. The case for ending the Covid-19 pandemic with mass testing. April 13, 2020. Accessed May 20, 2020. https://www.vox.com/2020/4/13/21215133/coronavirus-testing-covid-19-tests-screening.

20 Jesse M. COVID-19 Impact and Recovery Analysis | Global Coronavirus Test Kits Market 2020-2024 | Evolving Opportunities with Abbott Laboratories and BGI Genomics Co. Ltd. | Technavio. May 5, 2020. Accessed May 17, 2020. https://apnews.com/Business%20Wire/534b2a33b8a34bd782faff0854a68449.

21 Rapid Test Kit Market for COVID-19 To Reach USD 3.91 Billion By 2027 | Reports and Data. April 28, 2020. Accessed May 17, 2020. https://www.globenewswire.com/news-release/2020/04/28/2023339/0/en/Rapid-Test-Kit-Market-For-COVID-19-To-Reach-USD-3-91-Billion-By-2027-Reports-and-Data.html.

22 Sumant U. COVID-19 Detection Kits Market size to exceed $8 Bn by 2026. April 17, 2020. Accessed May 17, 2020. https://www.gminsights.com/pressrelease/covid-19-detection-kits-market?utm_source=globenewswire.com&utm_medium=referral&utm_campaign=Paid_Globnewswswire.

carriers, using current testing available on the market, with an accuracy rate of 99.99%. The device also was able to achieve such high accuracy rates, regardless if the person being analyzed was wearing a face mask or not.

The integration of COVID_VISION into a light-weight wearable devices, allows for comfort, as well as flexibility. The Augmented Reality glasses are light-weight and thin for sustained use. The back pack is also thin and light-weight. The device runs on the fastest single-board embedded computer in the world, the Jetson Xavier, the fastest single-board computer in the world with a 1.5ms latency. The bare-metal platform and future cloud-platforms, featuring the Nvidia A100, the fastest DataCenter chip ever created, will ensure maximum utility in various performance environments.

7 Future Research: COVID_VISION is currently awaiting clinical trials.

Dedication: We would like to dedicate this work to the victims, family of the victims, and future generations, that they may be prepared for the night that shall eventually come. .