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IEEE Engineering in Medicine & Biology Society (EMBC)
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Mini-Symposia Title:

New Diagnostic Tools and Algorithms for COVID-19

Mini-Symposia Organizer Name & Affiliation:

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Mohamed Elgendi, University of Manitoba

Mini-Symposia Speaker Name & Affiliation 3:

David Smith, Louisiana State University

Mini-Symposia Speaker Name & Affiliation 4:

Richard Fletcher, Massachusetts Institute of Technology

S Mini-Symposia Speaker Name & Affiliation 5:

Mini-Symposia Speaker Name & Affiliation 6:

Theme:

- ( ) 01. Biomedical Signal Processing
- ( ) 02. Biomedical Imaging and Image Processing
- ( ) 03. Micro/ Nano-bioengineering; Cellular/ Tissue Engineering &
- ( ) 04. Computational Systems & Synthetic Biology; Multiscale modeling
- ( ) 05. Cardiovascular and Respiratory Systems Engineering
- ( ) 06. Neural and Rehabilitation Engineering
- ( ) 07. Biomedical Sensors and Wearable Systems
- ( ) 08. Biorobotics and Biomechanics
- (•) 09. Therapeutic & Diagnostic Systems and Technologies
- ( ) 10. Biomedical & Health Informatics
- ( ) 11. Biomedical Engineering Education and Society
- ( ) 12. Translational Engineering for Healthcare Innovation and Commercialization

Mini-Symposia Synopsis— Max 2000 Characters

The worldwide COVID-19 pandemic has had a dramatic impact on the world in terms of mortality and economic stress. As part of medical and public health response to the pandemic, there is a need to provide large scale screening and diagnostic tools to enable better epidemiological surveillance among the population. In addition to better automated diagnostic tools in the hospitals, we also need better diagnostic and screening tools for public testing.

In this session, we present several different innovative technologies that have been demonstrated for identification and diagnosis of COVID-19.

For Hospitals and clinics, we present 3 talks on tools that can be used to improve and automate diagnosis in common hospitals:
+1) Predictive Model for COVID-19 Using X-ray Computed Tomography (CT-scan)

+2) New Imaging Biomarkers for COVID-19 in X-Ray Data From COVID-19 Patients in Louisiana, USA

+3) Comparison of Machine Learning Predictive Models for COVID-19 Using Simple X-Ray images

For Global health and Public Screening, we present 2 talks on low-cost tools that can be used by Community Health Workers in low-resource communities:
+4) Low-Cost Rapid Saliva Test for COVID-19 for Large Scale Screening

+5) Non-contact Thermal Imaging for Predicting COVID-19 Respiratory Infection Using Neural Net Model

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CT / Chest Radiography COVID-19 Open-Source AI Prognostication Predictive Model

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ABSTRACT:

The majority of COVID-19 patients can be managed safely at home, while some patients with initially mild symptoms deteriorate rapidly and require urgent hospital care. Preventable deaths occur when overwhelmed healthcare systems are unable to quickly provide life-saving measures. Poor outcomes are more common in males, older patients, and patients with comorbid conditions such as diabetes, hypertension, or coronary artery disease. However, reliable prognostic indicators and prognostic models for COVID-19 are lacking and this knowledge gap hinders clinical decision making.

Pulmonary involvement is a hallmark of COVID-19 disease and computerized tomography (CT) findings appear to correlate with outcome. The percentage of well-aerated lung has been shown to have prognostic value for COVID-19 patients at risk of ICU admission or death. Prognostic models that incorporate imaging features with clinical parameters can increase accuracy for diagnosing COVID-19 pneumonia and predicting outcome. However, the manual segmentation needed to quantify metrics such as well-aerated lung or opacification patterns common to COVID-19 infection can be laborious and time-consuming for radiologists to complete. Taking a machine learning approach, our group developed an open-source model for the automated segmentation of lung CTs. This model, known as COVID-L3-Net, aims to generate valuable metrics of the lungs derived from chest CT images that can be incorporated with demographic and clinical data into a prognostic model to predict outcome. The open-source model is trained on a globally sourced dataset of CT chest images and clinical outcomes of over 5000 COVID-19 patients. To improve the model's accuracy in detecting, classifying and quantifying lung regions, the model is trained with gold-standard reports and labels annotated by our team of expert radiologists. Currently, our model is trained to automatically segment CT images of the lung to quantify total lung volume, classify and quantify opacification patterns on the CT image, and calculate the volume of well-aerated lung. The latest version of the model is available open-source through our institution's Cloud Innovation Center, with a user interface to allow clinicians and scientists around the model to test our model against their local dataset (1). As we continue to annotate our dataset and iterate our model with international collaborators, we will also be launching L3-Net in the Radiology department of our local health care center where we will evaluate the impact of this artificial intelligence model on the radiology workflow and clinical outcomes. Data is still to come.

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References:

1. UBC Cloud Innovation Centre. Open Source AI Model for COVID-19 CT Diagnostics and Prognsis [Internet]. https://cic.ubc.ca/projects/open-source-ai-model-for-covid-19-ct-diagnostics-and-prognosis/

DATA AUGMENTATION IMPACT ON COVID-19 DETECTION USING X-RAY IMAGES

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ABSTRACT:

Many researchers are trying to detect COVID-19 using X-ray images. Some of them apply data augmentation, and others do not. For example, some studies of COVID-19 detection from chest X-rays have used several data augmentation techniques to improve the testing accuracies of deep learning models, including random rotation, translation, and horizontal flipping. In contrast, other studies have attempted to apply deep learning without a data augmentation step, which has created controversy over the use of data augmentation for detecting COVID-19 precisely and for detecting abnormalities in X-Ray images in general. To date, no reasoning is provided for including or not including the data augmentation.[1] Therefore, we sought to examine the impact of geometric augmentations as implemented in several recent publications for detecting COVID-19. A detailed comparison of 17 deep learning algorithms with and without different geometric augmentations will be discussed. Moreover, we removed the augmentation step from a recently published algorithm and reran the whole analysis to compare the data augmentation step's impact. The conclusion of our investigation is the geometrical augmentation may harm the detection accuracy.

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References:

Elgendi, M., et al. (2021). The effectiveness of image augmentation in deep learning networks for detecting COVID-19: A geometric transformation perspective. Front. Med. 8: 629134. doi: 10.3389/fmed.

Early pandemic spike in New Orleans coinciding with the emergence of medical imaging findings indicative of COVID-19 pneumonia

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ABSTRACT:

In February 2020, before COVID-19 had been detected in the region, the annual Mardi Gras festival in New Orleans became a silent superspreader event for SARS-CoV-2. In early March, New Orleans recorded its first case of COVID-19 pneumonia. As cases increased exponentially, health care workers were faced with a deadly pandemic virus but had limited means to diagnose it. The polymerase chain reaction (PCR) testing kit was in short supply, and the PCR results took days to return. Soon, a multi-society consensus statement identifying typical and atypical computed tomography findings of COVID-19 pneumonia was published.[1] At the same time, another diagnostic pattern[2] was emerging from chest radiographs obtained on hundreds of patients streaming into hospitals around the city. With the aid of these characteristic imaging findings, radiologists were able to aid in the diagnosis and triage of patients, especially when PCR testing was slow, unreliable, or unavailable.

1. Simpson S, Kay FU, Abbara S et al. Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA - Secondary Publication. **J Thorac Imaging** 2020;35(4):219–227.
2. A Characteristic Chest Radiographic Pattern in the Setting of the COVID-19 Pandemic. David L. Smith, John-Paul Grenier, Catherine Batte, and Bradley Spieler. **Radiology: Cardiothoracic Imaging** 2020 2:5

Neural Net Model for Improving Thermal Imaging Infection Screening: A Preliminary Study

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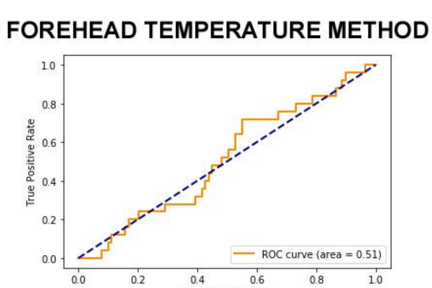
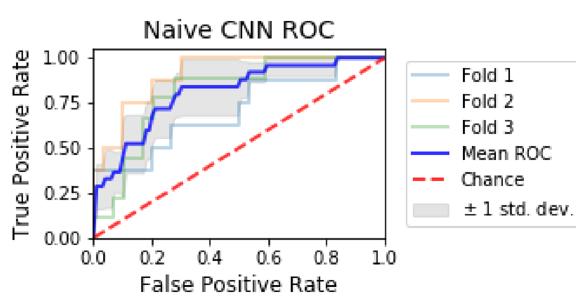
ABSTRACT

MOTIVATION: Recent pandemics such as the original SARS, MERS, and recent COVID-19, have popularized the use of non-contact thermal temperature measurement as a means of detecting individuals with an active infection. These methods include a handheld thermal thermometer as well as a thermal camera; however, in both cases, the temperature reading is taken from a person's forehead. While this simple approach can help detect individuals with a significant fever, it lacks sufficient sensitivity to detect early-stage infections which have either very mild fever or no fever. In an effort to improve sensitivity, we present recent work to develop a neural net machine learning algorithm to analyze thermal images and predict potential infections. **METHODS:** Data was collected from 89 healthy individuals plus 25 patients that were diagnosed with mild pulmonary infections that included primarily tuberculosis, viral pneumonia, and bacterial pneumonia. None of the patients had a forehead temperature above the official 101.4 °F, which is the official criteria for a fever that is often used for infection screening. To analyze the thermal images, a simple naïve convolutional neural net (CNN) model was created comprised of 2 convolutional layers, ReLU activation, max pooling layers, and an output sigmoid layer to provide binary predictions. The model was trained using cross-validation with the Adam optimizer algorithm and a binary cross-entropy loss function. For comparison, to explore the predictive value of forehead temperature, a separate logistic regression model was created using the temperature readings from the forehead taken from a 70-pixel zone in the forehead that was automatically located using a standard thermal image face detector model. **RESULTS:** As shown in the ROC plots below, the CNN model had a reasonably good prediction accuracy of AUC = 0.81, and the forehead temperature method logistic regression model had a very poor prediction accuracy of AUC = 0.51. **CONCLUSIONS:** Among a small population of subjects with mild infection symptoms, the use of machine learning algorithms to analyze the thermal images improved the ability to detect patients having a mild infection, and most patients with this mild infection could not be detected using just the forehead temperature alone. These results are encouraging and indicate that neural net algorithms are a promising method to improve the detection of early stage or mild infection that cannot be detected using the conventional forehead temperature method. Further research is needed to scale up the study and test this method with other types of infections. We are currently conducting a study with COVID-19 patients to validate these methods further with coronavirus patients as well.





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