Artificial Intelligence in COVID-19 Ultrastructure

Mohamed Y. Elwazir1,2, Somaya Hosny3

1Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN, USA, Department of 2Cardiology and 3Histology and Cell Biology, Faculty of Medicine, Suez Canal University, Ismailia, Egypt

Abstract

Artificial intelligence has found its way into numerous fields of medicine in the past decade, spurred by the availability of big data and powerful processors. For the COVID-19 pandemic, aside from predicting its onset, artificial intelligence has been used to track disease spread, detect pulmonary involvement in computed tomography scans, risk-stratify patients, and model virtual protein structure and potential therapeutic agents. This mini-review briefly discusses the potential applications of artificial intelligence in COVID-19 microscopy.

Keywords: Artificial intelligence, computer vision, COVID-19, machine learning

INTRODUCTION

Artificial intelligence (AI) and machine learning have witnessed an exponential growth in the past decade, driven by the advancements in computing hardware capabilities and the availability of large datasets, or “big data.” Medicine was a natural target for AI applications, and numerous AI-driven breakthroughs have been made on a range of frontiers including diagnosis, prognostication, and treatment. The core function of those applications is to be trained to identify features or trends that are imperceptible to the human eye and use them to make disease-related predictions.

AI in COVID-19

On December 30, 2019, an AI-based model, HealthMap, at Boston Children’s Hospital in the USA, issued a warning predicting a potential outbreak in China based on monitoring hospital reports. On the following day, another Canadian-based AI, BlueDot, also independently issued a similar warning to its clients. These systems use natural language processing and machine learning to cull data from hundreds of thousands of sources, including statements from official public health organizations, digital media, global airline ticketing data, livestock health reports, and population demographics. Nine days later, the WHO announced its first official warning on January 9, 2020.

And thus began the COVID-19 pandemic.

Aside from predicting the epidemic, AI has been used to diagnose COVID-19 pneumonia in chest computed tomography,[1] to risk-stratify patients[2] and to model and predict patterns of spread.[3] From an ultrastructure perspective, Google’s pioneering AI division, DeepMind, released an AI prediction of the virus’s protein structure based on genome sequencing.[4] This has been used as a base for further AI studies of protein folding in attempts to generate potential drugs that can affect viral replication or function, with a number of candidate drugs currently under investigation.[5]

While to date there have not been published applications of AI in microscopy of COVID-19, there have been several notable examples (outlined below) which can be applied in this setting. Microscopic findings in COVID-19 pneumonia include diffuse alveolar damage with CD4+ and CD8+ lymphocytic infiltration of the interstitium and around small vessels, with platelets, thrombi, and foci of hemorrhages. Cardiac findings include scattered individual cell myocyte necrosis with infrequent adjacent lymphocytes.[6]

All of these findings are easily amenable to analysis by computer vision, a subset of AI. To name a few examples,
computer vision has been used to detect and count lymphocytes and mitotic figures in breast cancer,[7] evaluate nuclear atypia,[8] detect lymph node metastasis,[9] diagnose and grade prostate cancer,[10] as well as quantify immunohistochemistry biomarkers.[11]

Potential applications for computer vision in COVID-19 histopathology to be tested include diagnosis of COVID-19 viremia from blood film images or COVID-19 pneumonia from bronchoalveolar lavage fluid. Another potential application can be detection of activated B-lymphocytes in the early stages of antibody production.

The biggest barrier to more widespread adoption of AI in the ultrastructural analysis of COVID-19 is the lack of data. Neural networks, the basis of deep learning systems, require large datasets in order to learn and generalize properly, whereas the diagnosis of COVID-19 is primarily serology based with only a small role for histopathology, mainly for research and outside the clinical workflow. Consequently, most available COVID-19 histopathology studies are autopsy based and include limited numbers of patients. However, even with relatively small numbers of images, a computer vision neural network can still be trained thanks to transfer learning. This entails training a network on a larger dataset for a task that shares some similarities with the task at hand so that the network can learn the common representations (such as the shape of different types of cells and organelles), and then finetuning the trained model on the smaller dataset of interest. The small dataset can then suffice since all that remains for the model to learn are the additional features specific to that dataset. As outlined earlier, there is an abundance of histologically trained models, any of which can offer added benefit by serving as a base for a COVID-19-specific histopathology model.

**Conclusion**

The COVID-19 pandemic is still unfolding and times are uncertain. Evolving our understanding of the virus and its pathogenesis is critical to developing a cure or vaccine, and AI is a powerful tool in our arsenal which can prove immensely useful if employed correctly.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Oostu K, Matsumoto T, Harada S, Kishi T. Antitumor and immunosuppressive activities of lankacidin-group antibiotics: Structure-activity relationships. Cancer Chemother Rep 1975;59:919-28.
2. Jiang X, Coffee M, Bari A, Wang J, Jiang X, Huang J, et al. Towards an artificial intelligence framework for data-driven prediction of coronavirus clinical severity. Comput Materials Continua 2020;63:537-51.
3. Santosh KC. AI-driven tools for coronavirus outbreak: Need of active learning and cross-population train/test models on multidimensional/multimodal data. Int J Med Syst 2020;44:93.
4. John Jumper KT, Kohli P, Hassabis D. And the AlphaFold Team, Computational Predictions of Protein Structures Associated with COVID-19 DeepMind Website; 2020.
5. Avchakov K, Burmistrova O, Fedichev P. AI for the Repurposing of Approved or Investigational Drugs against COVID-19; 2020.
6. Fox SE, Akmarbekov A, Harbert JL, Li G, Quincy Brown J, Vander Heide RS. Pulmonary and cardiac pathology in African American patients with COVID-19: An autopsy series from New Orleans. Lancet Respir Med 2020.
7. Roux L, Racoceanu D, Loménie N, Kulikova M, Irshad H, Klossa J, et al. Mitosis detection in breast cancer histological images An ICPAR 2012 contest. J Pathol Inform 2013;4:8.
8. Mahmood T, Arsalan M, Owais M, Lee MB, Park KR. Artificial intelligence-based mitosis detection in breast cancer histopathology images using faster R-CNN and deep CNNs, in J Clin Med 2020;10:749.
9. Liu Y, Gadeppalli K, Norouzi M, Dahl GE, Kohlberger T, Boyko A, et al. Detecting Cancer Metastases on Gigapixel Pathology Images. arXiv: Computer Vision and Pattern Recognition; 2017.
10. Litjens G, Sánchez CI, Timofeeva N, Hermsen M, Nagtegaal I, Kovacs I, et al. Deep learning as a tool for increased accuracy and efficiency of histopathological diagnosis. Sci Rep 2016;6:26286.
11. Kapil A, Meier A, Zuraw A, Steele KE, Rebelatto MC, Schmidt G, et al. Deep semi supervised generative learning for automated tumor proportion scoring on NSCLC Tissue needle biopsies. Sci Rep 2018;8:17343.