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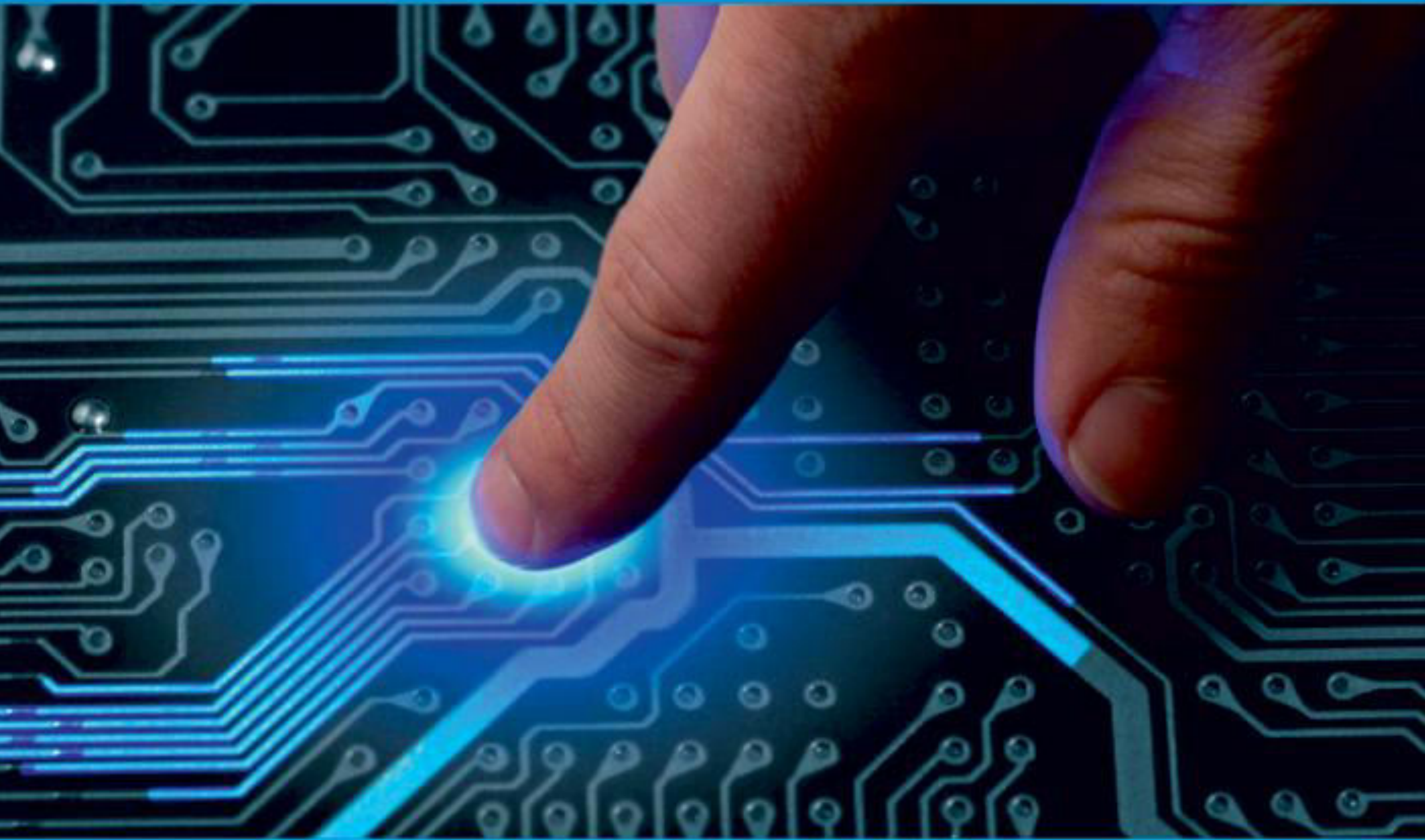

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Classification and Localization of Covid-19 Markers in Point-Of-Care Lung UltraSound Using Deep Learning

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ABSTRACT: Deep learning (DL) works have started to investigate DL-based solutions for the assisted diagnosis of Lung diseases. While existing works focus on CT scans, our project studies the application of DL techniques for the analysis of lung ultrasonography (LUS) images Specifically, we present a fully annotated dataset of LUS images collected from Kaggel.com, with labels indicating the degree of diseases severity at a frame-level, video-level, and pixel-level (segmentation masks). Leveraging these data, we introduce several deep models that address relevant tasks for the automatic analysis of LUS images. In particular, we present a deep network, derived from spatial Transformer Networks, which simultaneously predicts the diseases severity score associated with an input frame and provides localization of pathological artifacts in a weaklysupervised way.Furthermore, we introduce a new method based on uninorms for effective frame score aggregation at a videolevel. Finally, we benchmark state-of-the-art deep models for estimating pixel-level segmentation of COVID-19 imaging biomarkers. Experiments on the proposed dataset demonstrate satisfactory results on all the considered tasks, paving the way to future research on DL for the assisted diagnosis of COVID-19 from LUS data

KEYWORDS*:* LUS, spatial transform network, frame level, video level.

I. INTRODUCTION

The novel Coronavirus designated SARS-CoV-2 appeared in December 2019 to initiate a pandemic of respiratory illness known as COVID-19 which proved itself as a tricky illness that can emerge in various forms and levels of severity ranging from mild to severe with the risk of organ failure and death. From mild, self-limiting respiratory tract illness to severe progressive pneumonia, multiorgan failure, and death. With the progress of the pandemic and the rising number of the confirmed cases and patients who experience severe respiratory failure and cardiovascular complications, there are solid reasons to be tremendously concerned about the consequences of this viralinfection.Determining appropriate approaches to reach solutions for the COVID-19 related problems has received a great deal of attention. However, another huge problem that researchers and decision-makers have to deal with is the ever-increasing volume of the data, known as big data that challenges them in the process of fighting against the virus. This justifies how and to what extent Artificial Intelligence (AI) could be crucial in developing and upgrading health care systems on a global scale.

AI has been recently attracted increasing research efforts towards solving complex issues in several fields, including engineering, medicine, economy, and psychology. Hence, a critical situation like this necessitates mobilization and saving medical, logistic, and human resources, and AI can not only facilitate that but can save time in a period when even one hour of the time save could end in saving lives in all locations where Coronavirus is claiming lives. With the recent popularity of AI application in clinical contexts, it can play an important role in reducing the number of undesired deletions as well as improving the productivity and efficiency in studies where large samples are involved, and higher degrees of accuracy in prediction and diagnosis is intended. Utilizing big data can also facilitate viral activity modeling studies in any country. The analyses of results enable health care policymakers to prepare their country against the outbreak of the disease and make well-informed decisions.

However, while treatment strategies, crisis management, optimization, and improved diagnosis methods, such as medical imaging and image processing techniques could take benefit from AI which is capable of helping medical

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methods, it has not been desirably employed and well-appropriated to serve healthcare systems in their fights against COVID-19. For instance, one area that can take special advantage of AI's useful input is image-based medical diagnosis through which fast and accurate diagnosis of COVID-19 can take place and save lives. Appropriating AI techniques to deal with COVID-19 related issues can fill the void between AI-based methods and medical approaches and treatments. AI specialists' use of AI platforms can help in making connections between various parameters and speed up the processes to obtain optimum results. In this paper, our team relies on the findings of the most recent research focusing on COVID-19 and its various challenges to generalize and suggest a variety of strategies relevant but not limited to high-risk groups, epidemiology, and radiology, etc.

The present section focuses on the introduction of some applicable AI-based strategies that can support existing standard methods of dealing with COVID-19 in health care systems around the world. To foreground the enhanced effectiveness of these strategies and techniques, their formation has been informed by and based on the most recent AI-related published medical updates as well as the latest updates on COVID-19. Therefore, this section presents ideas that can enhance and speed up ANN-based methods obtaining process to improve treatment methods and health management as well as recognition and diagnosis. However, the optimal effectiveness of AI tools during the COVID-19 pandemic depends on the extent of human input and collaboration in different roles humans play. The knowledge of capabilities and limitations of AI, however, stays with data scientists who play an important role simply because they are the ones who code AI systems. Different steps in the application of AI-based methods employed to overcome COVID-19 challenges are presented in the flowchart shown in Fig.1. The first step is the preparation of the data which are necessary for data mining during data understanding, data preparation, and big data. The data under discussion here consist of medical information, such as clinical reports, records, images, and other various forms of information that can be transformed into data that can be understood by a machine. Objectives of data understanding include understanding data attributes and identifying main characteristics such as data volume and the total number of variables to summarize the data. Before processing and analysis comes data preparation that is the process through which raw data are refined and converted. In other words, it is a process in which data are reformatted, corrected, and combined to enriched data. Collecting, analyzing, and leveraging the data such as consumer, patient, physical, and clinical data ends in big data. It is at this stage that human intervention, as a part of machine learning methods, takes place and experts investigate and analyze the data to extract the data with the finest structures, patterns, and features.

Humans' contribution at this stage is important because their knowledge and potentials are not available to an ML solution that unlike humans can deal with huge data sets far beyond the extent that humans could handle or observe simultaneously. Moreover, Deep Learning (DL) methods could be employed in cases where enormous or complex data processing challenges ML or traditional means of data processing. As a subset of machine learning, DL consists of numerous layers of algorithms that provide a different interpretation of the data it feeds on. However, DL is mainly different from ML because it presents data in the system in a different manner. Whereas DL networks work by layers of Artificial Neural Networks (ANN), ML algorithms are usually dependent on structured data. Unlike supervised learning which is the task of learning a function mapping an input to an output based on example input-output pairs, unsupervised learning is marked by minimum human supervision and could be described as a sort of machine learning in search of undetected patterns in a data set where no prior labels exist.

In conventional medicine, alternatively called allopathic medicine, biomedicine, mainstream medicine, orthodox medicine, and Western medicine, medical doctors and other professional health care providers such as nurses, therapists, and pharmacists use drugs, surgery, or radiation to treat illnesses and eliminate symptoms. AI could be extensively applied for COVID-19; however, we aim at finding the best possible solutions COVID-19 related issues that have put the biggest challenges ahead of health care systems. Accordingly, these solutions have been categorized into 3 parts, including high-risk groups, outbreak, and control, recognizing, and diagnosis. ANNs in diagnosis and tracing the symptoms in 5 layers. Although the process has been specifically designed for COVID-19 related problems, it has the potential for use in other medical imaging analyses.

According to the World Health Organization (WHO), viral and infectious diseases continue to appear and pose a serious threat to public health and well-being. Coronavirus is a broad family of viruses that causes ailments ranging from common cold and flu to severe respiratory issues. According to NCBI, "In the last 20 years, there have been several viral epidemics that have been reported such as the Severe Acute Respiratory Syndrome Coronavirus or better known as SARS-COV which was declared a pandemic by WHO in 2002 - 2004 and H1N1 influenza in 2009. With most recently, Middle East Respiratory Syndrome Coronavirus better known as MERS- COV which hit its first outbreak in Saudi Arabia in 2012". In the chronology of modern times, cases of unrecognized low respiratory infections were first detected during mid-December 2019 in Wuhan, the largest metropolitan city in Hubei province of China. This strange new pneumonia was named "COVID-19" by WHO. WHO declared this surge a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, as it had affected almost 20 countries of the world.

There are no specific treatments for this virus so far, but one can reduce the spread of infection by maintaining personal hygiene and social distancing. There have been recoveries around the world, but the pandemic is still not under

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control. This pandemic has affected the whole world not only in terms of health and hygiene but also in terms of the global economy. Apart from the adverse effects of COVID-19, there have been certain constructive influences around the world. As the world was facing losses, our nature gained something from this pandemic, the harmful particulate matter was eliminated from the environment, and most importantly the largest ever ozone hole detected was closed during this pandemic. So it becomes really important to understand the features and characteristics of this disease and predict/estimate the further spread of this disease around the world and how it is going to impact the coming generations and the lives of the people when things become normal.

The Covid-19, an acronym for "Coronavirus Disease2019", is a respiratory illness caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), a contagious virus belonging to a family of single-stranded, and positive-sense RNA viruses known as coronaviridae. Much like the influenza virus, SARS-CoV-2 attacks the respiratory system, causing ailments such as cough, fever, fatigue, and breathlessness. While the exact source of the virus is unknown, scientists have mapped the genome sequence of the SARS-CoV-2, and have determined it to be a member of the β-COV genera of the coronavirus family, which typically derives its gene sources from bats and rodents [1]. The COVID19 was first reported to affect human life in Wuhan City, in the Hubei province of China in December 2019. Since then, the COVID-19 has spread like wildfire throughout the rest of the world, marking its presence in 213 countries and independent territories [2]. According to the WHO, the current global tally1 of confirmed coronavirus cases stands at 2,285,210 while the death toll has reached 155,124 [2]. The rapid rise in the number of COVID-19 incidents worldwide has prompted the need for immediate countermeasures to curb the catastrophic effects of the COVID-19 outbreak. To this end, this paper evaluates the use of varied technologies such as IOT, UAVs, AI, blockchain, and 5G, that could help mitigate the adverse effects of this pandemic and expedite the recovery process. However, before exploring the potential technological solutions for COVID-19 pandemic impact management, we provide a comprehensive review of the COVID-19, including its clinical features, diagnosis, treatment, and the impact of its outbreak on the global economy.

The first case of MERS-CoV infection was detected in Saudi Arabia, which initiated a large-scale epidemic in the Middle Eastern countries that ultimately led to 871 fatalities. The COVID-19 outbreak came to light on 31 December 2019 when 27 cases of pneumonia of unknown etiology were reported at the WHO's country office in China (refer to fig. 2 for the entire timeline). The epicenter of the outbreak was linked to Wuhan's wholesale market for seafood and other exotic animals, including snakes, bats, and marmots. A new strain of a highly contagious β-coronavirus, SARS-CoV-2, has been deemed responsible for the rapid outbreak of COVID-19. Distinguishing characteristics of the virus include its extremely contagious nature and relatively long (5-14 days) incubation period. During this period, a person can be infected by the virus and not show any symptoms at all. Therefore, people infected with the disease may unknowingly serve as silent carriers of the virus, contributing to a high reproductive number2 for the COVID-19 virus. While some studies indicate that SARS-CoV-2 could be susceptible to heat and ultraviolet (UV) light, the virus does not have any cure, vaccine, or standard treatment protocols to date.

The massive outbreak of the COVID-19 has prompted various scientists, researchers, laboratories, and organizations around the world to conduct large-scale research to help develop vaccines and other treatment strategies. In the months following the COVID-19 outbreak, several papers examining different aspects of the COVID-19 have been published.

Owing to the lack of any concrete treatment strategy, social distancing has been identified as the best possible defense strategy against the COVID-19 pandemic at the time of this writing. However, the need for social distancing has prompted governments around the world to impose lockdowns, which has marked a huge dent in the global economy. All non-essential services have been forced to shut down, causing virtually all the industrial sectors to face significant disruptions in the supply chain and, consequently, putting billions of people at risk of losing their jobs. Furthermore, the rapid outbreak of COVID-19 has forced governments to restrict the trade of a majority of the goods across country borders, leaving international trade flows on the verge of collapse. Finally, we analyze the impact of the COVID-19 pandemic on the overall economy by thoroughly dissecting its impact on different economic sectors

II. RELATED WORK

The dataset which we are taken in this proposed method is lung ultrasonography (LUS) videos. Each video is converted into frames. By using a spatial transform network we classify the COVID-19 markers is called a prediction of scores. The spatial transform network is trained by converting the images of the last frame in each video into binary format. Next, the trained images are stored and ground truth labels are loaded. We apply the U-Net architecture for the semantic segmentation of data. This network classifies the image based on the segmented class. Then we get the segmented output image.

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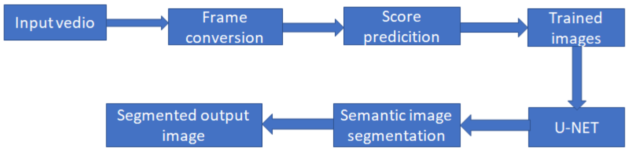

Block diagram of the proposed method

A. Input Video

The input we are taking the Lung Ultrasonography (LUS) Videos. We are downloading from the kaggle.com website.

B. Frame Conversion

These Frame Conversion block passes the input through the output and sets the output sampling mode to the value of the sampling mode of output signal parameters, which can be either frame-based or sample-based.The frame conversion block does not make any changes to the input signal other than the sampling mode.

C. Score Prediction

These score predictions are classified into 3 stages by using the spatial transform network

In stage 1: Abnormality

In stage 2:Moderate

In stage 3: Severe

D. Trained Images

After that images are trained to a fixed amount of pixels that is 0-255.so all the data is in the same format from these we can perform easily.

E. U-NET

This network is predefined in the matlab program. It consists of encoders and decoders. Frames are input there also, here we check every pixel in the frame so we can use encoders and decoderswhen the image is changed from high to low use the encoders but the output image consists high level so we use decoders to change the image from low level to high level.

F. Semantic Image Segmentation

By using the convolutional neural network images are recognized, semantic segmentation describes the process of associating each pixel of an image with a class label.

G. Segmented Output Image

It shows the output image consists of black and white for our eye visible. If there is white that part is covid part remaining black part is normal

Flow chart:

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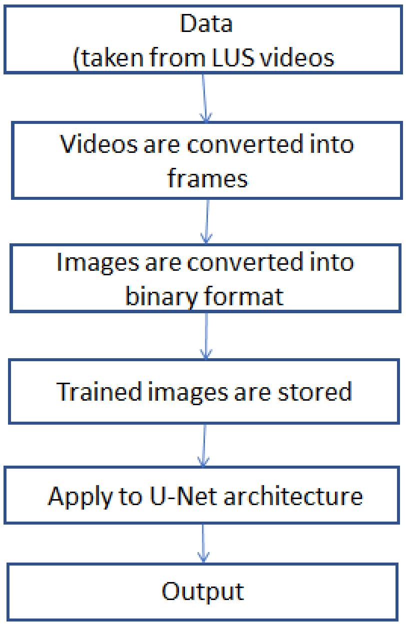

III. RESULTS

The below figure represents the input video of this project. This video is in the format of a gif.

Figure 1: Input video.

Trains the network for image classifications problems. The below figure shows the training progress of the network.

Figure 2: Training progress.

Creates a message dialog box after the classification of the score by using a spatial transform network.

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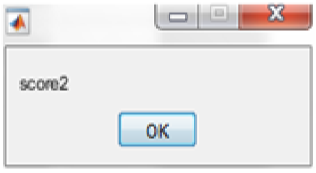

Figure 3: frame based score prediction.

The below figure represents the architecture of the U-net. This network consists of several layers.

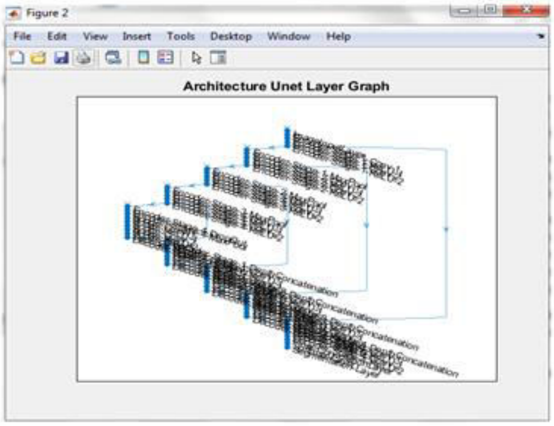

Figure 4: U-Net architecture.

Trains a network for image classification problems. The below figure shows the training progress of the network.

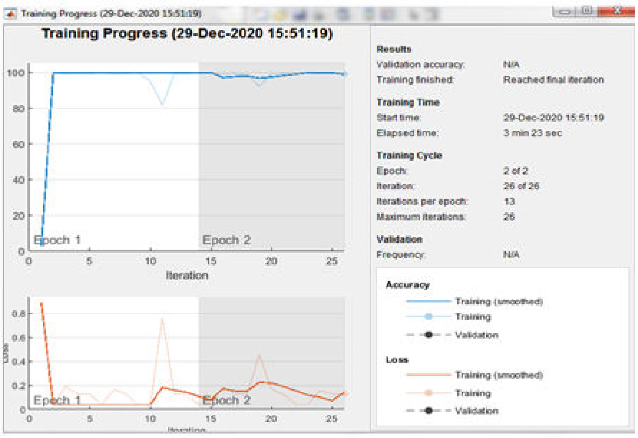

Figure 5: Training progress of U-Net architecture.

Semantic segmentation involves labelling each pixel In an imagewith a class. Overtime

Figure 6: Semantic segmentation.

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REFERENCES

[1] R. Niehus, P. M. D. Salazar, A. Taylor, and M. Lipstick, "Quantifying bias of COVID-19 prevalence and severity estimates in Wuhan, China that depends on reported cases in international travelers," medRxiv, p. 2020.02.13.20022707, Feb 2020.
[2] S. Salehi, A. Abedi, S. Balakrishnan, and A. Gholamrezanezhad, "Coronavirus Disease 2019 (COVID-19): A Systematic Review of Imaging Findings in 919 Patients," Am J Roentgenol, pp. 1–7, Mar 2020.
[3] M. Jamshidi et al., "Artificial Intelligence and COVID-19: Deep Learning Approaches for Diagnosis and Treatment," in IEEE Access, vol. 8, pp. 109581-109595, 2020, DOI: 10.1109/ACCESS.2020.3001973.
[4] J. Long, E. Shelhamer and T. Darrell, "Fully convolutional networks for semantic segmentation," 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Boston, MA, 2015, pp. 3431-3440, DOI: 10.1109/CVPR.2015.7298965.
[5] A. Bernheim et al., "Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection," Radiology, p. 200463, Feb 2020. [Online]. Available: http://pubs.rsna.org/doi/10.1148/radiol.2020200463
[6] F. Mojoli, B. Bouhemad, S. Mongodi, and D. Lichtenstein, "Lung ultrasound for critically ill patients," pp. 701–714, Mar 2019.
[7] R. Raheja, M. Brahmavar, D. Joshi, and D. Raman, "Application of Lung Ultrasound in Critical Care Setting: A Review," Cureus, vol. 11, no. 7, Jul 2019.
[8] Y. Amatya, J. Rupp, F. M. Russell, J. Saunders, B. Bales, and D. R. House, "Diagnostic use of lung ultrasound compared to chest radiograph for suspected pneumonia in a resource-limited setting," International Journal of Emergency Medicine, vol. 11, no. 1, Dec 2018.
[9] E. Poggiali et al., "Can Lung US Help Critical Care Clinicians in the Early Diagnosis of Novel Coronavirus (COVID-19) Pneumonia?" Radiology, p. 200847, Mar 2020.
[10] Q. Y. Peng et al., "Findings of lung ultrasonography of novel coronavirus pneumonia during the 2019 – 2020 epidemic," Intensive Care Medicine, no. 87, pp. 6–7, Mar 2020.
[11] G. Soldati et al., "Is there a role for lung ultrasound during the covid-19 pandemic?" J Ultrasound Med, 2020.
[12] ——, "Proposal for international standardization of the use of lung ultrasound for COVID-19 patients; a simple, quantitative, reproducible method," J. Ultrasound Med., 2020.
[13] K. Stefanidis et al., "Lungsonography and recruitment in patients with early acute respiratory distress syndrome: A pilot study," Critical Care, vol. 15, no. 4, p. R185, Aug 2011.
[14] K. A. Stewart et al., "Trends in Ultrasound Use in Low and Middle-Income Countries: A Systematic Review." International Journal of MCH and AIDS, vol. 9, no. 1, pp. 103–120, 2020.
[15] L. Tutino, G. Cianchi, F. Barban, S. Batacchi, R. Cammell, and A. Peris, "Time needed to achieve completeness and accuracy in bedside lung ultrasound reporting in Intensive Care Unit," SJTREM, vol. 18, no. 1, p. 44, Aug 2010.
[16] R. J. van Sloun, R. Cohen, and Y. C. Eldar, "Deep learning in ultrasound imaging," Proceedings of the IEEE, vol. 108, no. 1, pp. 11–29, Jul 2019. [Online]. Available: http://arxiv.org/abs/1907.02994
[17] R. J. van Sloun and L. Demi, "Localizing b-lines in lung ultrasonography weakly-supervised deep learning, in-vivo results," J-BHI, 2019.
[18] G. Soldati et al., "Towards computer-aided lung ultrasound imaging for the management of patients affected by covid-19," under submission.
[19] M. Jaderberg et al., "Spatial transformer networks," in NIPS, 2015.
[20] S. Roy, A. Siarohin, E. Sangineto, S. R. Bulo, N. Sebe, and E. Ricci, "Unsupervised domain adaptation using feature-whitening and consensus loss," in CVPR, 2019.
[21] R. Diaz and A. Marathe, "Soft labels for ordinal regression," in CVPR, 2019.
[22] V. Melnikov and E. H¨ullermeier, "Learning to aggregate using uninorms," in ECML, 2016.
[23] O. Ronneberger, P. Fischer, and T. Brox, "U-net: Convolutional networks for biomedical image segmentation," in MICCAI, 2015.
[24] P. Rajpurkar et al., "Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning," arxiv preprint arXiv:1711.05225, 2017.
[25] D. Dong, Z. Tang, S. Wang, H. Hui, L. Gong, Y. Lu, Z. Xue, H. Liao, F. Chen, F. Yang, et al., "The role of imaging in the detection and management of covid-19: a review," IEEE Reviews in Biomedical Engineering, 2020.
[26] F. Shi, J. Wang, J. Shi, Z. Wu, Q. Wang, Z. Tang, K. He, Y. Shi, and D. Shen, "Review of artificial intelligence techniques in imaging data acquisition, segmentation, and diagnosis for covid-19," IEEE Reviews in Biomedical Engineering, 2020.

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[27] J. Chen et al., "Deep learning-based model for detecting 2019 novel coronavirus pneumonia on high-resolution computed tomography: a prospective study," medRxiv, 2020.
[28] S. Wang et al., "A deep learning algorithm using CT images to screen for coronavirus disease (covid-19)," medRxiv, 2020.
[29] X. Xu et al., "Deep learning system to screen coronavirus disease 2019 pneumonia," arxiv preprint arXiv:2002.09334, 2020.
[30] S. Liu et al., "Deep learning in medical ultrasound analysis: a review," Engineering, 2019.
[31] B. Zhou, A. Khosla, A. Lapedriza, A. Oliva, and A. Torralba, "L Learning deep features for discriminative localization," in CVPR, 2016.
[32] G. Soldati et al., "Simple, Safe, Same: Lung Ultrasound for COVID-19 (LUSCOVID19)," ClinicalTrials.gov Identifier: NCT04322487, 2020.
[33] G. Soldati, M. Demi, R. Inchingolo, A. Smargiassi, and L. Demi, "On the physical basis of the pulmonary sonographic interstitial syndrome," J Ultrasound Med, vol. 35, no. 10, pp. 2075–2086, Oct 2016.
[34] K. Wada, "label me: Image Polygonal Annotation with Python," https://github.com/wkentaro/labelme, 2016.
[35] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in NIPS, 2012.
[36] M.Sajjadi, M. Javanmardi, and T.Tasdizen, "Regularization with stochastic transformations and perturbations for deep semi-supervised learning," in NIPS, 2016.
[37] C. Winship and R. D. Mare, "Regression models with ordinal variables," American sociological review, pp. 512–525, 1984.
[38] K. Crammer and Y. Singer, "Pranking with ranking," in NIPS, 2002.
[39] R. R. Yager and A. Rybalov, "Uniform aggregation operators," Fuzzy Sets Syst., vol. 80, no. 1, p. 111–120, May 1996.
[40] Z. Zhou, M. M. R. Siddiquee, N. Tajbakhsh, and J. Liang, "Unet++: A nested u-net architecture for medical image segmentation," in Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support. Springer, 2018, pp. 3–11.
[41] L.-C. Chen, Y. Zhu, G. Papandreou, F. Schroff, and H. Adam, "Encoder decoder with atrous separable convolution for semantic image segmentation," in Proceedings of the European conference on computer vision (ECCV), 2018, pp. 801–818.
[42] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in CVPR, 2016.
[43] Y. Gal and Z. Ghahramani, "Dropout as a Bayesian approximation: Representing model uncertainty in deep learning," in ICML, 2016.
[44] R. R. Selvaraju, M. Cogswell, A. Das, R. Vedantam, D. Parikh, and D. Batra, "Grad-cam: Visual explanations from deep networks via gradient-based localization," in Proceedings of the IEEE international conference on computer vision, 2017, pp. 618–626.
[45] J. C.-H. Cheung and K. N. Lam, "POCUS in COVID-19: pearls and pitfalls," Tech. Rep. 0, Apr 2020.
[46] S. Sippel, K. Muruganandan, A. Levine, and S. Shah, "Review article: Use of ultrasound in the developing world," International Journal of Emergency Medicine, vol. 4, no. 1, p. 72, Dec 2011.
[47] S. Shah, B. A. Bellows, A. A. Adedipe, J. E. Totten, B. H. Backlund, and D. Sajed, "Perceived barriers in the use of ultrasound in developing countries," Critical Ultrasound Journal, vol. 7, no. 1, no. 1, Dec 2015