Covid-19 X-ray Image Classification

Maneesh Kumar Singh
University of Illinois at Urbana-Champaign
mksingh4@illinois.edu

Raman Walwyn-Venugopal
University of Illinois at Urbana-Champaign
rsw2@illinois.edu

Satish Reddy Asi
University of Illinois at Urbana-Champaign
sasi2@illinois.edu

Srikanth Bharadwa Samudrala
University of Illinois at Urbana-Champaign
sbs7@illinois.edu

ABSTRACT

TODO

1. INTRODUCTION

As part of graduate course Deep learning for healthcare, we have decided to reproduce and improve current research on COVID-19 classification using X-ray.

2. MOTIVATION

COVID-19 pandemic has ravaged the world on an unprecedented scale. It has caused loss of millions of lives and long lasting damages on surviving patients. X-ray imaging is very important part of diagnosis of Covid-19 and other pneumonia and is often the first-line diagnosis in many cases. Using deep learning for X-ray classification is an ongoing research area. We have taken this paper to strengthen our understanding of deep learning models and improve the current research.

3. LITERATURE SURVEY

3.1 COVID-19 classification using chest CT

X. Bai and Wang were able to create an AI system that could differentiate COVID-19 and other pneumonia using a chest CT scan. They approached this as a classification problem and used the EfficientNet B4 architecture which was a CNN based network. They were able to achieve results of 96% accuracy, 95% sensitivity , 96% specificity, and an area under receiver operating characteristic curve of 0.95 and an area under the precision recall curve of 0.90. When compared with radiologists on the same test dataset, the AI system performed better. This study concluded that the AI can support radiologists in detection of Covid 19 in Chest CT images.

3.2 Focal loss for dense object detection

Lin T, Goyal P, Girshick R propose Focal loss, a modification to the standard cross entropy criterion that focuses weights for loss on hard examples versus well classified examples. This is accomplished by adding a factor $(1 - p_t)^\gamma$ to the standard cross entropy criterion where setting $\gamma > 0$ reduces the relative loss for well-classified examples ($p_t > .5$). This results in achieving higher accuracy than using the standard cross entropy loss and surpassed speed and accuracy when compared with state of the art two stage detectors; Faster R CNN Variants.

3.3 Towards contactless patient positioning

This paper discussed about patient positioning routine that comprised a novel robust dynamic fusion (RDF) algorithm for accurate 3D patient body modeling. With 'multi-modal' inference capability, RDF can be trained once and used across different applications (without re-training). They have used multiple CNN branches o learn the joint feature representation and a fully-connected parameter regressor module to estimate the 3D mesh parameters.

3.4 Deep learning COVID-19 features on CXR using limited training data sets

The authors of this paper, proposed a patch-based convolutional neural network approach with a relatively small number of trainable parameters for Covid-19 diagnosis. The architecture contains first pre-processed data that are fed into a segmentation network [FC-DenseNet] to extract lung areas. From this segmented lung area, classification network is used to classify the corresponding diseases using a patch-by-patch training and inferences [ResNet-18 (pre-trained) and many ResNet-18 models are used for K patches], final decision is made based on the majority voting from previous layers. A Grad-CAM saliency map is calculated to provide an interpretable result. This method has an accuracy of 91.9%, compared to that of 92.4% for COVID-Net.

3.5 COVID19-Net Deep Convolutional Neural Network

This is the first open source network design for COVID-19 detection from CXR images, our final research paper also considers this as its baseline for experiments. This paper considered COVIDx dataset which contains 13,975 CXR images for training and experiments. COVID-Net architecture makes heavy use of a lightweight residual 'projection expansion projection extension' (PPEX) design pattern that contains multiple levels of convolution layers with fully connected layers and a softmax at the end. COVID-Net achieved higher test accuracy than other architectures such as VGG-19 and ResNet-50.

3.6 Noise-robust segmentation of COVID-19 from CT images

This is a CNN model developed to be effective with detection of COVID-19 lesions from CT images that have a lot of noise. This paper discusses how Wang et al devel-

oped a novel noise-robust learning framework based on self-ensembling of CNNs. To better deal with the complex lesions, a novel COVID-19 Pneumonia Lesion segmentation network (COPLE-Net) was proposed that uses a combination of max-pooling and average pooling to reduce information loss during downsampling, and employs bridge layers to alleviate the semantic gap between features in the encoder and decoder. Experimental results with CT images of 558 COVID-19 patients showed the effectiveness of the noise-robust Dice loss function, COPLE-Net and adaptive self-ensembling in learning from noisy labels for COVID-19 pneumonia lesion segmentation. To make the training process robust against noisy labels, a novel noise-robust Dice loss function was proposed and integrated into a self-ensembling framework, where an adaptive teacher and an adaptive student are introduced to further improve the performance in dealing with noisy labels. The experiments used 2D CNNs for slice-by-slice segmentation, and implemented COPLE-Net, 1 LNR-Dice and the adaptive self-ensembling framework in Pytorch with the PyMIC 3 library on a Ubuntu desktop with an NVIDIA GTX 1080 Ti GPU. The proposed COPLE-Net was compared with four state-of-the-art networks for semantic or medical image segmentation

1. 3D nnU-Net that is extended from 3D U-Net
2. Attention U-Net 3) ScSE U-Net
3. ESPNetv2 and proven to be most effective with noisy images.

In addition, COPLE-Net was compared with three variants: COPLE-Net (-A), COPLE-Net (-D) and COPLE-Net (-B)

3.7 Data

The following datasets that we are considering for this project:

1. Covid Chest X-ray (CCX) dataset: This dataset contains COVID-19 pneumonia images as well few X-ray images from other classes. The dataset can be obtained from github at this link https://github.com/ieee8023/covid-chestxray-dataset
2. Kaggle Chest X-ray (KCX) dataset: This dataset contains normal, bacterial pneumonia, and nov-COVID-19 viral pneumonia. The dataset can be obtained from Kaggle at this link https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

In the FLANNEL paper, 5508 chest x-ray images across 2874 independent patient cases. Both dataset contains anteroposterior (AP) and posteroanterior (PA) view.
As done in the research paper, we will include both AP and PA views. Due to AP and PA views being different types of X-ray images, horizontal flips and random noise will be used to convert PA into AP view.

3.8 Tables

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly

Table 1: Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
π	1 in 5	Common in math
\$	4 in 5	Used in business
Ψ_1^2	1 in 40,000	Unexplained usage

in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material is found in the *LaTeX User's Guide*.
Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed dvi output of this document.
To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents and the table caption. As with a single-column table, this wide table will "float" to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed dvi output of this document.

3.9 Theorem-like Constructs

Other common constructs that may occur in your article are the forms for logical constructs like theorems, axioms, corollaries and proofs. There are two forms, one produced by the command `\newtheorem` and the other by the command `\newdef`; perhaps the clearest and easiest way to distinguish them is to compare the two in the output of this sample document:
This uses the **theorem** environment, created by the `\newtheorem` command:

THEOREM 1. *Let f be continuous on $[a, b]$. If G is an antiderivative for f on $[a, b]$, then*

$$\int_a^b f(t)dt = G(b) - G(a).$$

The other uses the **definition** environment, created by the `\newdef` command:

Definition 1. If z is irrational, then by e^z we mean the unique number which has logarithm z:

$$\log_e^z = z$$

Two lists of constructs that use one of these forms is given in the *Author's Guidelines*.
There is one other similar construct environment, which is already set up for you; i.e. you must *not* use a `\newdef` command to create it: the **proof** environment. Here is a example of its use:

PROOF. Suppose on the contrary there exists a real number L such that

$$\lim_{x\to\infty} \frac{f(x)}{g(x)} = L.$$

Then

$$l = \lim_{x\to c} f(x) = \lim_{x\to c} \left[gx \cdot \frac{f(x)}{g(x)}\right] = \lim_{x\to c} g(x) \cdot \lim_{x\to c} \frac{f(x)}{g(x)} = 0 \cdot L = 0,$$

Table 2: Some Typical Commands

Command	A Number	Comments
`\alignauthor`	100	Author alignment
`\numberofauthors`	200	Author enumeration
`\table`	300	For tables
`\table*`	400	For wider tables

which contradicts our assumption that $l \neq 0$. □

Complete rules about using these environments and using the two different creation commands are in the *Author's Guide*; please consult it for more detailed instructions. If you need to use another construct, not listed therein, which you want to have the same formatting as the Theorem or the Definition[**?**] shown above, use the `\newtheorem` or the `\newdef` command, respectively, to create it.

4. EXPERIMENTAL SETUP

AWS (custom cluster/SageMaker) pandas Pytorch

5. CONCLUSIONS

This paragraph will end the body of this sample document. Remember that you might still have Acknowledgements or Appendices; brief samples of these follow. There is still the Bibliography to deal with; and we will make a disclaimer about that here: with the exception of the reference to the LaTeX book, the citations in this paper are to articles which have nothing to do with the present subject and are used as examples only.

6. ACKNOWLEDGEMENTS

This section is optional; it is a location for you to acknowledge grants, funding, editing assistance and what have you. In the present case, for example, the authors would like to thank Gerald Murray of ACM for his help in codifying this *Author's Guide* and the **.cls** and **.tex** files that it describes.

APPENDIX

A. HEADINGS IN APPENDICES

The rules about hierarchical headings discussed above for the body of the article are different in the appendices. In the **appendix** environment, the command **section** is used to indicate the start of each Appendix, with alphabetic order designation (i.e. the first is A, the second B, etc.) and a title (if you include one). So, if you need hierarchical structure *within* an Appendix, start with **subsection** as the highest level. Here is an outline of the body of this document in Appendix-appropriate form:

A.1 Introduction

A.2 The Body of the Paper

A.2.1 Type Changes and Special Characters

A.2.2 Math Equations

A.2.2.1 Inline (In-text) Equations.

A.2.2.2 Display Equations.

A.2.3 Citations

A.2.4 Tables

A.2.5 Figures

A.2.6 Theorem-like Constructs

A Caveat for the TEX Expert

A.3 Conclusions

A.4 Acknowledgements

A.5 Additional Authors

This section is inserted by LaTeX; you do not insert it. You just add the names and information in the `\additionalauthors` command at the start of the document.

A.6 References

Generated by bibtex from your .bib file. Run latex, then bibtex, then latex twice (to resolve references) to create the .bbl file. Insert that .bbl file into the .tex source file and comment out the command `\thebibliography`.

B. MORE HELP FOR THE HARDY

The acmproc-sp document class file itself is chock-full of succinct and helpful comments. If you consider yourself a moderately experienced to expert user of LaTeX, you may find reading it useful but please remember not to change it.