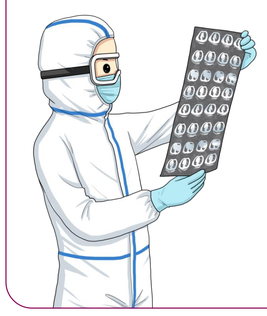
# The Comparisons of Age and Gender Stratified COVID-19 CT Deep Learning Detection Models

Group 5: Yaru Zhou, Lingyun Wu, Zaiqiu Cao

## Our Findings



- The patient characteristics of age and gender played an important role in COVID-19 CT diagnosis.
- Using age and gender stratified models in setting up COVID-19 CT deep learning detection models might promote the model performance.

## Introduction

- Coronavirus diseases 2019 (COVID-19) had caused over **83 million** cases and over **1.8 million** deaths in the world before 05/01/2020 (1).
- One diagnosis method of COVID-19 is reverse-transcription polymerase chain reaction (RT-PCR) testing. However, it has several drawbacks:
  - Take approximately five to six hours to reveal the results;
  - The sensitivity is only 60% to 70%;
  - Testing kits are not enough
  - Unlike CT scans, not able for earlier diagnosis and early intervention.
- So, in the diagnosis, CT scans played an irreplaceable role (2). A lot of deep learning models based on convolutional neural networks (CNNs) have been implemented for detecting COVID-19 CT images, but they did not take age and gender into consideration (3).
- Studies have been proved the severity of symptoms of COVID-19 varies by biological gender and age. Male and people aged over 50 are more likely to be infected and have negative outcomes (4,5).

## Objective

- Illustrate different deep learning assist COVID-19 detection models: non-stratified, age-stratified and gender-stratified models.
- Compare the performance of these stratified models.

## Methods

- The general process of this study was shown following:

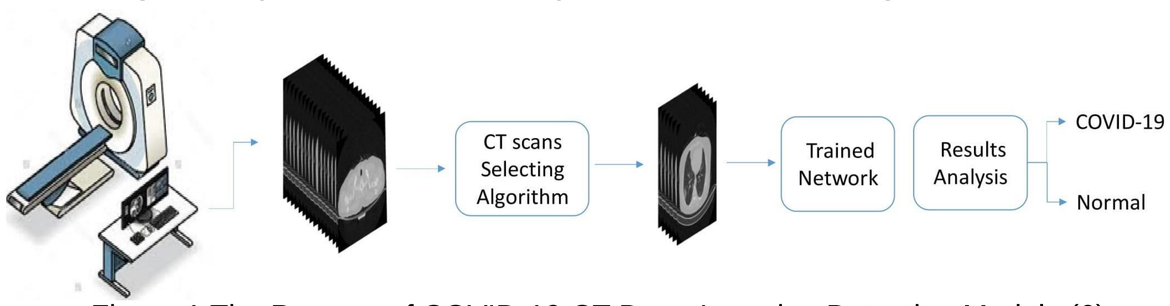



Figure 1 The Process of COVID-19 CT Deep Learning Detection Models (6)

- The structure of the model: ResNet50V2-FPN.

  ResNet50V2, an updated version ResNet50, is one kind of CNNs. Feature pyramid network (FPN) can help detecting features at different scales.

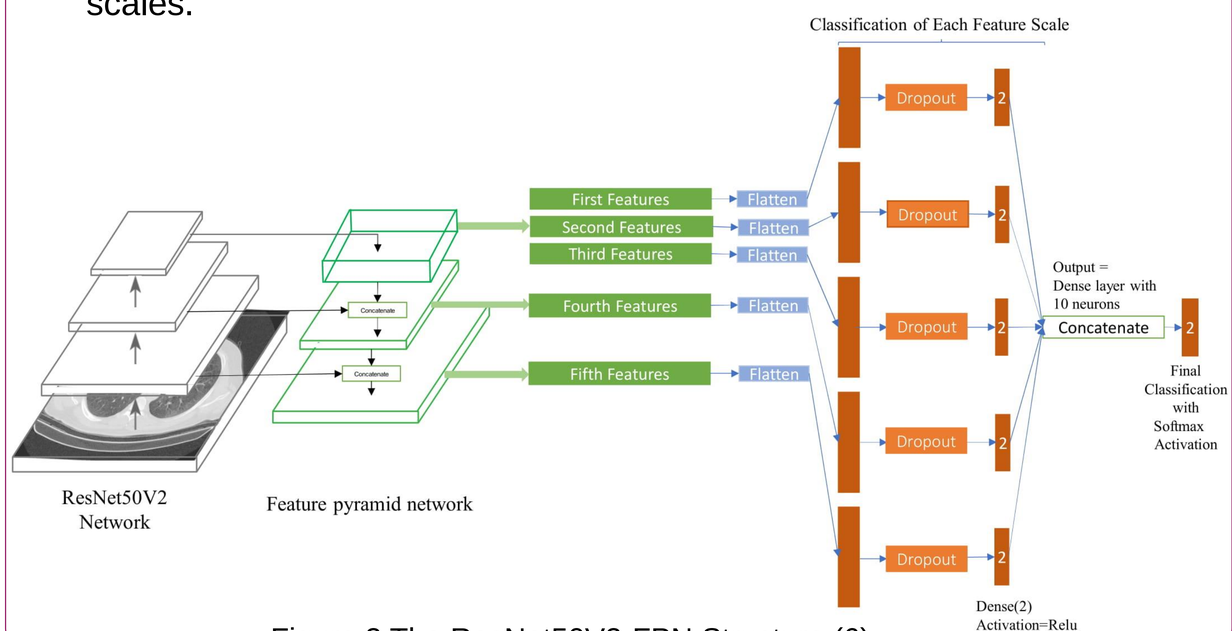



Figure 2 The ResNet50V2-FPN Structure (6)

## Dataset

Table 1 Dataset of Different Stratified Models

| Model | COVID-19* | | Normal | |
|---|---|---|---|---|
| | Patients (N**) | Images (N) | Patients (N) | Images (N) |
| **Non-Stratified** | 47 | 1077 | 141 | 4715 |
| **Age-Stratified 1** | | | | |
| Age≥50 | 48 | 1332 | 48 | 1564 |
| Age<50 | 47 | 950 | 234 | 8212 |
| **Age-Stratified 2** | | | | |
| Age≥40 | 74 | 1935 | 124 | 4364 |
| Age<40 | 21 | 347 | 158 | 5412 |
| **Gender-Stratified** | | | | |
| Female | 39 | 876 | 183 | 5633 |
| Male | 56 | 1400 | 136 | 5299 |

*COVID-19 = Coronavirus diseases 2019;
**N = number.

After image selection, there were 12258 chest CT images from 377 patients selected. Then they were stratified by age and gender. In this study, age had two study methods:

•Age 50- generally considered as the boundary to stratify COVID-19 CT dataset (5);

•Age 40- the median age.

## Results

Table 2 Summary of Different Stratified Model Performance in Classifying Patients

| | Sensitivity | | Specificity | | Precision | | Recall | | F1-Score | |
|---|---|---|---|---|---|---|---|---|---|---|
| | COVID-19* | Normal | COVID-19 | Normal | COVID-19 | Normal | COVID-19 | Normal | COVID-19 | Normal |
| **Non-Stratified** | 0.946 | 0.941 | 0.941 | 0.946 | 0.484 | 0.997 | 0.946 | 0.941 | 0.641 | 0.968 |
| **Age-Stratified 1** | | | | | | | | | | |
| Age≥50 | 0.917 | 0.939 | 0.939 | 0.917 | 0.893 | 0.955 | 0.917 | 0.939 | 0.905 | 0.947 |
| Age<50 | 0.941 | 0.839 | 0.839 | 0.941 | 0.229 | 0.998 | 0.941 | 0.839 | 0.369 | 0.912 |
| **Age-Stratified 2** | | | | | | | | | | |
| Age≥40 | 0.967 | 0.901 | 0.901 | 0.967 | 0.625 | 0.995 | 0.967 | 0.901 | 0.759 | 0.946 |
| Age<40 | 0.852 | 0.744 | 0.744 | 0.852 | 0.064 | 0.997 | 0.852 | 0.744 | 0.120 | 0.852 |
| **Gender-Stratified** | | | | | | | | | | |
| Female | 0.918 | 0.953 | 0.953 | 0.918 | 0.449 | 0.997 | 0.912 | 0.949 | 0.605 | 0.969 |
| Male | 0.982 | 0.940 | 0.940 | 0.982 | 0.611 | 0.999 | 0.983 | 0.935 | 0.753 | 0.968 |

* COVID-19 = Coronavirus diseases 2019.

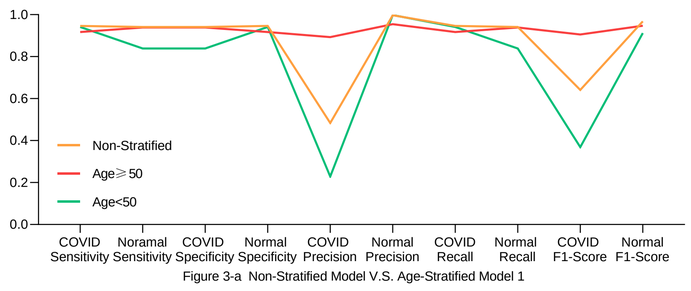



Figure 3-a Non-Stratified Model V.S. Age-Stratified Model 1

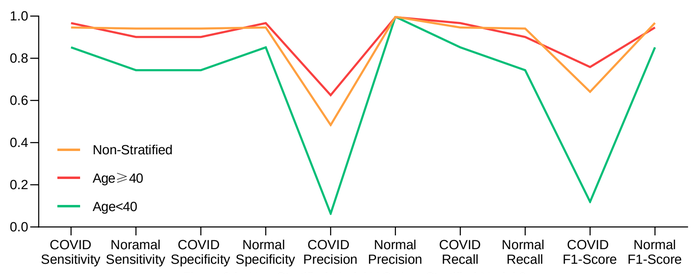



Figure 3-b Non-Stratified Model V.S. Age-Stratified Model 2

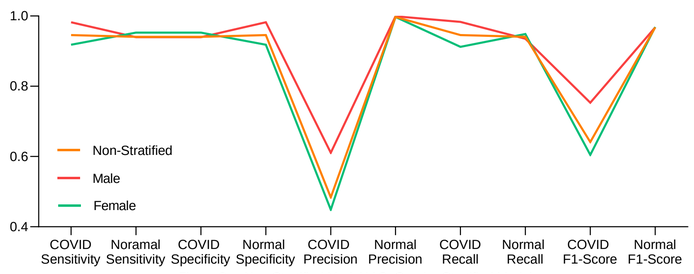



Figure 3-c Non-Stratified Model V.S. Gender-Stratified Model

Figure 3 Different Stratified Model Performance in Classifying Patients

**The female** stratified model outperformed in sensitivity, recall, F1-score of normal patients, and the specificity of COVID-19.

**The elder group** of age-stratified model outperformed non-stratified model in the precision of COVID-19 patients. The increasing precision indicates the necessary of using stratified dataset in building up models.

**The younger group** of age-stratified model performed worse than non-stratified model. Especially the age<40 stratified model, which performed worst among all of the models. There were significant decreases in the model performance between this model and non-stratified model ($p$<0.001).

**The male** stratified model performed better in almost all metrics, except for subtle decreases in the sensitivity, recall of normal patients, and specificity of COVID-19 patients.

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**Karolinska Institutet & Stockholm University**
**Address**: Department of Learning, Informatics, Management and Ethics (LIME), Karolinska Institutet, Stockholm
**E-mail**: zaiqiu.cao@stud.ki.se, lingyun.wu@stud.ki.se, yaru.zhou@stud.ki.se
**Telephone**: +46 765509144, +46 729031934, +46 738721731