Development of algorithms for detection of pneumonia and SARS-Cov-2 using X-ray images

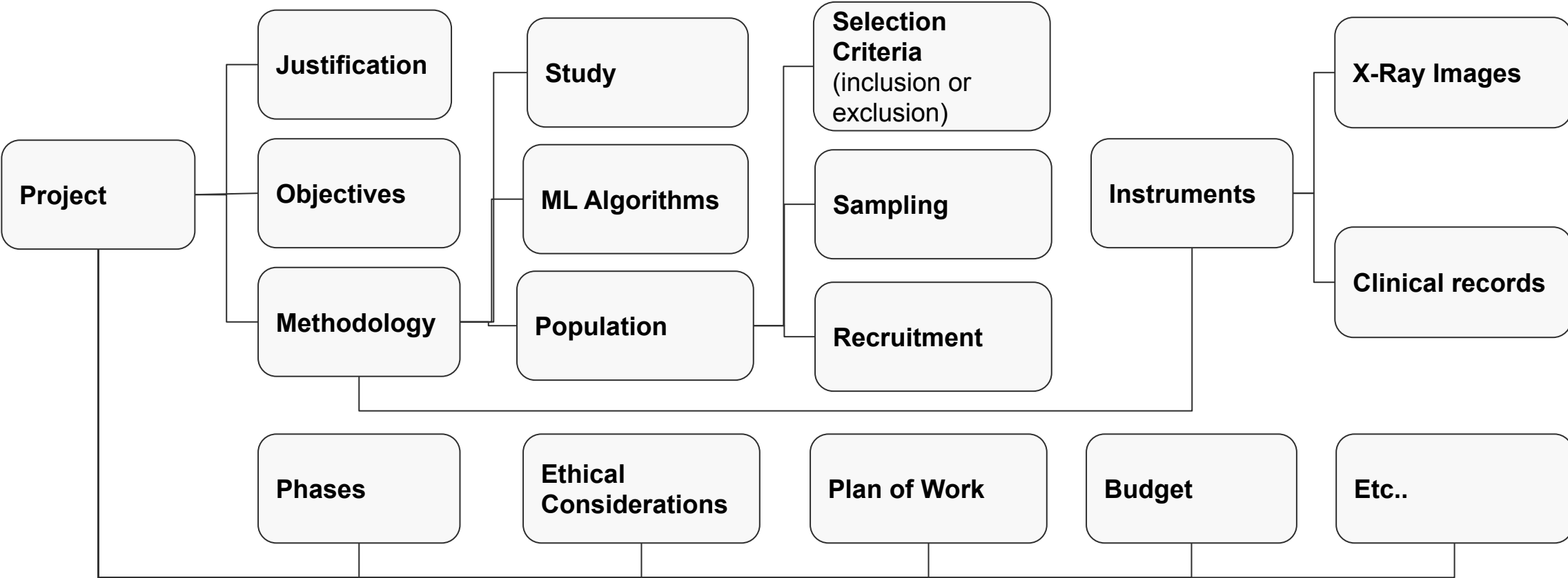Omar Zapata, Enric Tejedor, Pere Mato   EP-SFT

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Outline

- Context
- Open Datasets
- Preprocessing
  - Basic utils
  - Autocrop
  - ML model to classify sagittal view vs coronal view
- ML models for classification:
  - Two class: Covid-19 vs healthy people
  - Multiclass: Covid-19 vs pneumonia vs healthy people
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Context

What is required for a medical project?

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Project ─┬─ Justification
         ├─ Objectives
         ├─ Methodology ─┬─ Study
         │               ├─ ML Algorithms
         │               └─ Population ─┬─ Selection Criteria (inclusion or exclusion)
         │                              ├─ Sampling
         │                              └─ Recruitment ── Instruments ─┬─ X-Ray Images
         │                                                             └─ Clinical records
         └─ Phases    Ethical Considerations    Plan of Work    Budget    Etc..
```

Context

Open Datasets

- Despite the issues to get the dataset from the hospital, we did some prototypes with open datasets:
    - BIMCV-COVID19 is available online and provides 1.6 TB of high resolution X-Ray 2D

    - Kaggle dataset with 219 COVID-19, 1341 normal, and 1345 viral pneumonia chest X-ray (CXR) images, 1 GB data in low quality. Winner of the COVID-19 Dataset Award by Kaggle Community.

Preprocessing (Basic utils)

What has to be checked in the image file?

We have to check if:

- The file is empty
- The minimum size is 224x224
- The minimum intensity (if it is too blank)
- The maximum intensity (if it is too white)
- The right number of channels (if it is correctly extracted from the DICOM should be 1 channel only)

If the image does not pass those filters, it is discarded.

Additionally, we put there the algorithm for resizing medical images using bicubic interpolation, suggested in this paper and implemented by OpenCV.

Preprocessing (Autocrop)

This algorithm helps to cut out the "empty" spaces of the images to improve the quality
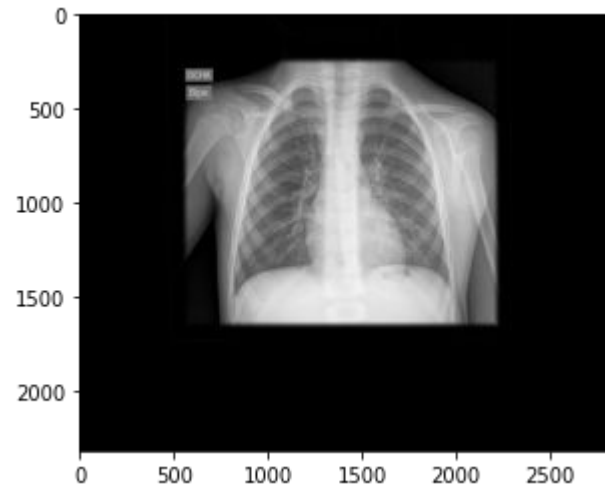

Autocrop

# Preprocessing (Sagittal view)

- Images taken in the sagittal plane are a problem:
  - Currently considered unnecessary
  - Mixed with the other images
  - They can produce errors for the diagnosis in the ML models.
- The ML model to classify those images is described in this paper https://arxiv.org/pdf/2006.01174.pdf in the Image preprocessing section page 8.
- They suggest transfer learning in an model called EfficientNet using the weights for imagenet.
- I manually selected 3834 sagittal view and 3834 coronal view with high quality.
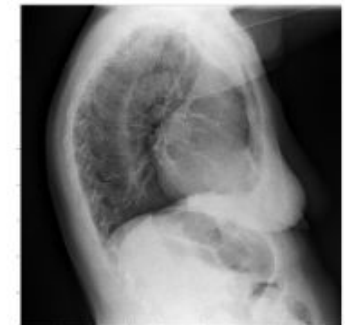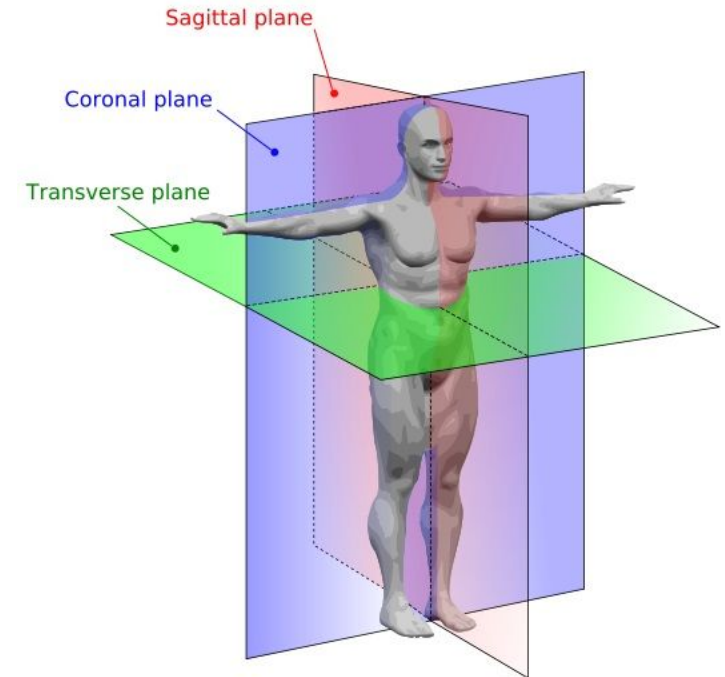
Preprocessing (Sagittal view)

- [EfficientNet](#) is a multiclass classifier and it was modified for two class classification.
- Output layer is a sigmoid
- Loss function is binary cross entropy
- Optimizer is Adam
- Trained with 7668 images
- It is a huge model with 17 millions of parameters

  with very good results as is shown in the confusion matrix.

Confusion Matrix

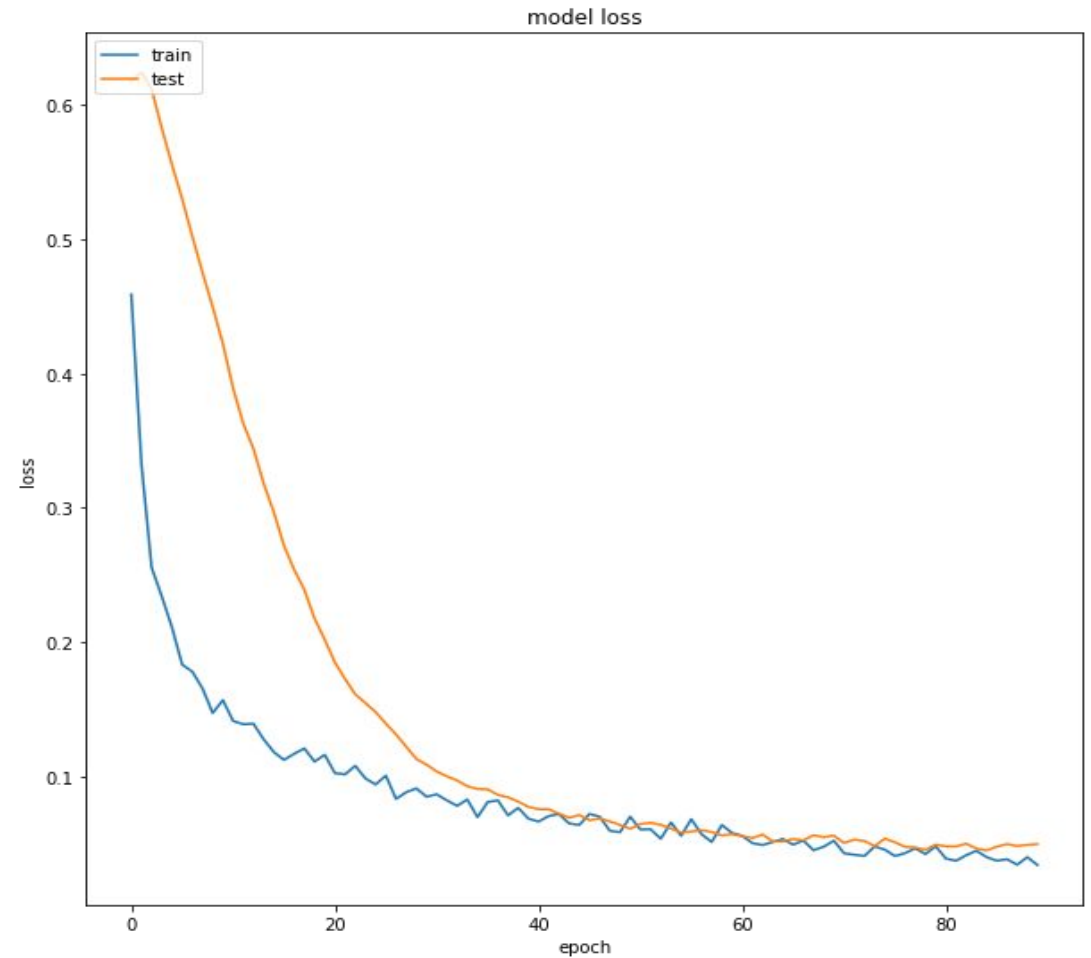accuracy=0.9993; misclass=0.0007
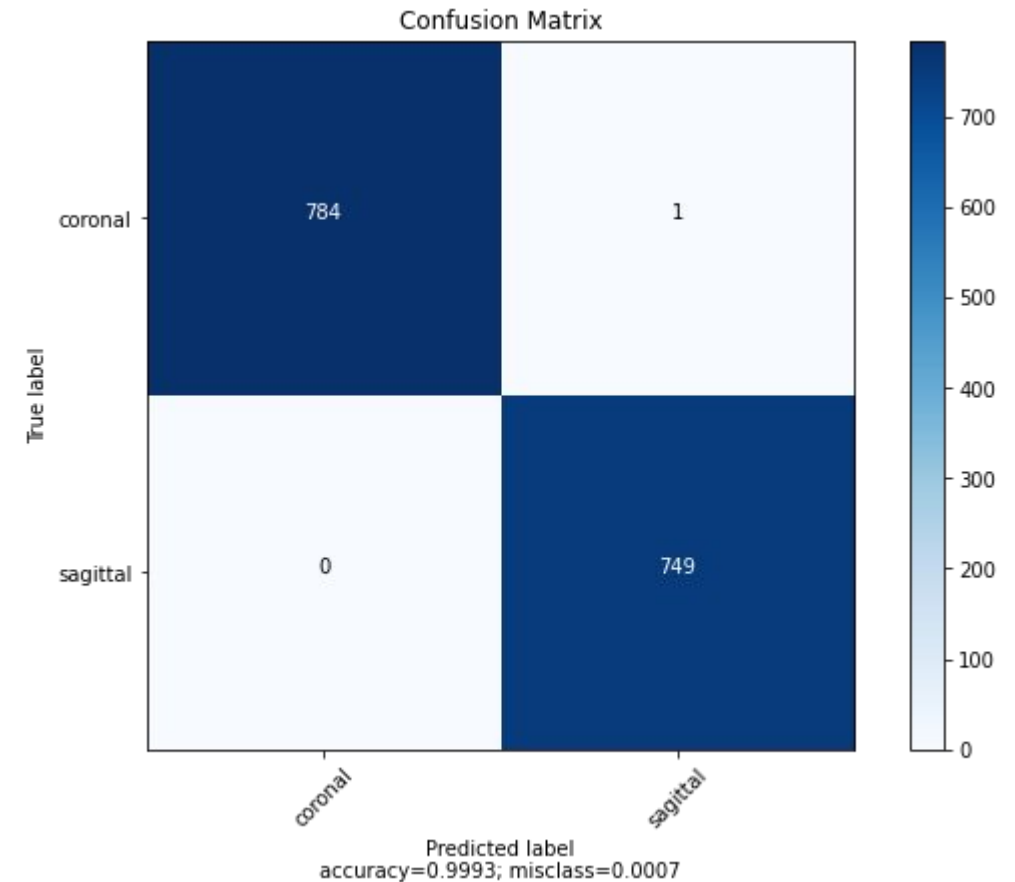
ML models for classification (COVID-19 vs healthy)

- We developed a prototype for **two-class**
  - Covid-19 vs healthy.
- The prototype takes **X-Ray** images as input
  - We use an award-winning public dataset (winner of the COVID-19 Dataset Award in kaggle).
- Our models are based on **Convolutional Neural Networks** (CNN), with our own architecture.

Confusion Matrix

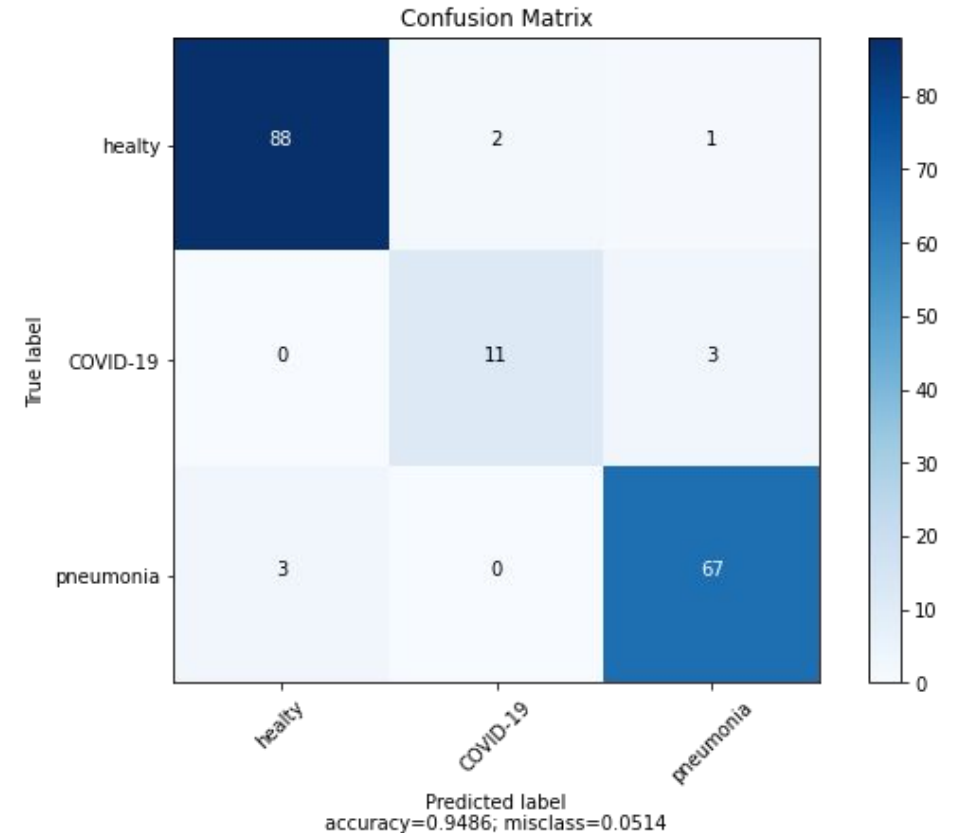accuracy=0.9894; misclass=0.0106
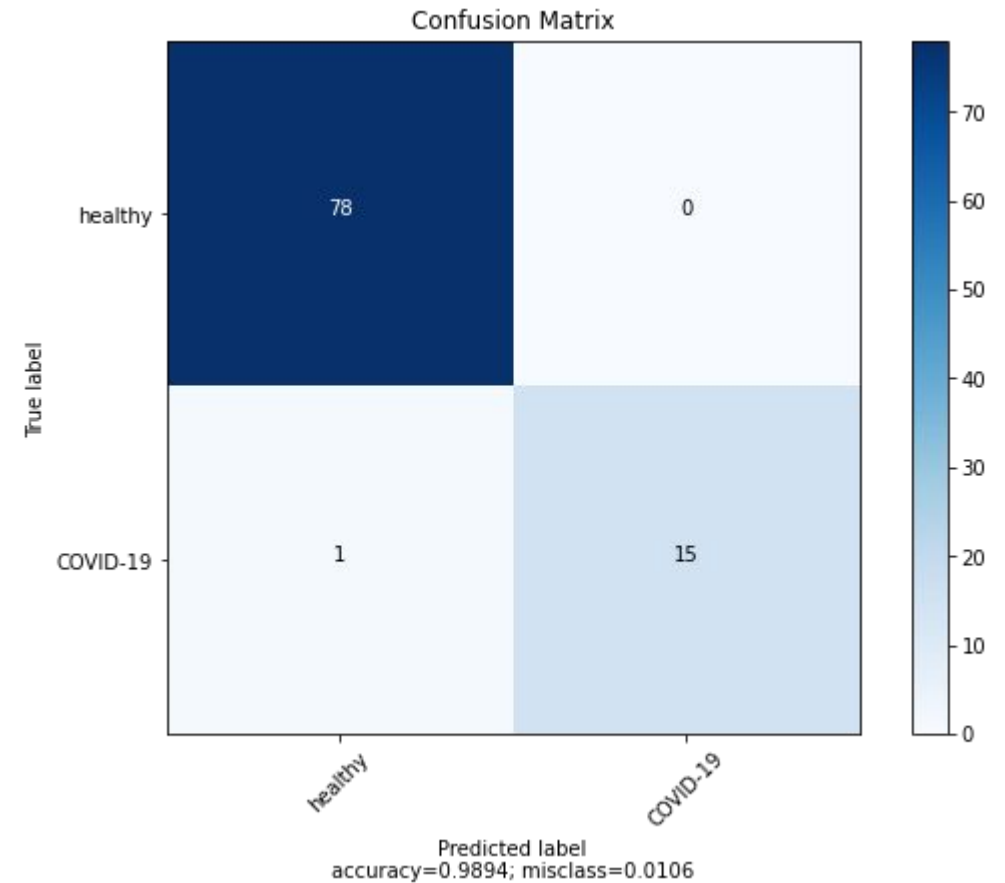
ML models for classification (COVID-19 vs healthy)

- For the initial prototype, we are using low resolution images 224x224 with one channel.
- Total images used: 1560
- Trained with tensorflow-gpu 1.15
- Server specs:
  - Intel(R) Core(TM) i9-9900K CPU @ 3.60GHz
  - GPU Nvidia Geforce RTX 2070 8 GB VRAM
  - 32 GB RAM
- Takes around 90 epochs to converge
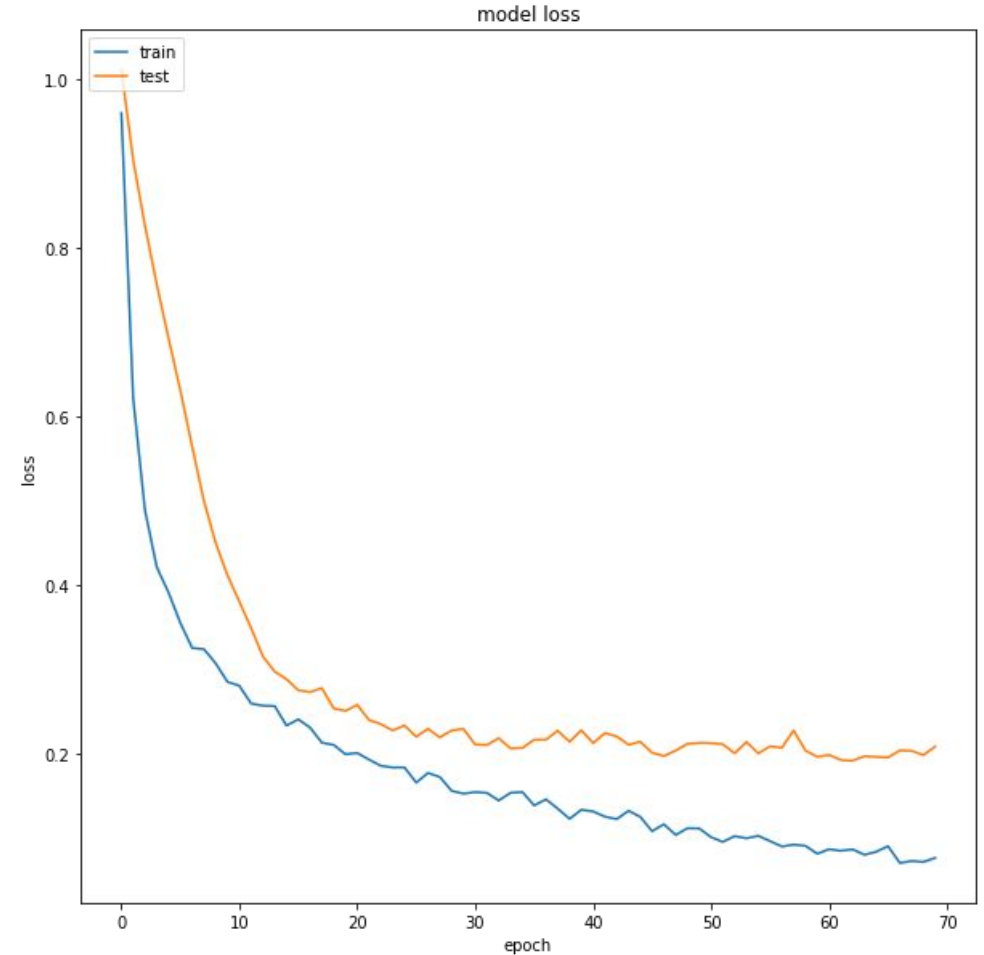 - ~6 minutes (GPU)

ML models for classification (Viral-pneumonia vs COVID-19 vs healthy)

- Using the same approach we developed a prototype for **multi-class classification**
  - Viral-pneumonia vs Covid-19 vs healthy
- The model takes **X-Ray** images as input
  - We use an award-winning public dataset (winner of the COVID-19 Dataset Award in kaggle)
- It is based on **Convolutional Neural Networks** (CNN) as well, with our own architecture.

Confusion Matrix

accuracy=0.9486; misclass=0.0514

ML models for classification (COVID-19 vs healthy)

- Low resolution images 224x224 with one channel.
- Total images used: 2905
- Trained with tensorflow-gpu 1.15
- Server specs:
  - Intel(R) Core(TM) i9-9900K CPU @ 3.60GHz
  - GPU Nvidia Geforce RTX 2070 8 GB VRAM
  - 32 GB RAM
- Takes around 70 epochs to converge
  - ~20 minutes (GPU)

Conclusions

- Developed tools for preprocessing using open datasets for COVID-19
  - Helps discard images (Bad quality or sagittal view)
  - Improves image quality with the auto-crop
- Prototypes developed using open datasets:
  - Two class classification (COVID-19 vs healthy)
  - Multi-class classification (Viral-pneumonia vs COVID-19 vs healthy)

Questions

References

- Image planes were taken from: https://my-ms.org/mri_planes.htm
- https://arxiv.org/pdf/2006.01174.pdf
- http://proceedings.mlr.press/v97/tan19a.html
- https://ieeexplore.ieee.org/document/6611042
- https://ojs.unud.ac.id/index.php/jik/article/download/69207/39370/

https://against-covid-19.web.cern.ch