Prácticas Externas 1 (Hospitales y Salud)

Curso 2020/21

Grado en Ingeniería Biomédica

Hospital Universitario Fundación Alcorcón
SaludMadrid
Comunidad de Madrid

Universidad Rey Juan Carlos

Lung Ultrasound
for COVID detection

Students: **PABLO LASO-MIELGO** [1]
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Tutor: **RAFAEL GARCÍA CARRETERO**

Year 2020/21

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BIOMEDICAL ENGINEERING DEGREE

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- **Results** (Pablo)
- **Conclusion** (Alejandro and Pablo)

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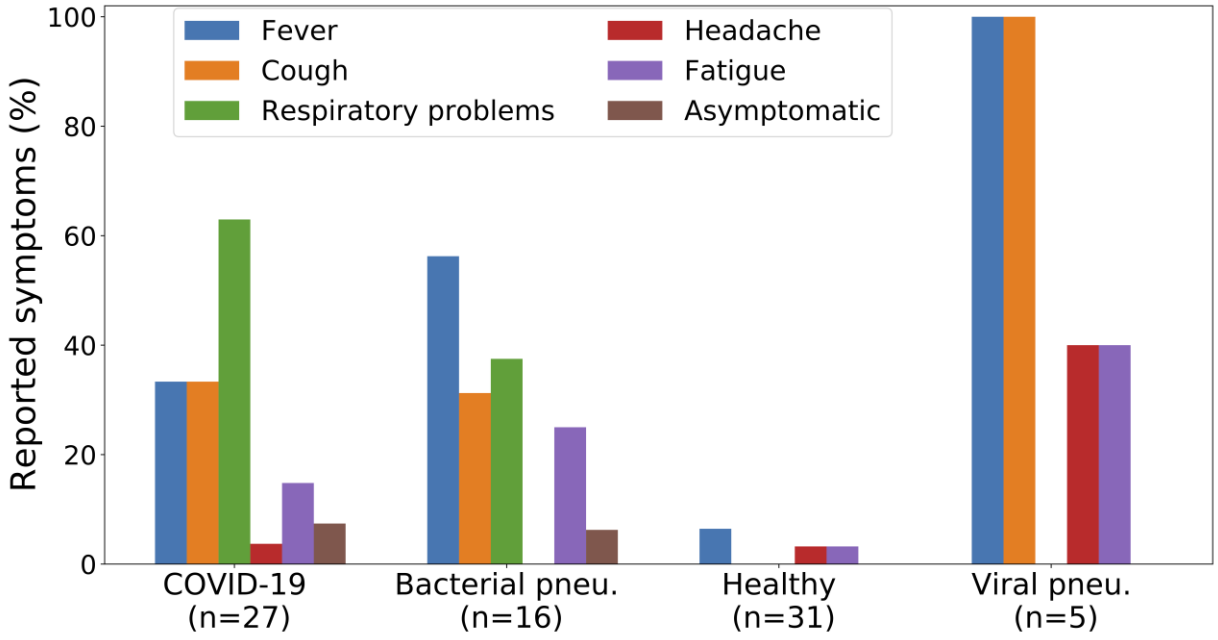
- **Conclusion** (Alejandro and Pablo)

Introduction and Objectives

PABLO

COVID-19 detection via **Lung US**

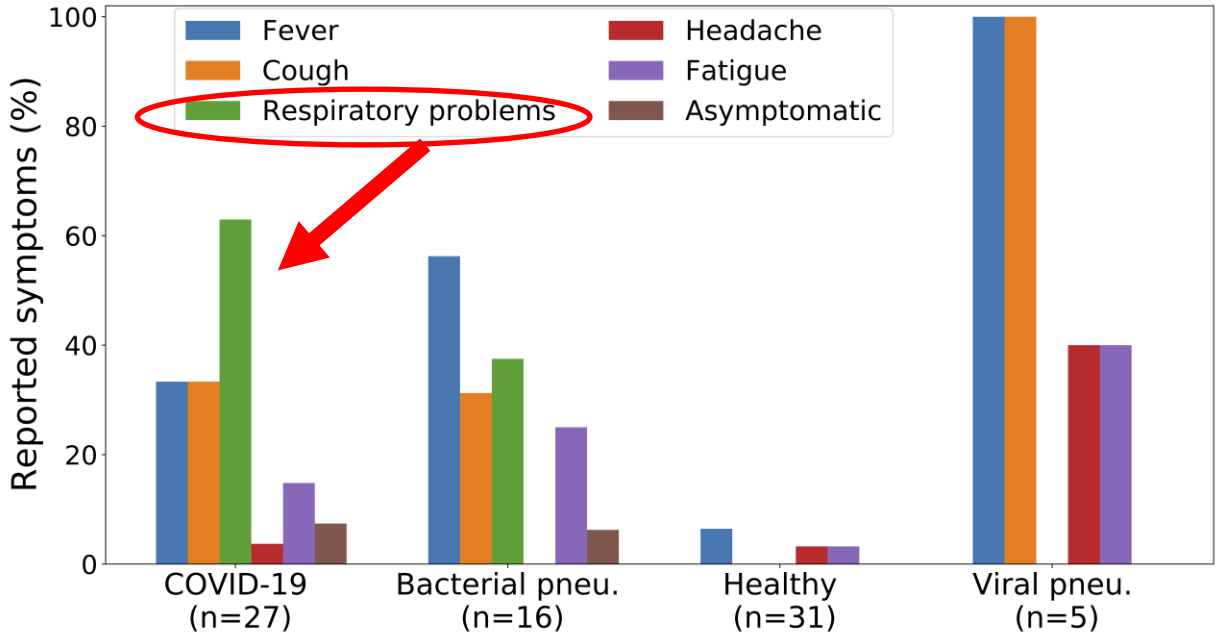


- **Non-ionizing**
- **Fast**
- **Point of Care**

Introduction and Objectives

PABLO

COVID-19 detection via **Lung US**

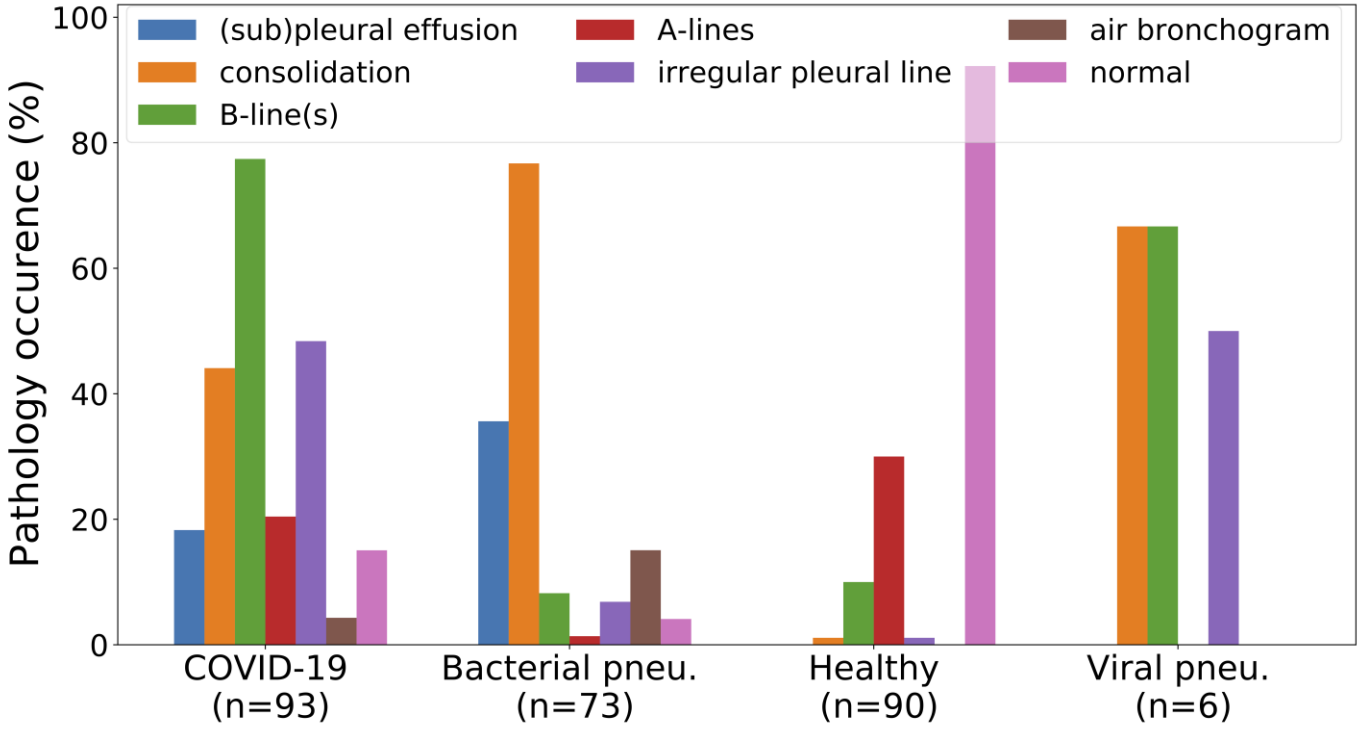


- **Non-ionizing**
- **Fast**
- **Point of Care**

Introduction and Objectives

PABLO

COVID-19 detection via **Lung US**



Introduction and Objectives

PABLO

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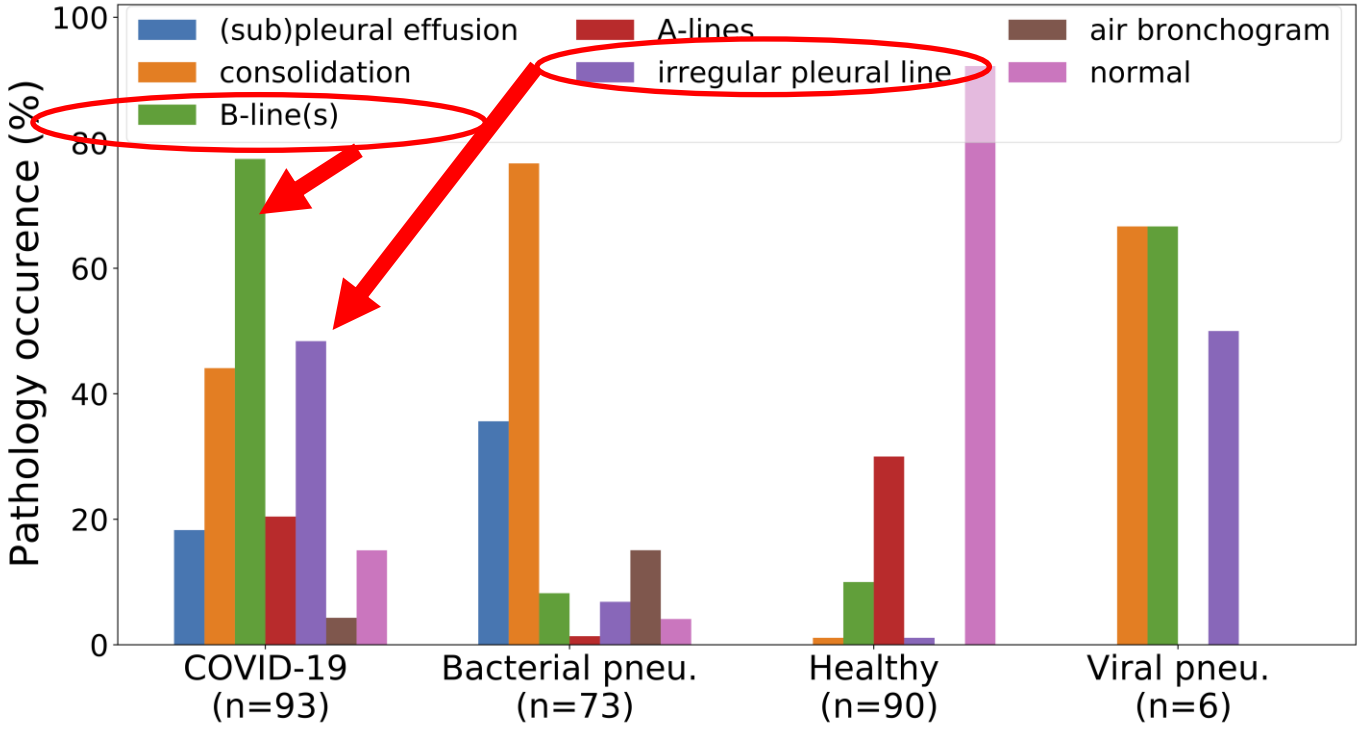
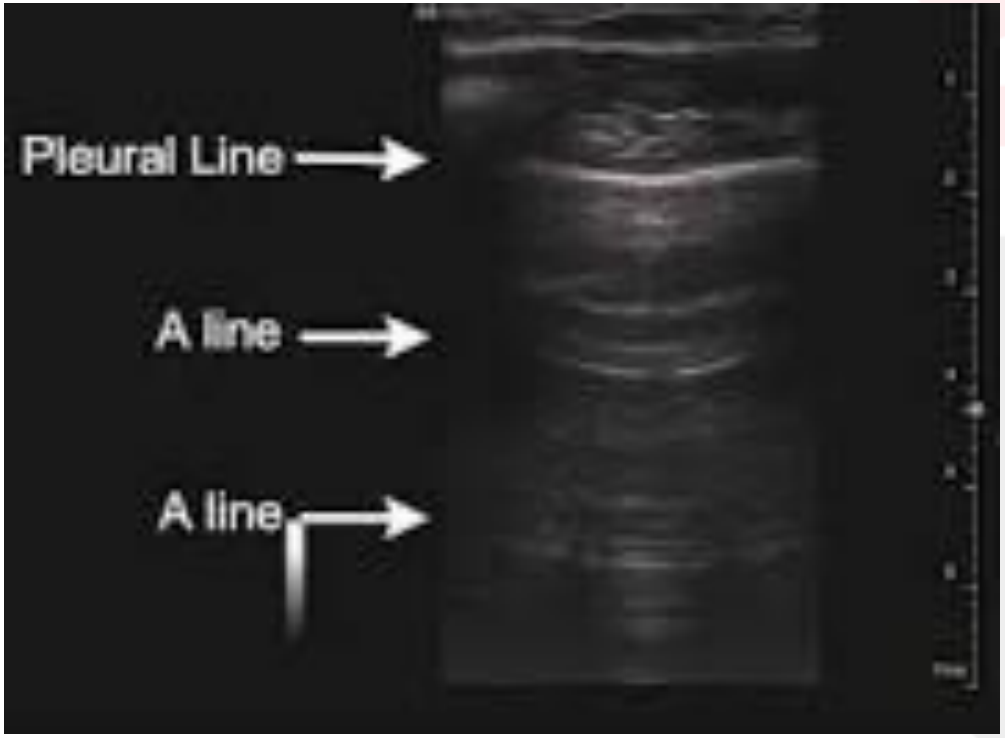


Introduction and Objectives

PABLO

COVID-19 detection via **Lung US**

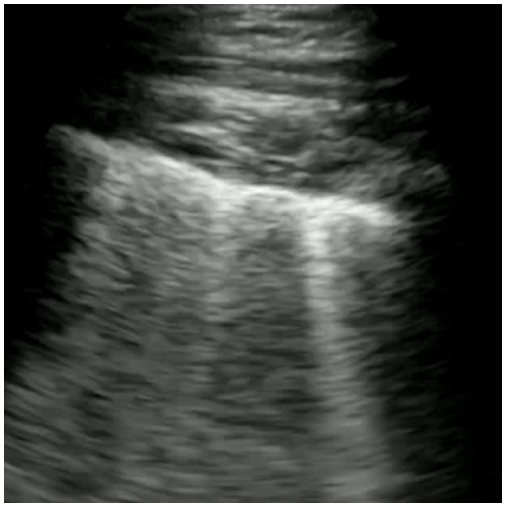


Introduction and Objectives

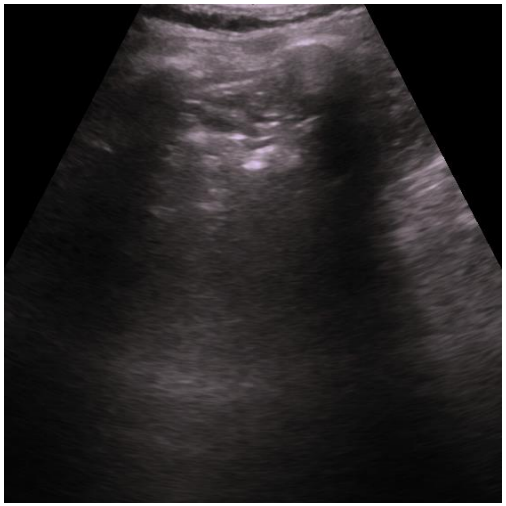
PABLO

COVID-19 detection via **Lung US**

Healthy (A-lines)



COVID-19 (B-lines)



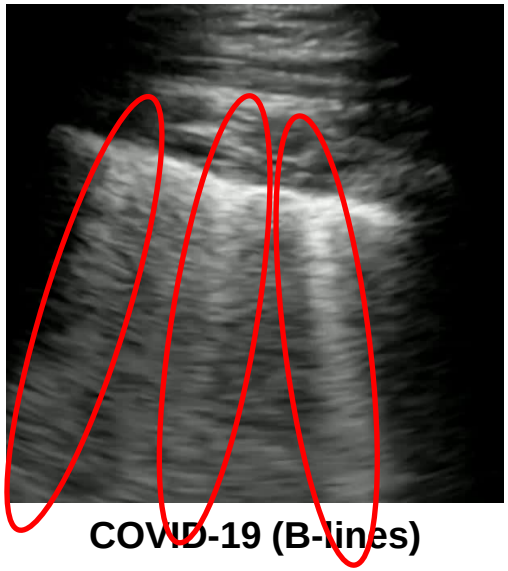
Pneumonia

Introduction and Objectives

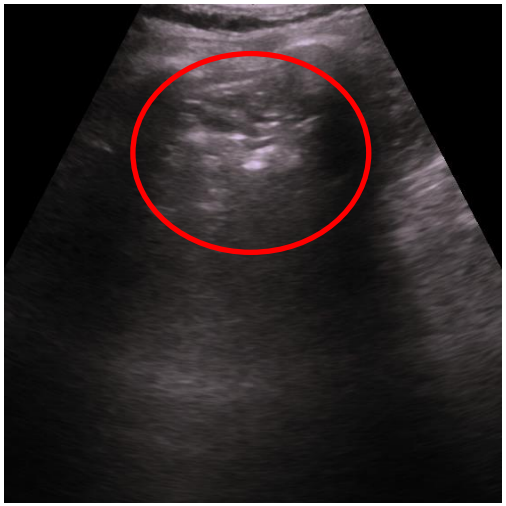
PABLO

COVID-19 detection via **Lung US**

Healthy (A-lines)



COVID-19 (B-lines)



Pneumonia

Introduction and Objectives

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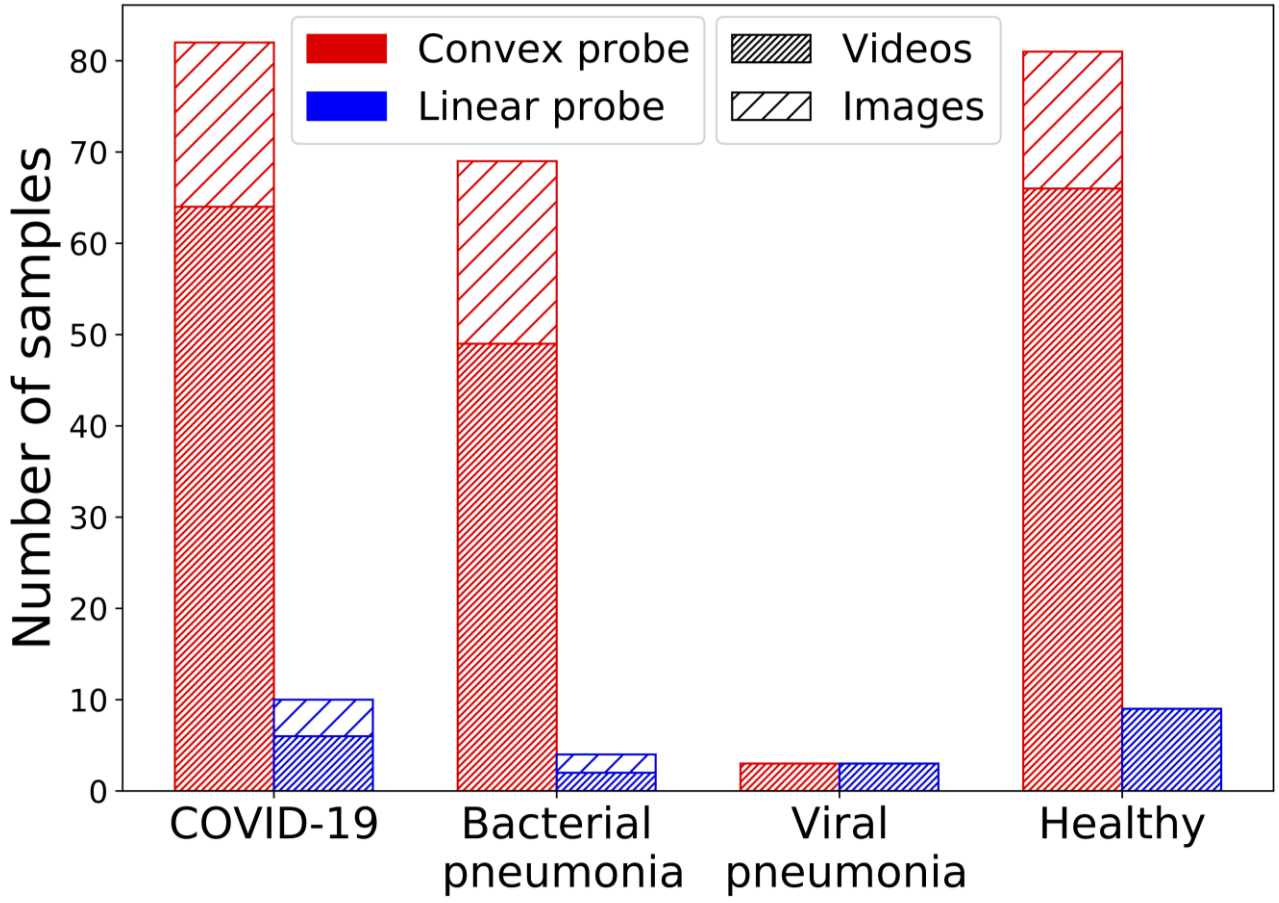
POCUS dataset



Introduction and Objectives

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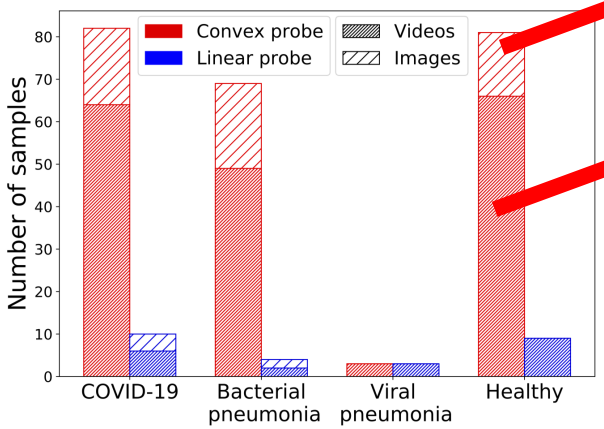


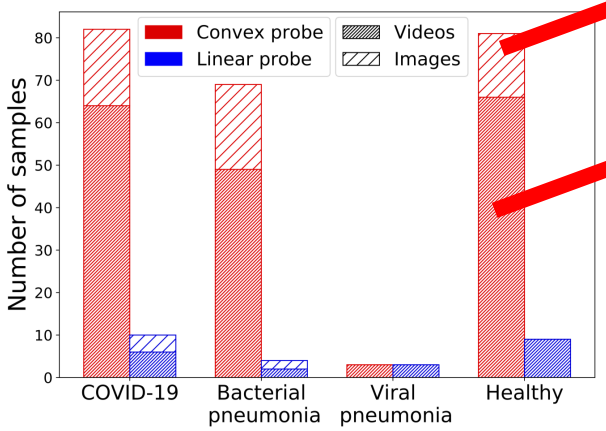
Very little independent images

Larger amount of videos

Introduction and Objectives

PABLO

POCUS dataset



Very little independent images

Larger amount of videos

Maybe splitting videos into frames to have more images?

Presentation workflow

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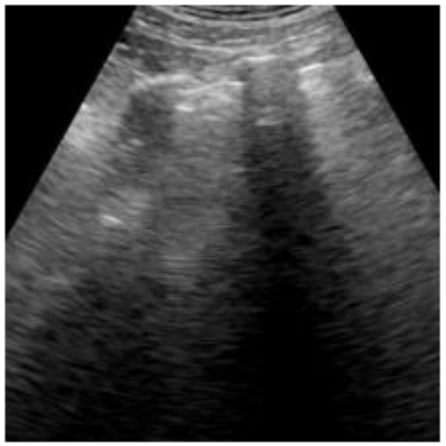
Methodology: **Image Pre-processing**

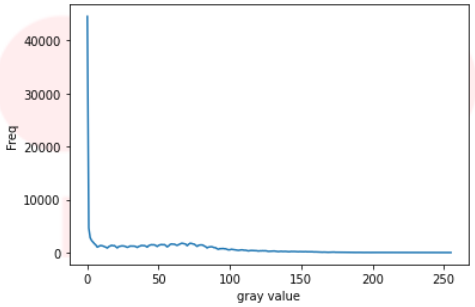
Steps

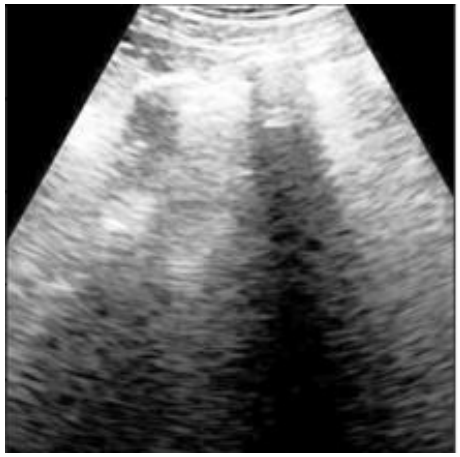
- Histogram equalization
- Pleural approximation
- Pleural resection

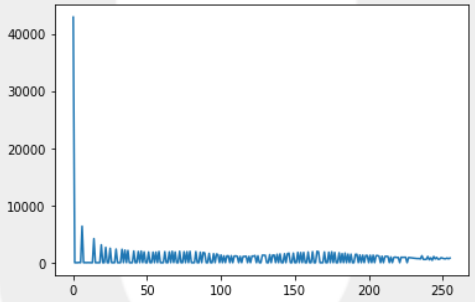
Histogram equalization

- Low contrast images
- Narrow histogram
- Difficulty to detect objects









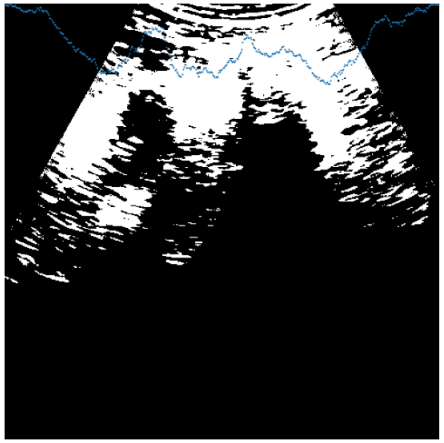
Pleural approximation

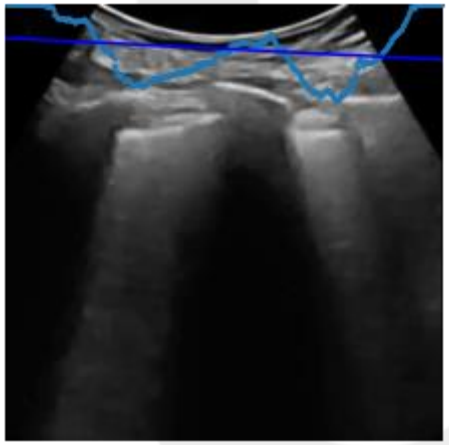
Steps

1. Binarization using thresholding

1. Middlepoint

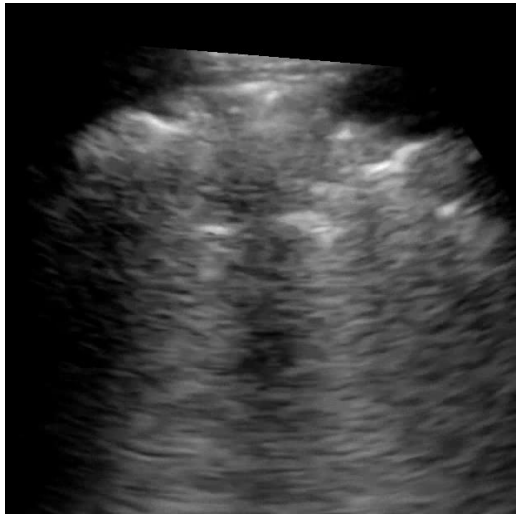
1. Regression line

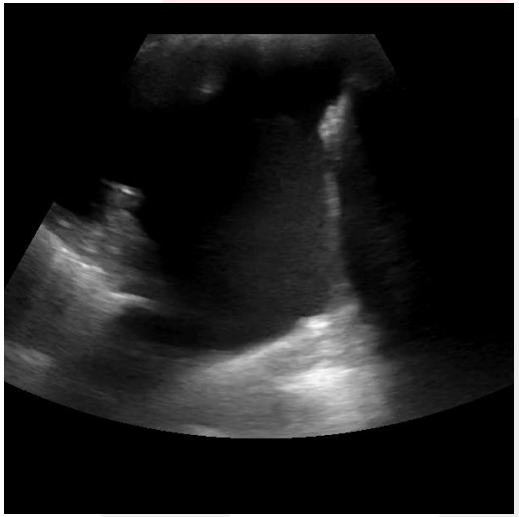




Pleural resection

- Using the regression line, perform pleural resection





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Results: **Image-Classification**

Simple CNN

Layer (type)	Output Shape	Param #
conv2d_9 (Conv2D)	(None, 148, 148, 32)	896
max_pooling2d_9 (MaxPooling2	(None, 74, 74, 32)	0
conv2d_10 (Conv2D)	(None, 72, 72, 64)	18496
max_pooling2d_10 (MaxPooling	(None, 36, 36, 64)	0
conv2d_11 (Conv2D)	(None, 34, 34, 128)	73856
max_pooling2d_11 (MaxPooling	(None, 17, 17, 128)	0
flatten_3 (Flatten)	(None, 36992)	0
dropout_2 (Dropout)	(None, 36992)	0
dense_6 (Dense)	(None, 512)	18940416
dense_7 (Dense)	(None, 3)	1539

Total params: 19,035,203
Trainable params: 19,035,203
Non-trainable params: 0

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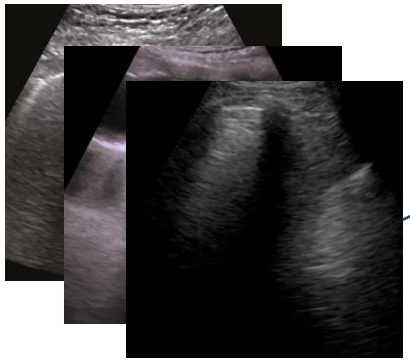
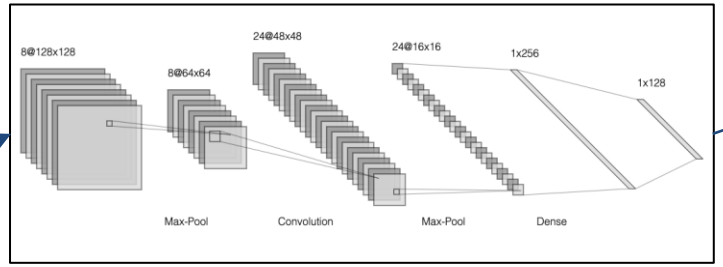
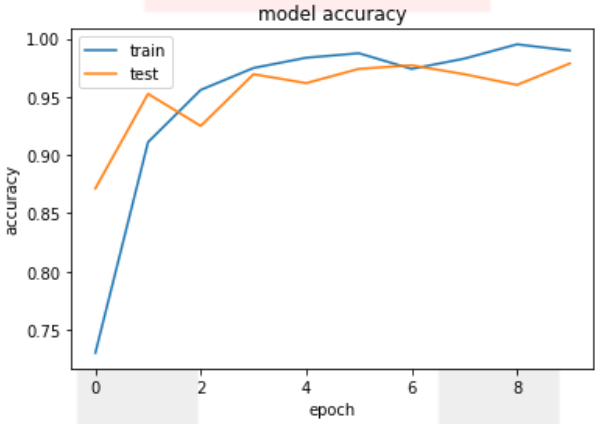
Results: **Image Classification**

Raw images

Overfitting!

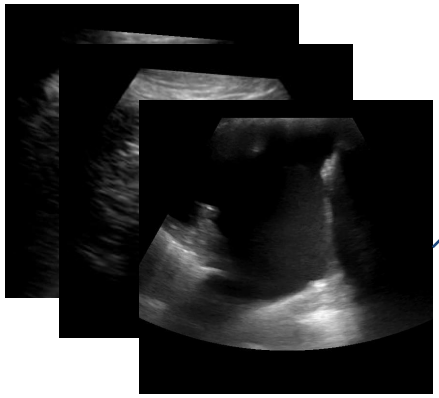


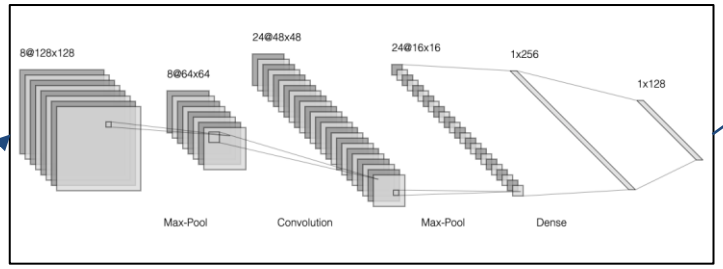


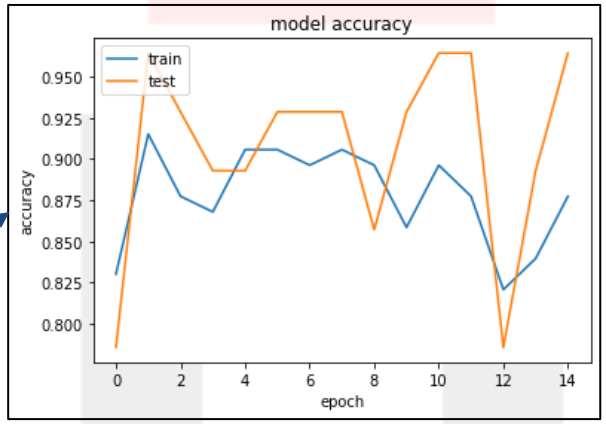


Results: **Image Classification**

Pre Processed images







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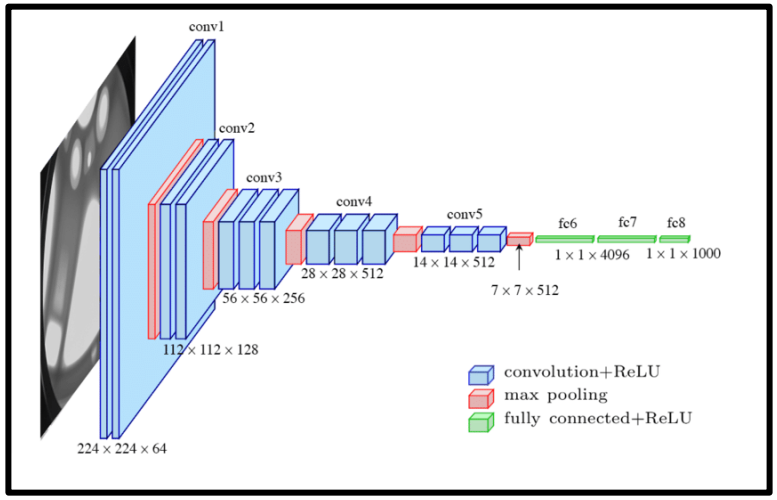
Methodology: **Transfer Learning**

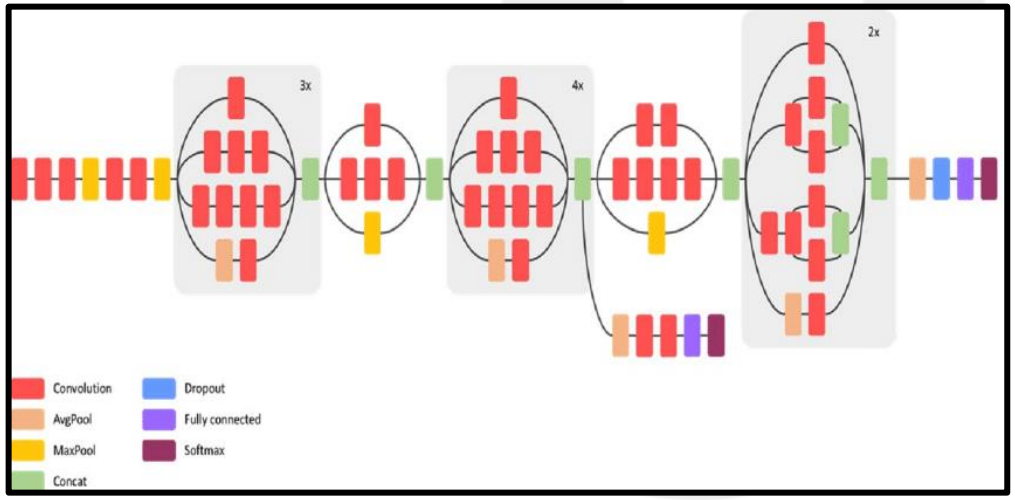
PABLO

- Generalization.
- Faster Training (pre-trained layers).

VGG16



InceptionV3



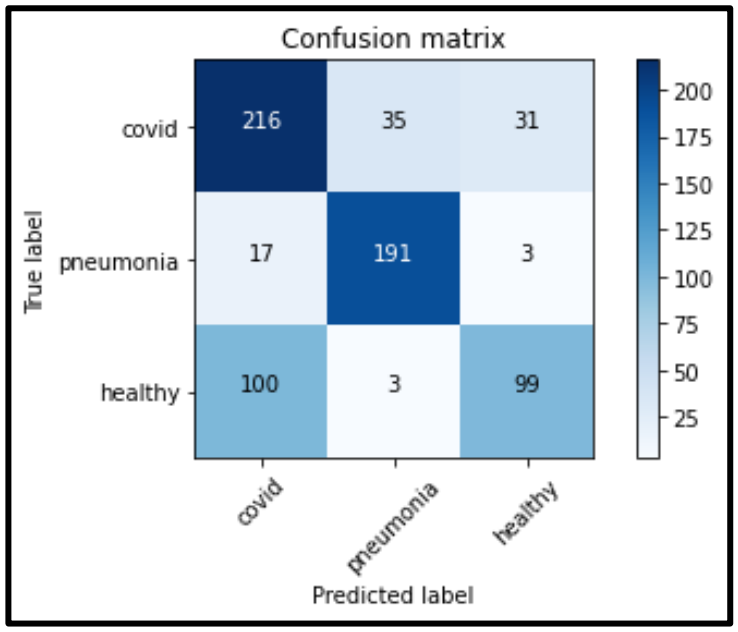
Methodology: **Transfer Learning**

PABLO

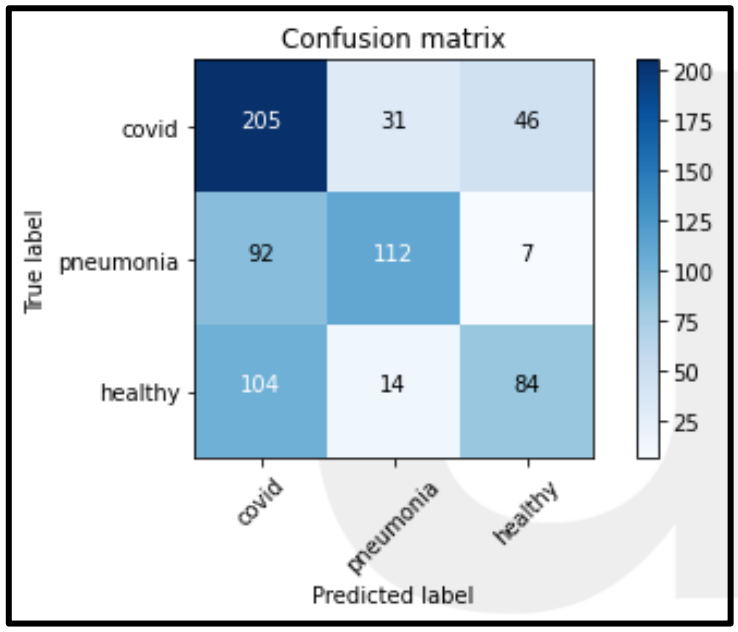
VGG16

- Excellent performance for pneumonia.
- Not so for COVID-19.

VGG16



InceptionV3



Methodology

PABLO

- **Image** classification
  → split video into frames
  → overfitting

  → Transfer Learning
  → works for pneumonia

- **Video** classification → how?

Methodology

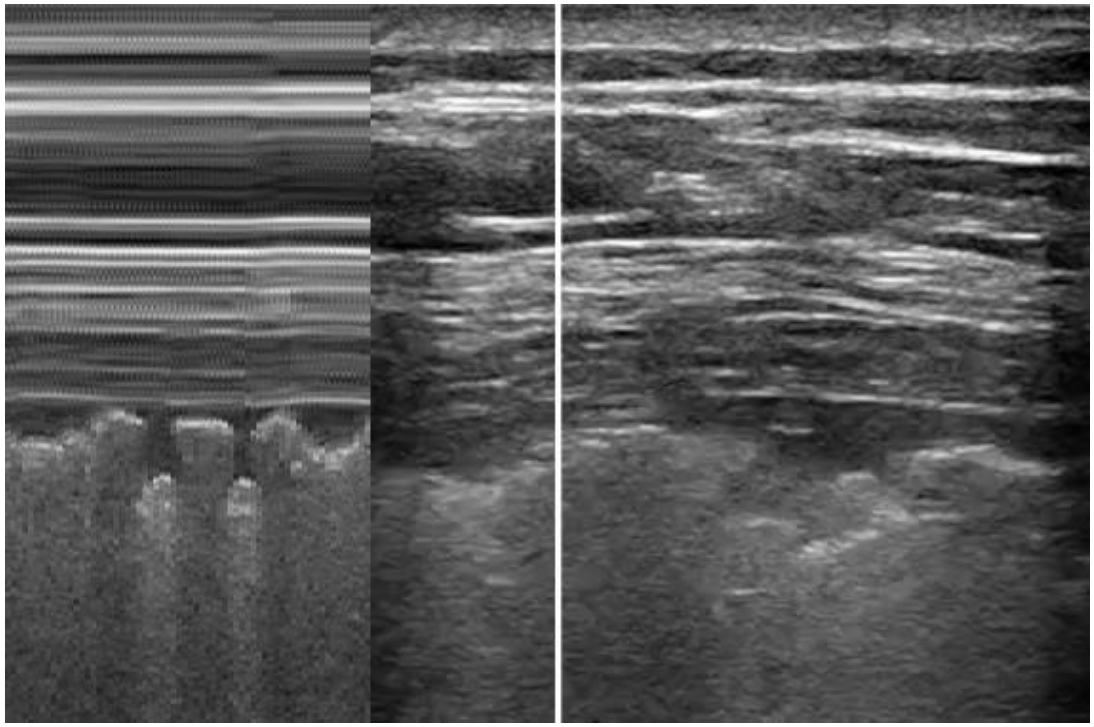
- **Image** classification
  - → split video into fr
    - → c
  - → Trans
    - ks for pneumonia
- V cation → how?

M-mode US

Methodology: **Video Pre-processing**

PABLO

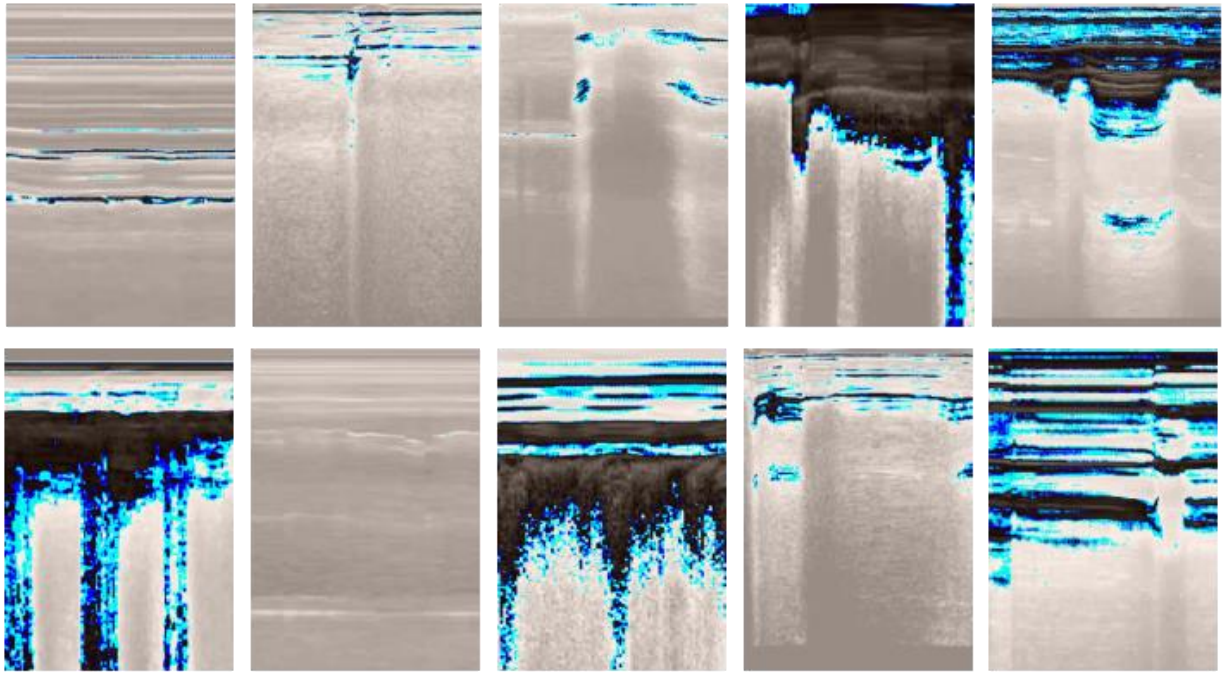
- One image per video ← M-mode US



Methodology: **Video Pre-processing**

PABLO

- M-mode US + **VGG16 pre-processing**!



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Results: **Video Classification**

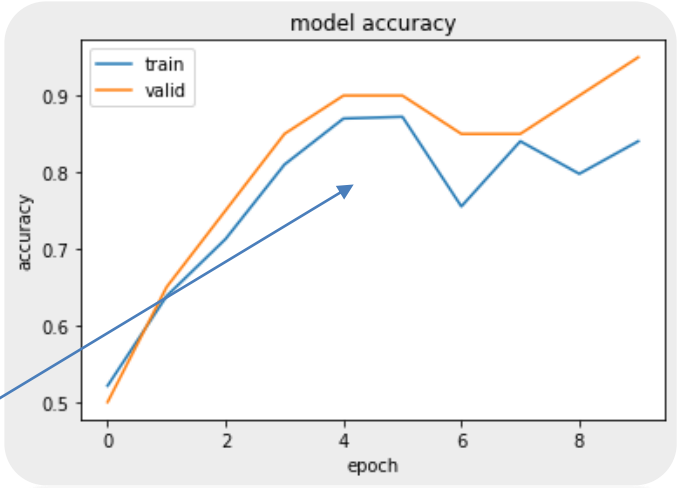
PABLO

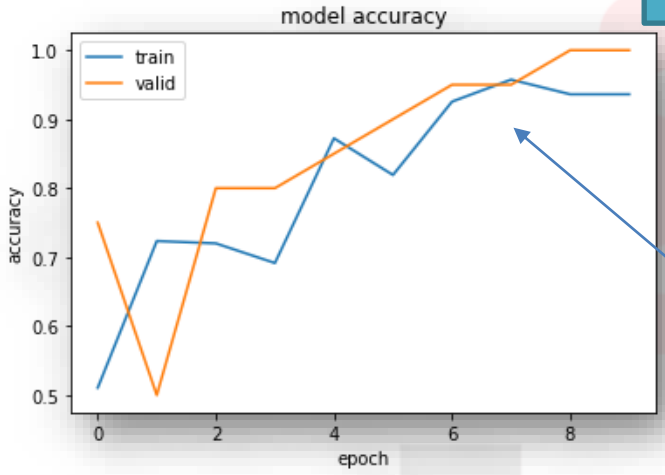
Simple CNN

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_2 (Conv2D)            (None, 723, 512, 32)      896
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 361, 256, 32)      0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 361, 256, 64)      18496
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 180, 128, 64)      0
_________________________________________________________________
flatten_1 (Flatten)          (None, 1474560)           0
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 2949122
=================================================================
Total params: 2,968,514
Trainable params: 2,968,514
Non-trainable params: 0
_________________________________________________________________
```

Conclusions: **Video classification**

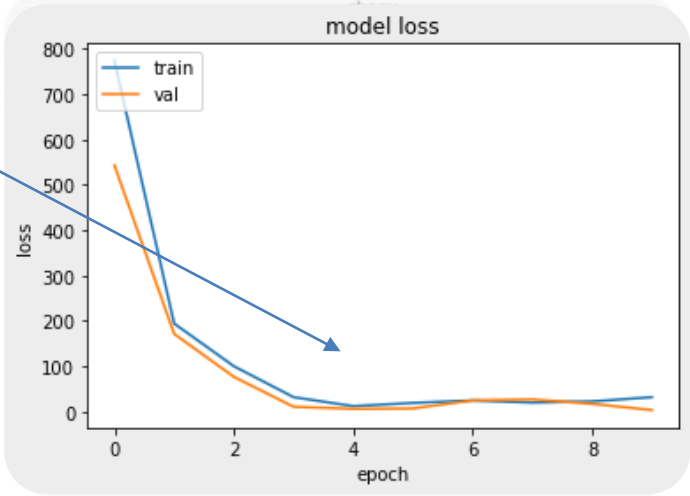
PABLO

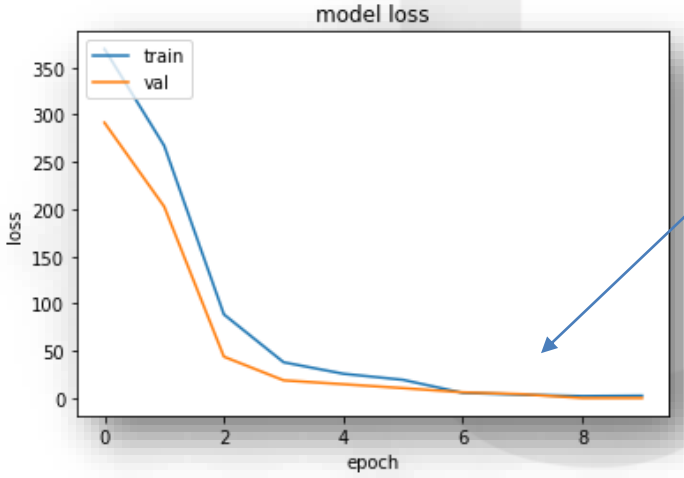




Train: 0.87
–
valid:0.90

Train: 0.95
–
Valid: 0.95





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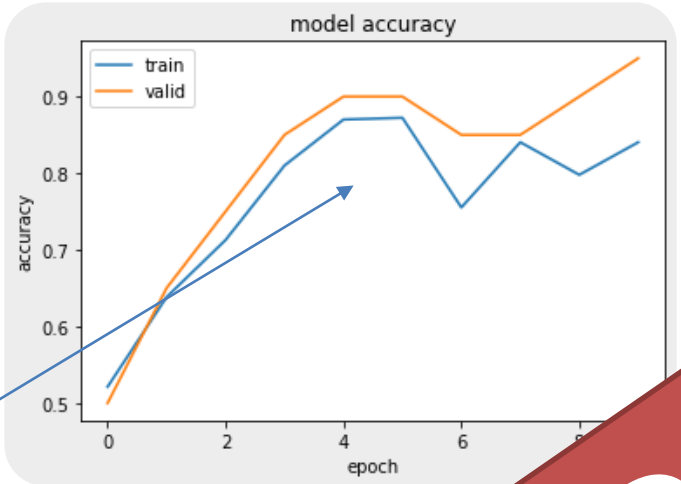
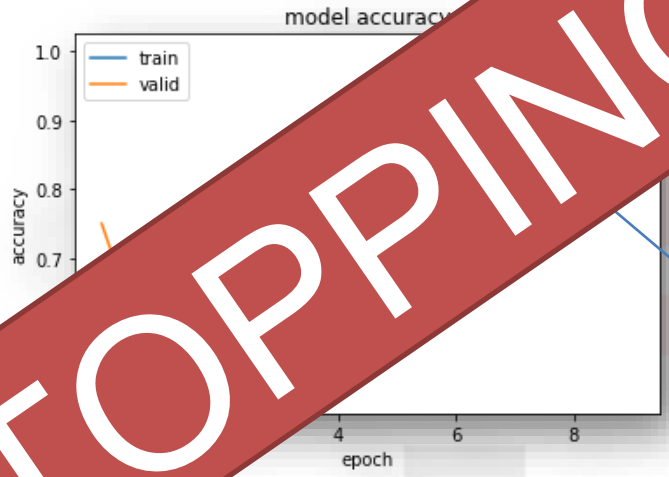
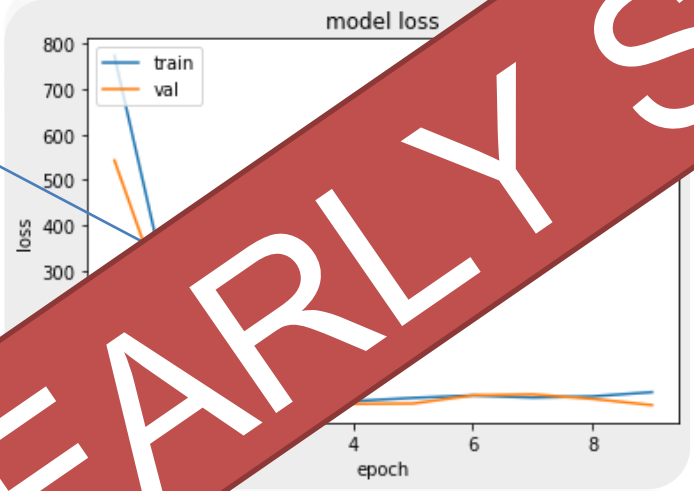
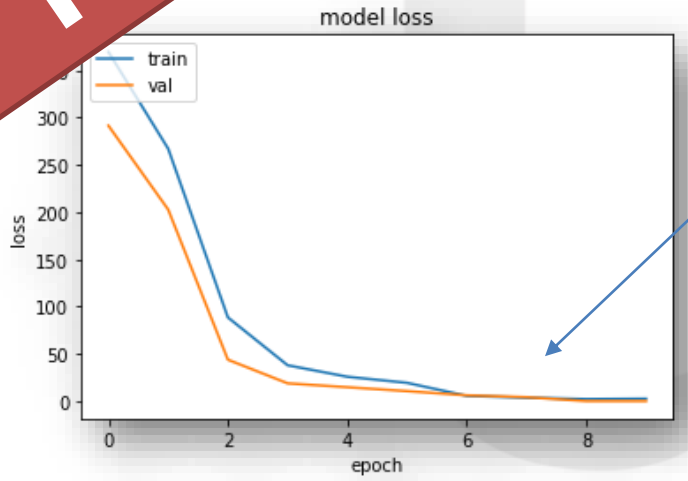
Conclusions: **Video classification**





Train: 0.87
–
valid:0.90





Train: 0.95
–
Valid: 0.95

EARLY STOPPING

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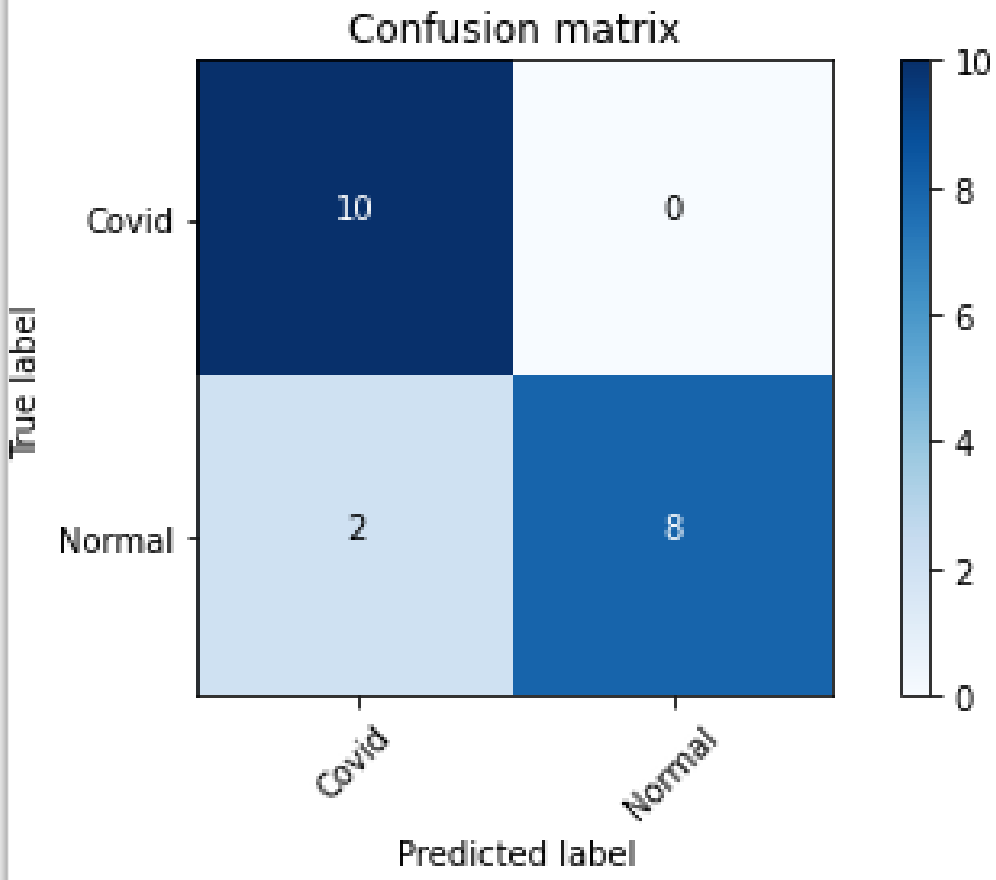
Results: **Video Classification**

PABLO



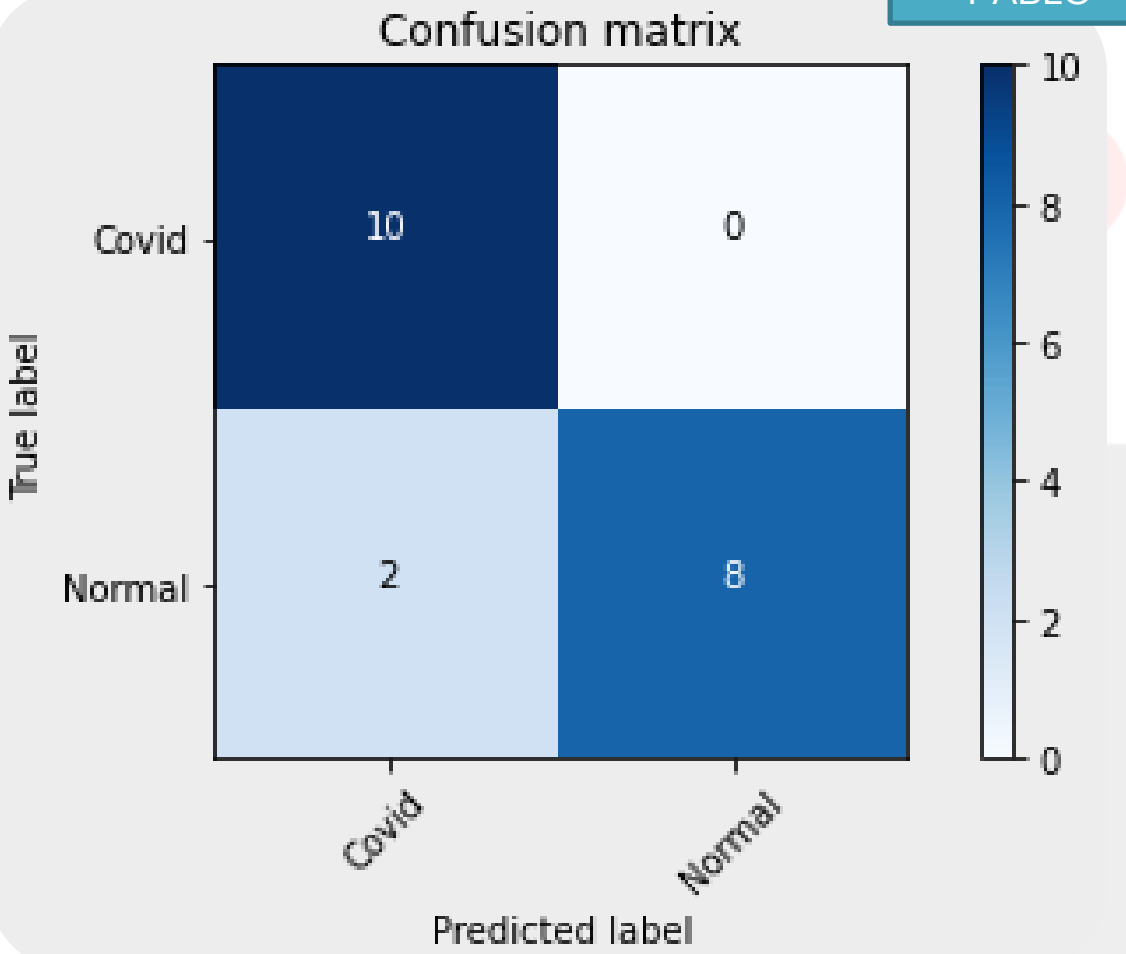
- **High accuracy.**
- **Generalizing ability.**

Conclusions: **Video classification**

PABLO

Test set

No errors on COVID-19 cases



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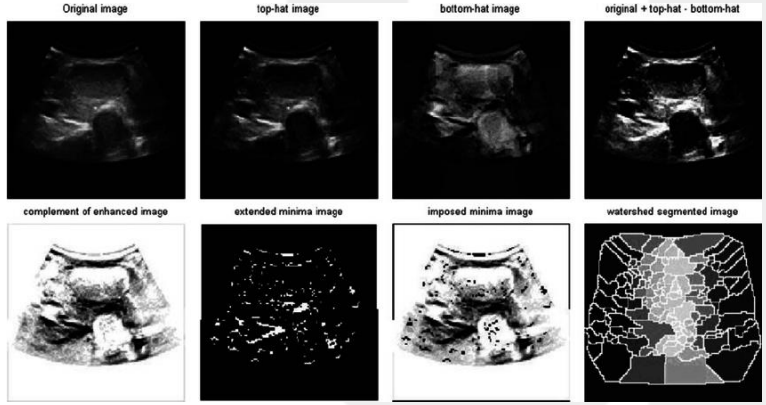
Conclusions: **Image classification**

- Ability to **generalize** as the **main challenge.**

- **Higher computational power**(AWS,GCP**)**
- Robust **pre-processing**(Better resection, edge detection)



Conclusions: **Transfer Learning**

PABLO

- Correcting image overfitting
- Performs very well on **pneumonia**
- Not so on COVID-19

Conclusions: **Video classification**

PABLO

- **Video analysis:**
  - **One image** per video (not multiple and inter-dependent frames).

- Computationally **faster** and cheaper**.**
  - **Time**-dimensional information.
    - Anatomical areas **scoring**.

Acknowledgments and workload

- **HUFA**
  - **Intro** to LUS and lung anatomy
  - First images and videos

- **URJC**
  - Rafael: huge **support** at the beginning stages of the project.

- **Alejandro**:
  - Preprocessing
  - **Pleural lines** (complex preprocessing)
  - Complex CNN

PABLO

- First image CNN (overfitting).
- Standard preprocessing (MIA course).
- POCUS database organization.
- Latex: abstract, Intro, Problem Statement, References, etc.
- **Transfer Learning**.
- **Video preprocessing**.
- Video classification.
- …

Appendix

PABLO

POCUS database (mostly videos):

https://github.com/jannisborn/covid19_ultrasound/tree/master/data

Butterfly database (videos only):

https://www.butterflynetwork.com/covid-19

Q&A

QUESTIONS?