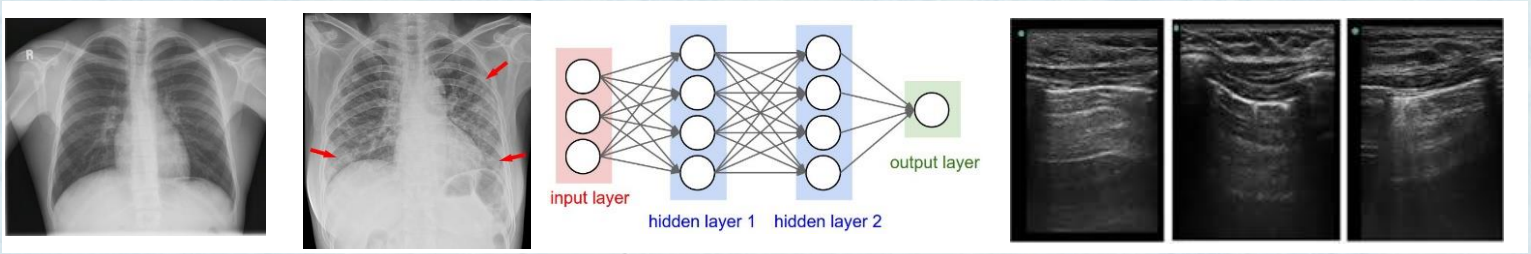


Point of Care Image Analysis for COVID-19

Daniel Yaron, Daphna Keidar, Elisha Goldstein, Yair Shachar, Ayelet Blass, Oz Frank, Nir Schipper, Nogah Shabshin, Ahuva Grubstein, Dror Suhami, Naama R. Bogot, Chedva Weiss, Eyal Sela, Amiel A. Dror, Mordehay Vaturi, Federico Mento, Elena Torri, Riccardo Inchingolo, Andrea Smargiassi, Gino Soldati, Tiziano Perrone, Libertario Demi, Meirav Galun, Shai Bagon, Yishai M. Elyada, Yonina C. Eldar

WEIZMANN INSTITUTE OF SCIENCE

SAMPL LAB
Signal Acquisition Modeling Processing and Learning

Team

- Team Coordinators:
  - Dr. Yishai Elyada, Mobileye – X-ray
  - Dr. Nogah Shabshin, Haemek Medical Center – Medical
  - ***Dr. Shai Bagon***, Weizmann AI Center (WAIC) - Ultrasound
  - Prof. Libertario Demi, University of Trento - Ultrasound
- Participants:
  - Clinical forum at Weizmann + Drs. Ahuva Grubstein (Beilinson), Naama Bogot (SZMC), Amiel Dror (Nehariyah Medical)
  - Volunteers from various companies and hospitals throughout Israel including Daniel Yaron, Daphna Keidar, Elisha Goldstein, Yair Shachar, Nadav Nehmadi, Meirav Galun, Oz Frank, Nir Schipper
  - Collaborators in Italy: Frederico Mento, Gino Soldati, Andrea Smargiassi, Riccardo Inchingolo , Elena Torri
  - Computing services from WEXAC

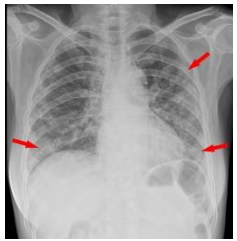
The Challenge

- To provide rapid diagnosis and monitoring for COVID-19 patients from different hospitals
- To create a method that is faster and more sensitive than RT-PCR
- To use Lung Ultrasound (LUS) for COVID-19 monitoring and stratification

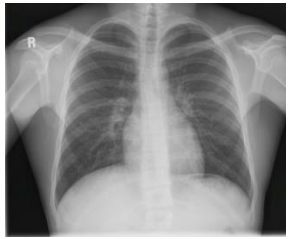
Our Solution

- Identifying COVID-19 in X-ray & Ultrasound scans using Deep Learning
- Using X-ray data from four different hospitals in Israel
- Using LUS data from five different hospitals in Italy

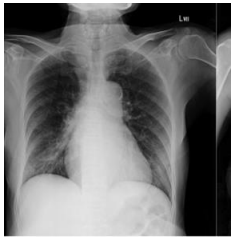
Severe COVID19
Ground glass clearly seen



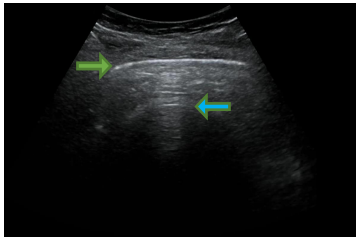
Healthy



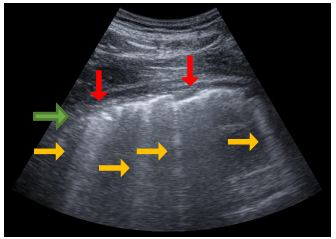
COVID-19



Healthy



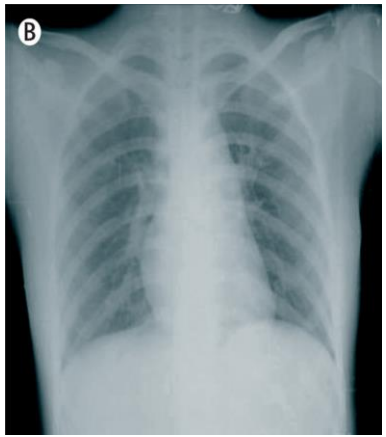
Severe

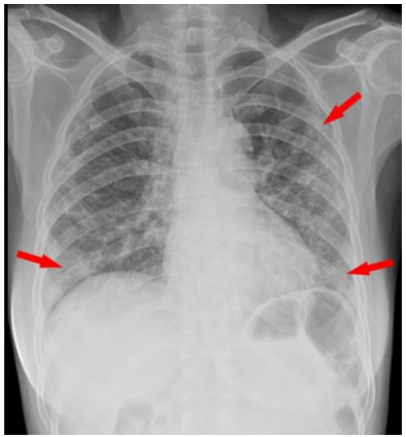


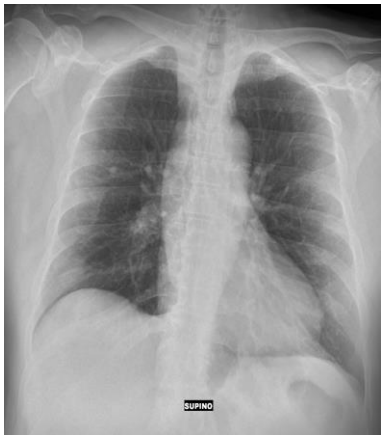

X-ray

Chest X-Ray

- Chest X-ray: COVID-19 is a respiratory disease – presentation in the lungs
- High access to X-ray machines, field deployment
- Portable X-rays are easy to transport & sanitize

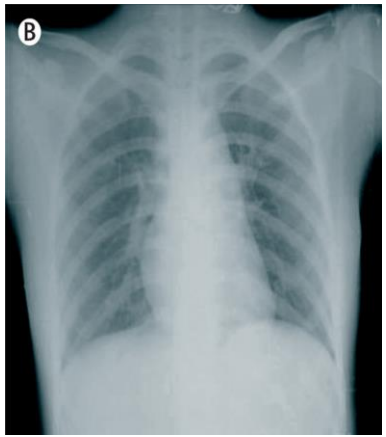


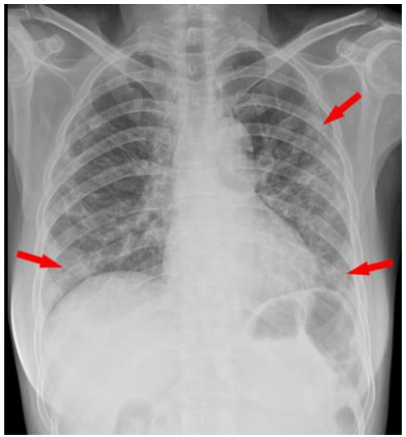


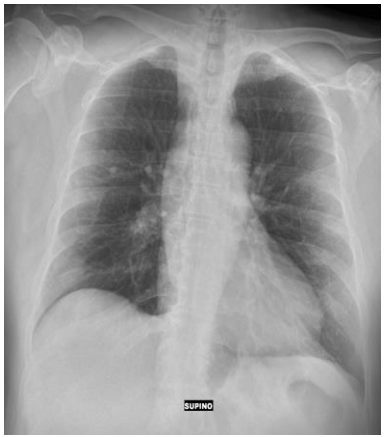


Chest X-Ray

- Challenges:
  - Hard to distinguish COVID-19 from other respiratory diseases
  - Publicly available datasets have strong limitations







Pipeline

Use X-Ray images dataset

Collecting as much different images from many hospitals

Comparing our results

Compare different networks performance to find the best one

Train our NN

Testing the different networks on our dataset

Dataset Collection

- Shaare Zedek Medical Center ~1000 Images
- Rabin Medical Center Beilinson ~800 Images
- Emek Medical Center ~300 Images
- Galilee Medical Center ~100 Images

~1100 Covid-19 images
~1100 Non-Covid-19 images

Controls: patients with a variety of respiratory diseases

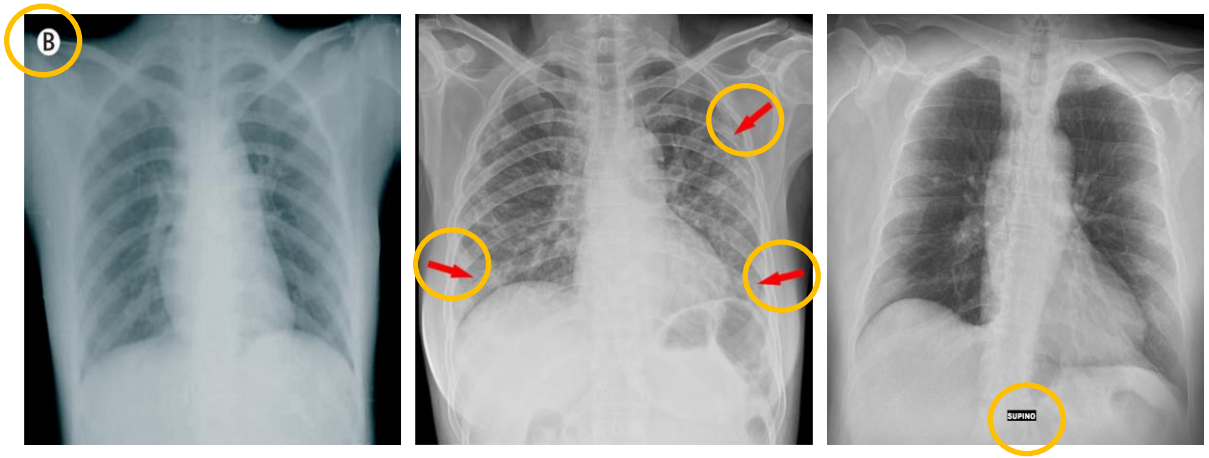


Image Pre-processing

1. **Normalization**: size, brightness, etc.

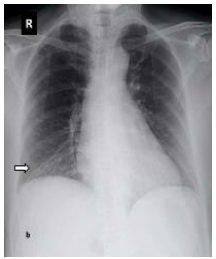


Image Pre-processing

1. **Normalization**: size, brightness, etc.
2. **Augmentation**: rotate, sharpen, contrast, shear, blur, scale, flip

- Discussed with Radiologists to verify the parameters
- Augmentations don't change the image label

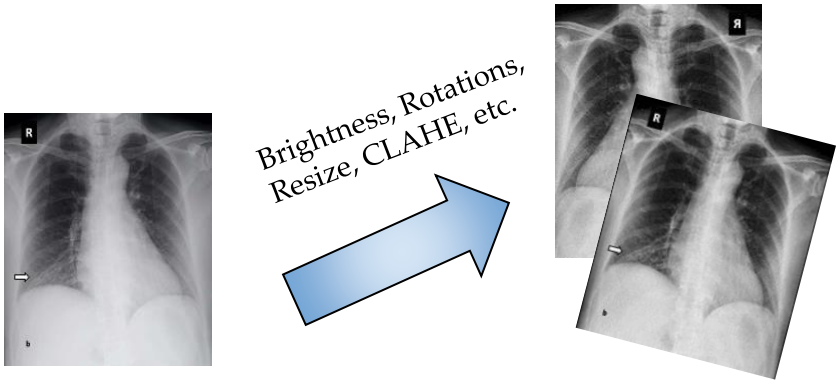
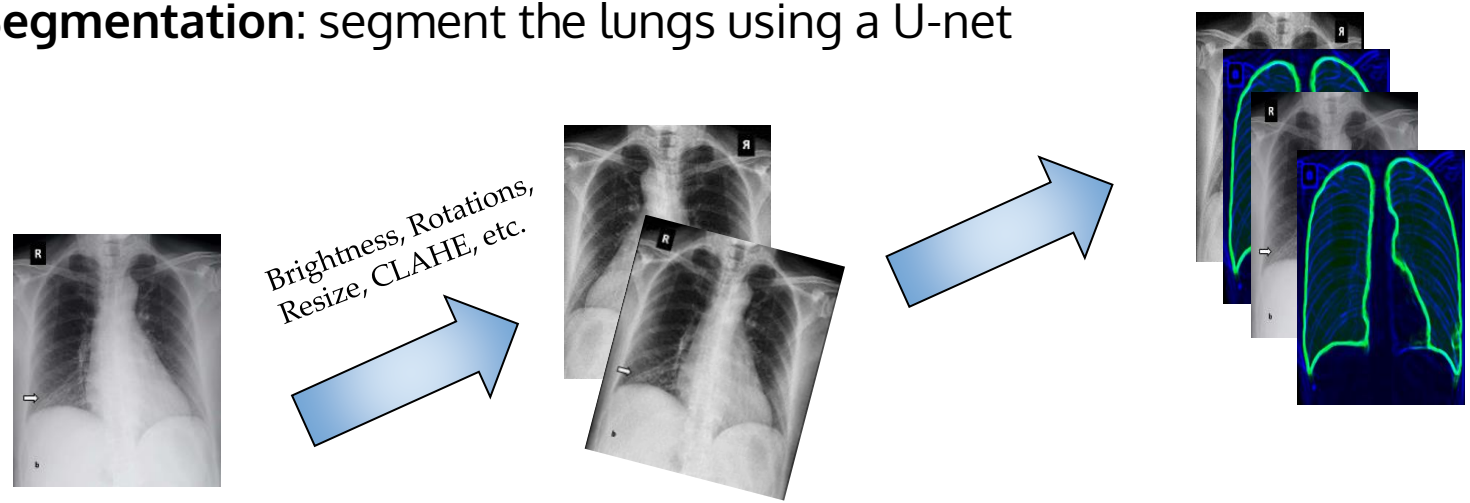


Image Pre-processing

1. **Normalization**: size, brightness, etc.
2. **Augmentation**: rotate, sharpen, contrast, shear, blur, scale, flip
   - Discussed with Radiologists to verify the parameters
   - Augmentations don't change the image label
3. **Segmentation**: segment the lungs using a U-net



Pipeline

Use X-Ray images dataset

Collecting as much different images from many hospitals

Comparing our results

Compare different networks performance to find the best one

Train our NN

Testing the different networks on our dataset

Neural Network Ensemble

- Based on transfer learning
- **Networks used:** ResNet18, ResNet50, ResNet101, VGG16, Chexpert
- Output prediction - average score of 4 best networks

Pipeline

Use X-Ray images dataset

Collecting as much different images from many hospitals

Comparing our results

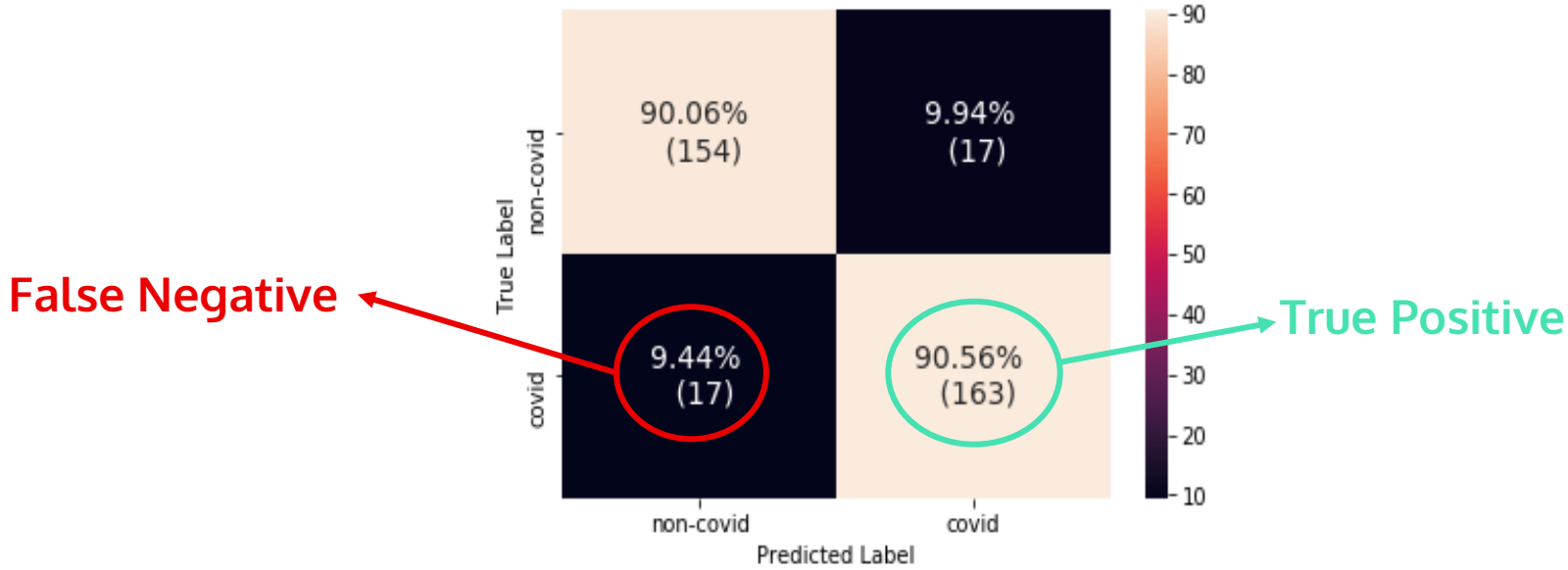
Compare different networks performance to find the best one

Train our NN

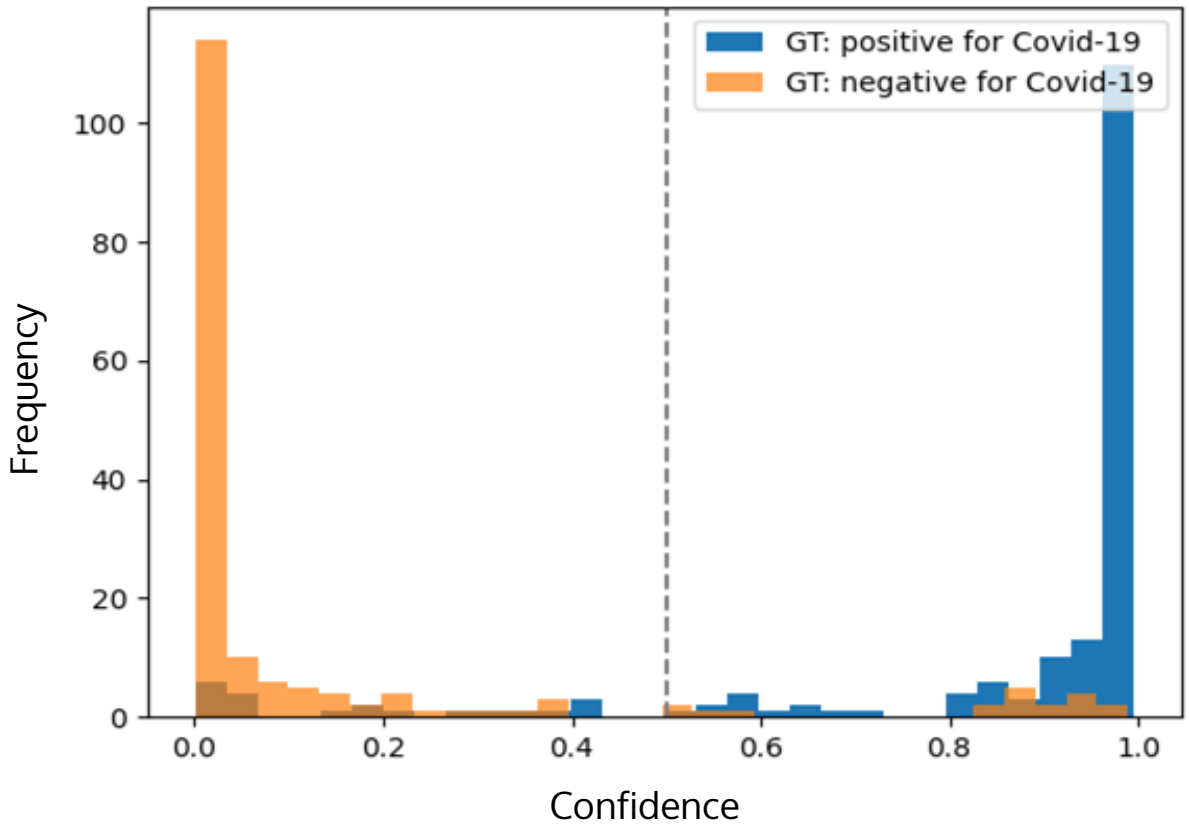
Testing the different networks on our dataset

Results

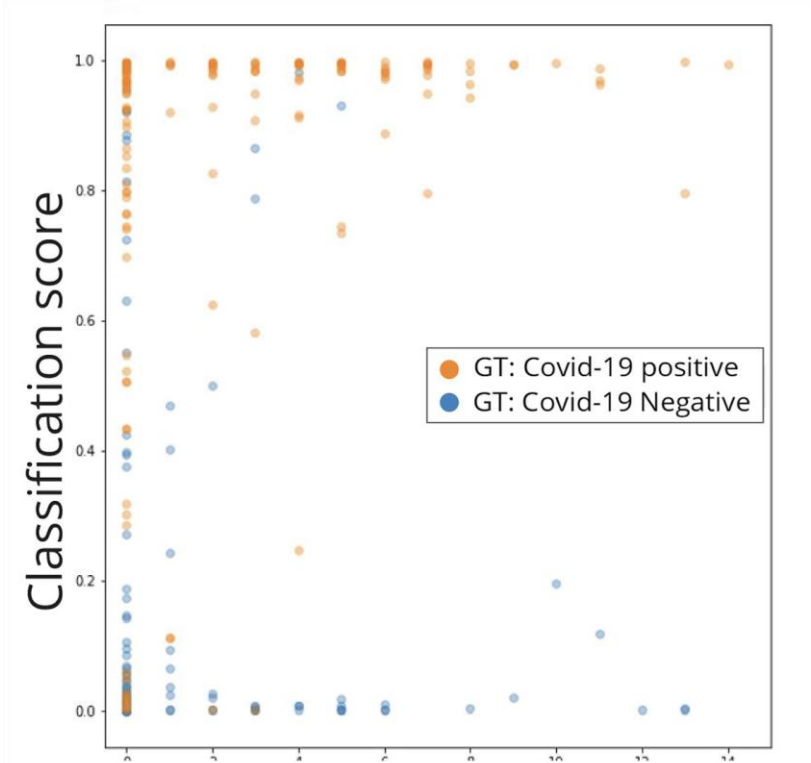
- Over 90% detection accuracy on diverse data of admitted patients
- Immediate on-site results



Confidence in labels

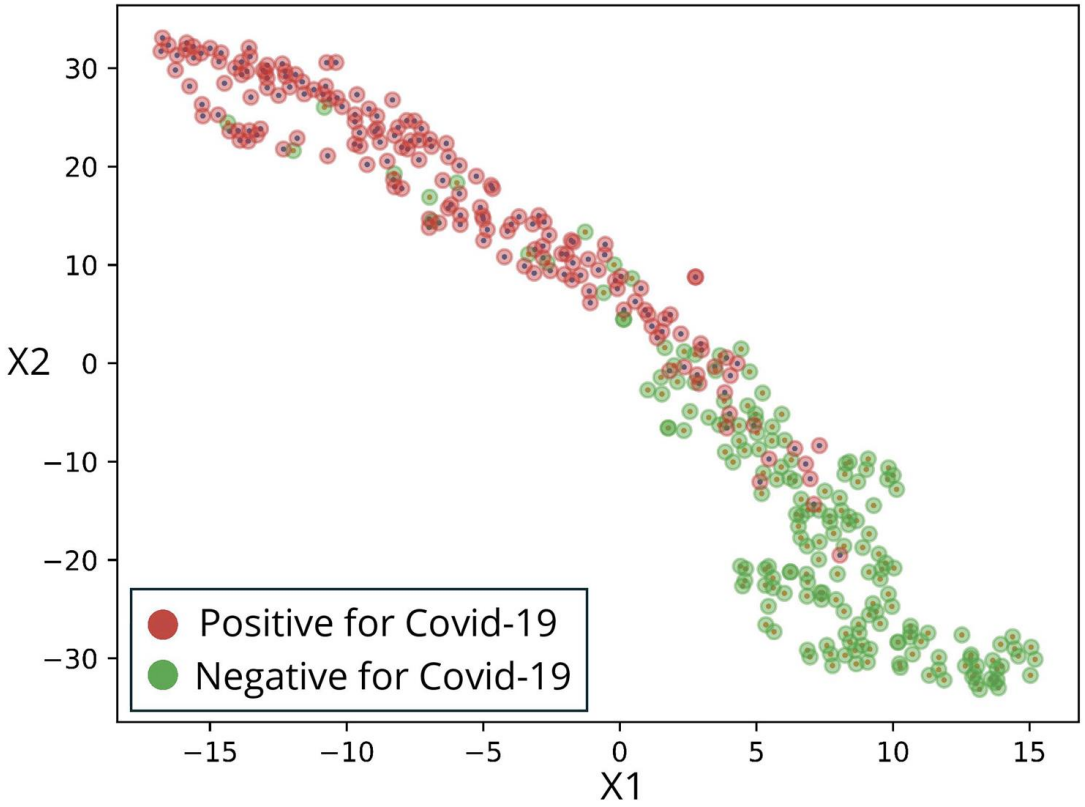


Confidence increases with time from onset



Time from onset in which the scan was taken

COVID-19 vs non-COVID-19 features



Lung Ultrasound (LUS)

Lung US - Collaboration

- Collaboration with a group of Italian clinicians and researchers
- **Libertario Demi, Frederico Mento**

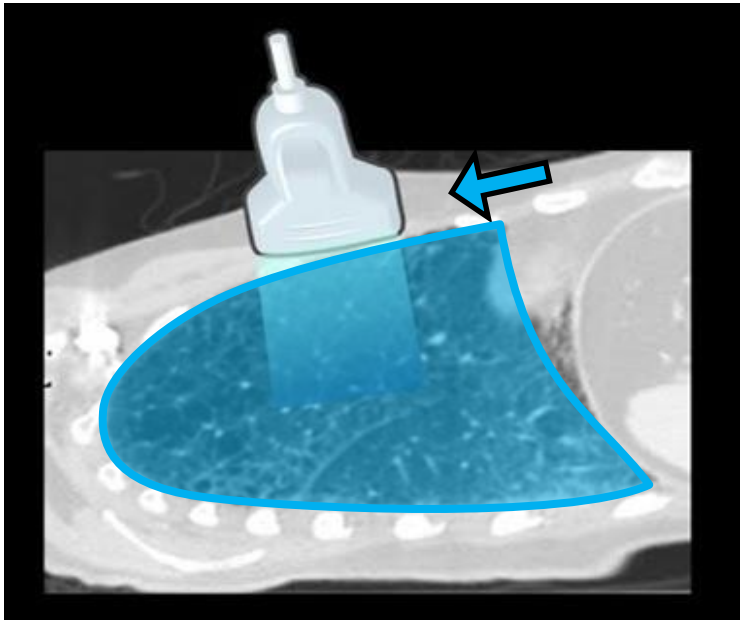
  Department of Information Engineering and Computer Science, University of Trento
- **Gino Soldati**

  Diagnostic and Interventional Ultrasound Unit, Valle del Serchio General Hospital, Lucca
- **Andrea Smargiassi, Riccardo Inchingolo**

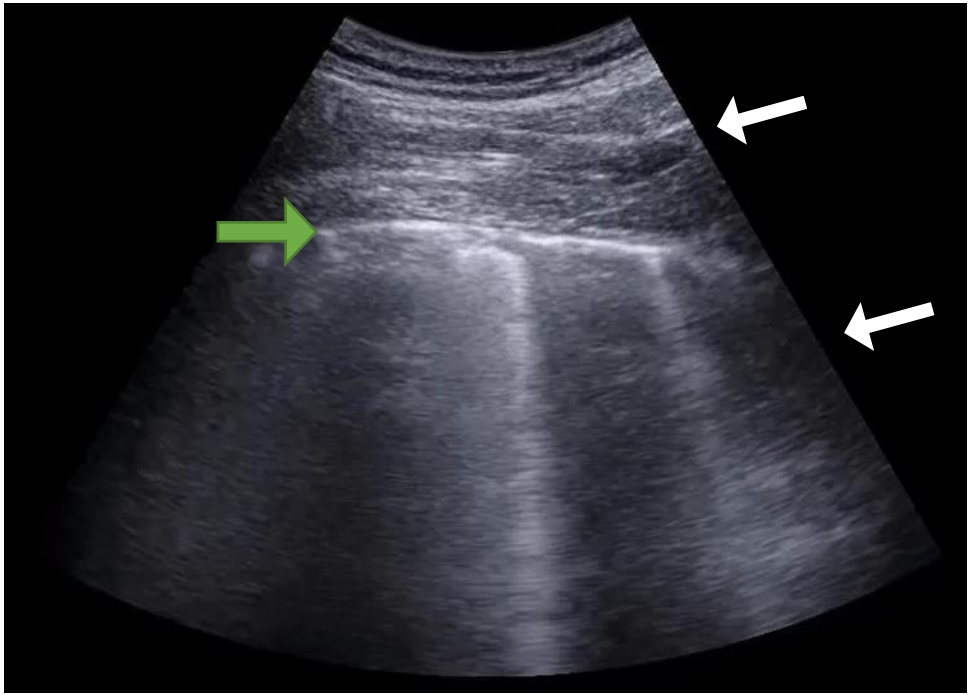
  Dept. of Cardiovascular and Thoracic Sciences-Fondazione Policlinico Universitario A. Gemelli IRCCS
- **Elena Torri**

  Bresciamed

The Challenge of LUS

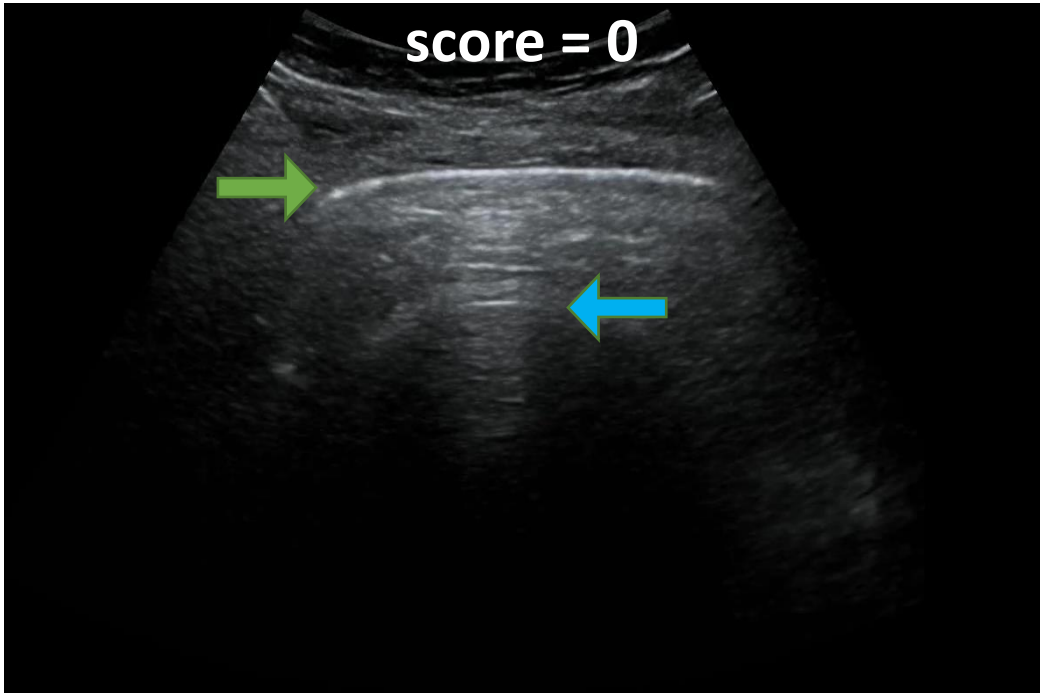


The Challenge of LUS



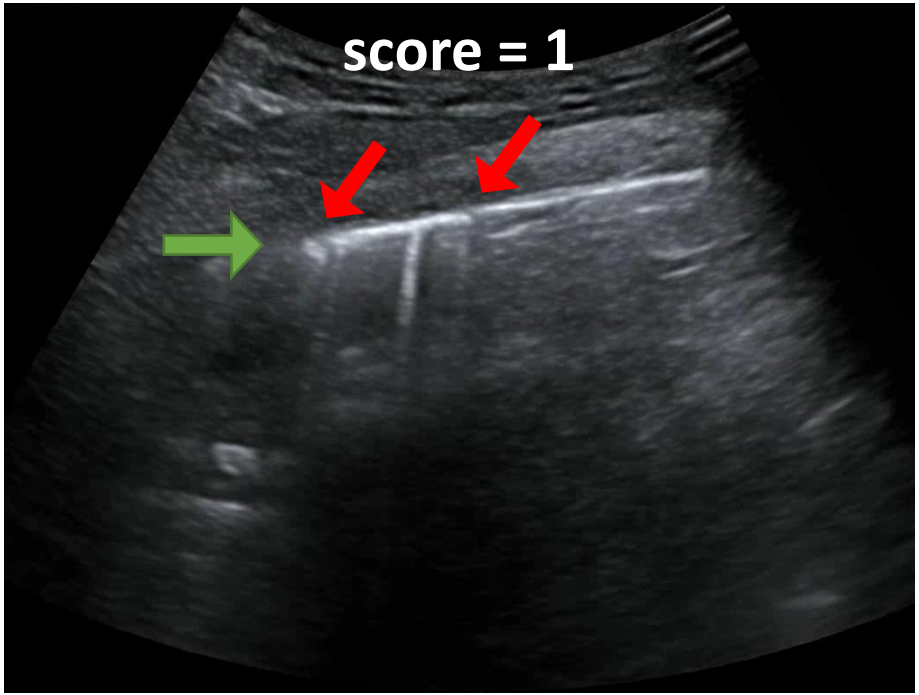
LUS frames taken from ICLUS dataset, Ultrasound Laboratory Trento (ULTRa)

Grading COVID-19 Using LUS



Soldati, Gino et al. "Proposal for international standardization of the use of lung ultrasound for COVID-19 patients; a simple, quantitative, reproducible method" *Journal of Ultrasound in Medicine (2020)*

Grading COVID-19 Using LUS



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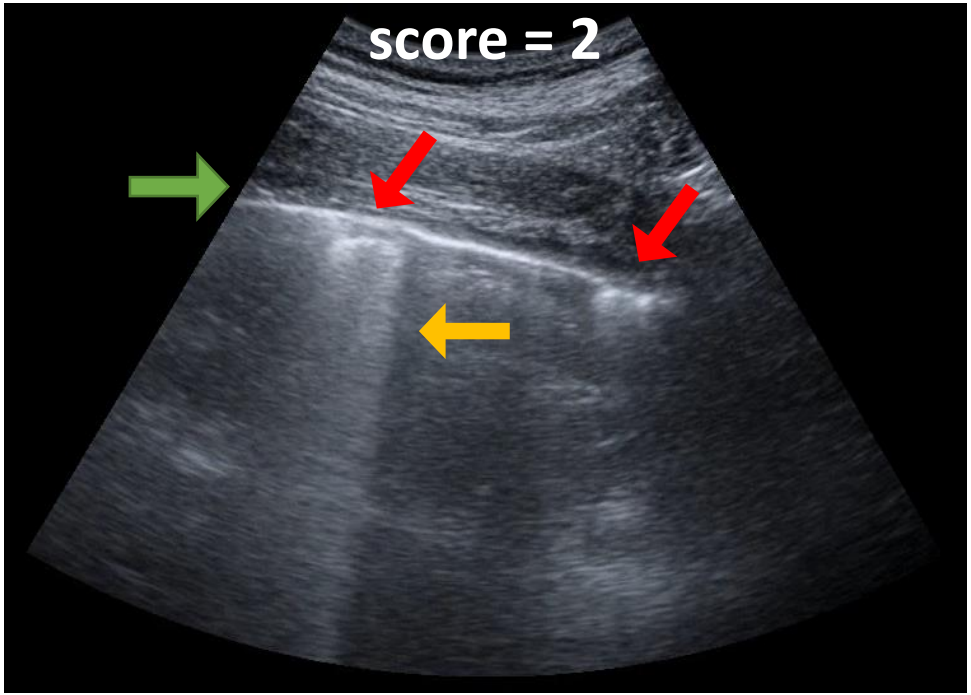
Grading COVID-19 Using LUS



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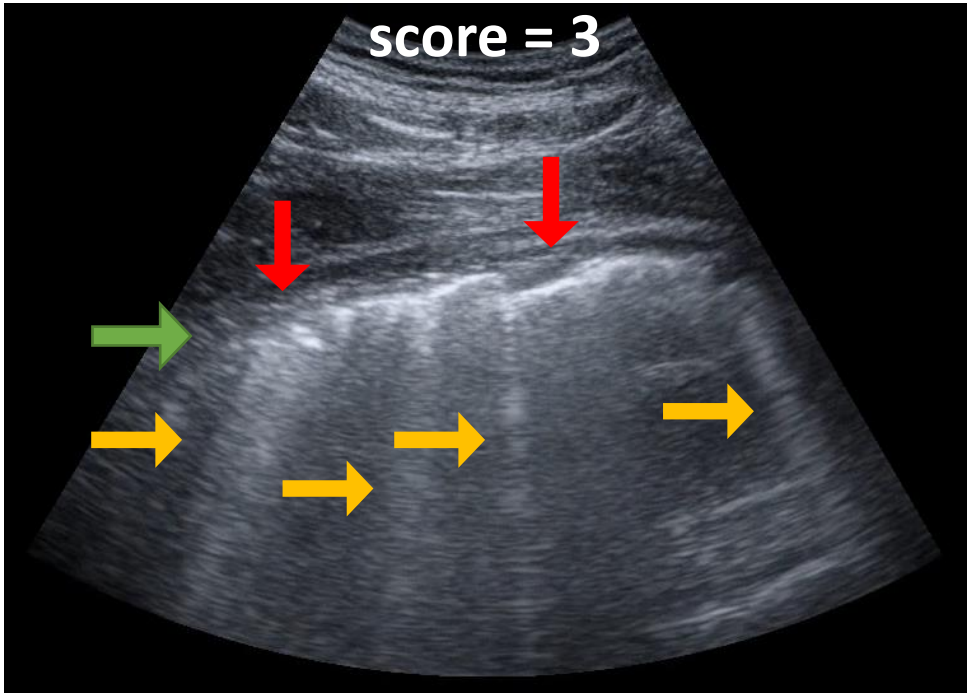
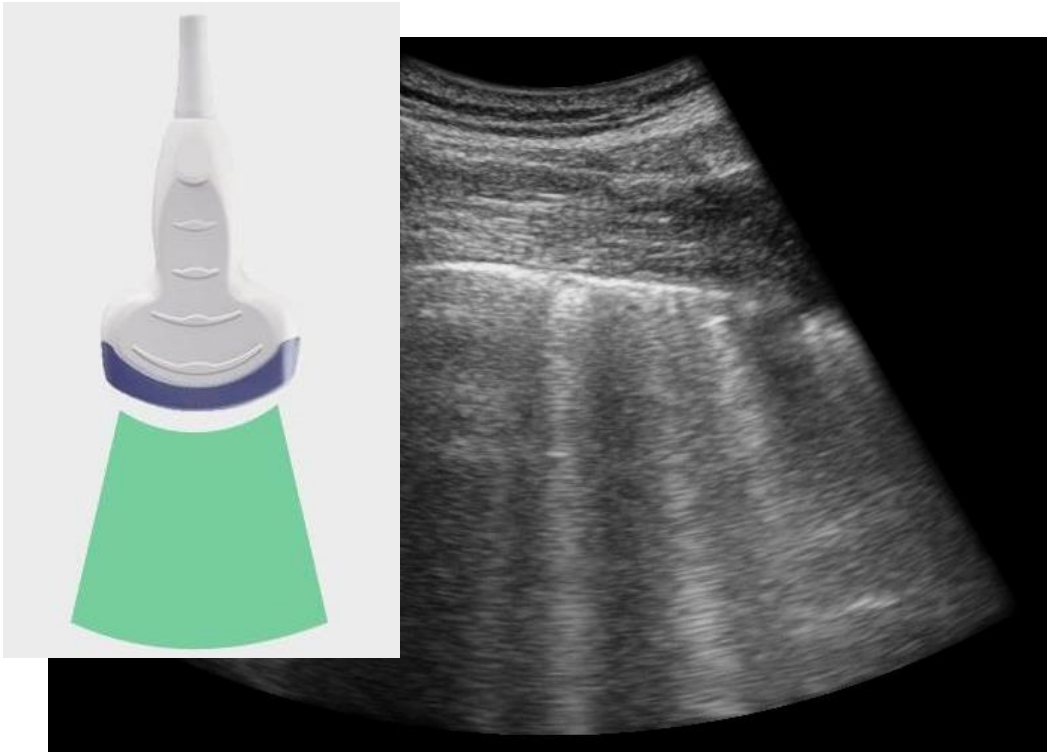


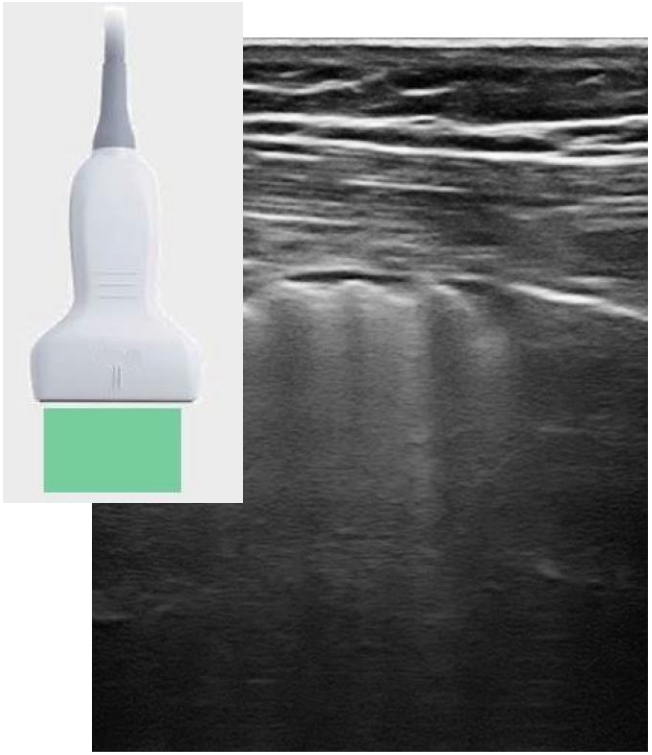
Soldati, Gino et al. "Proposal for international standardization of the use of lung ultrasound for COVID-19 patients; a simple, quantitative, reproducible method" *Journal of Ultrasound in Medicine (2020)*

Vertical Artefacts

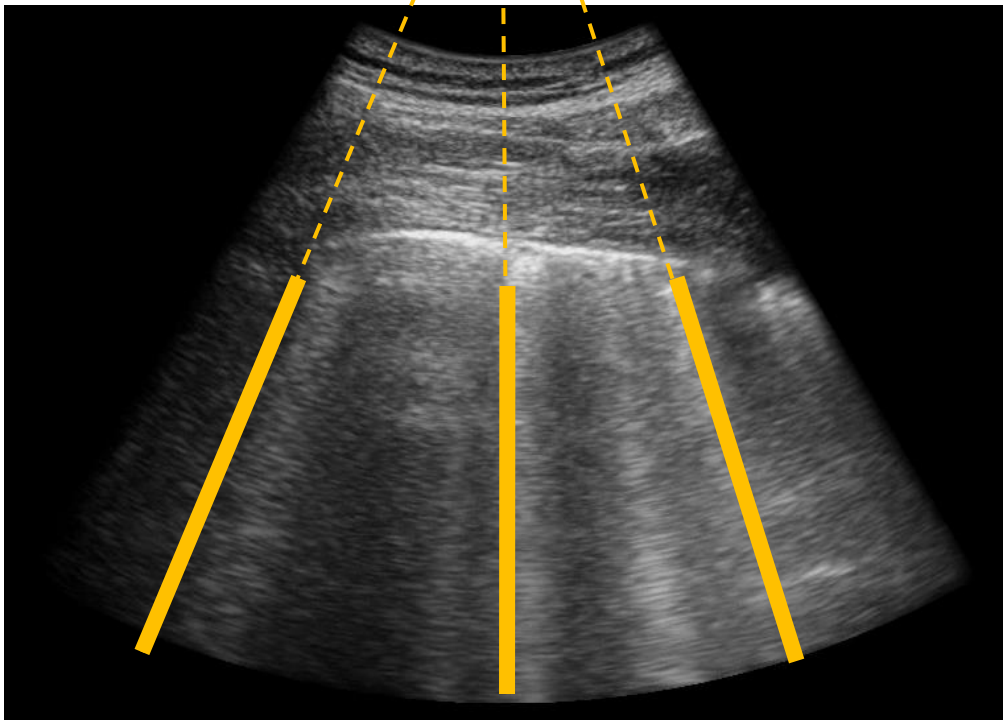
Convex

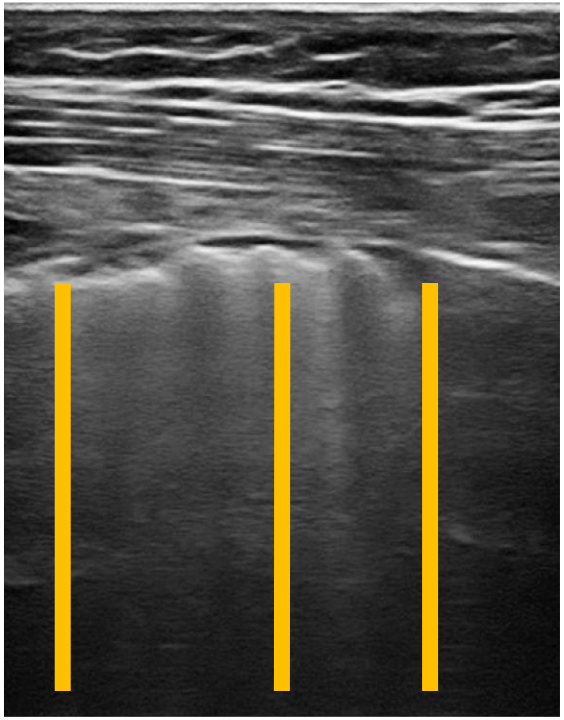


Linear



Vertical Artefacts





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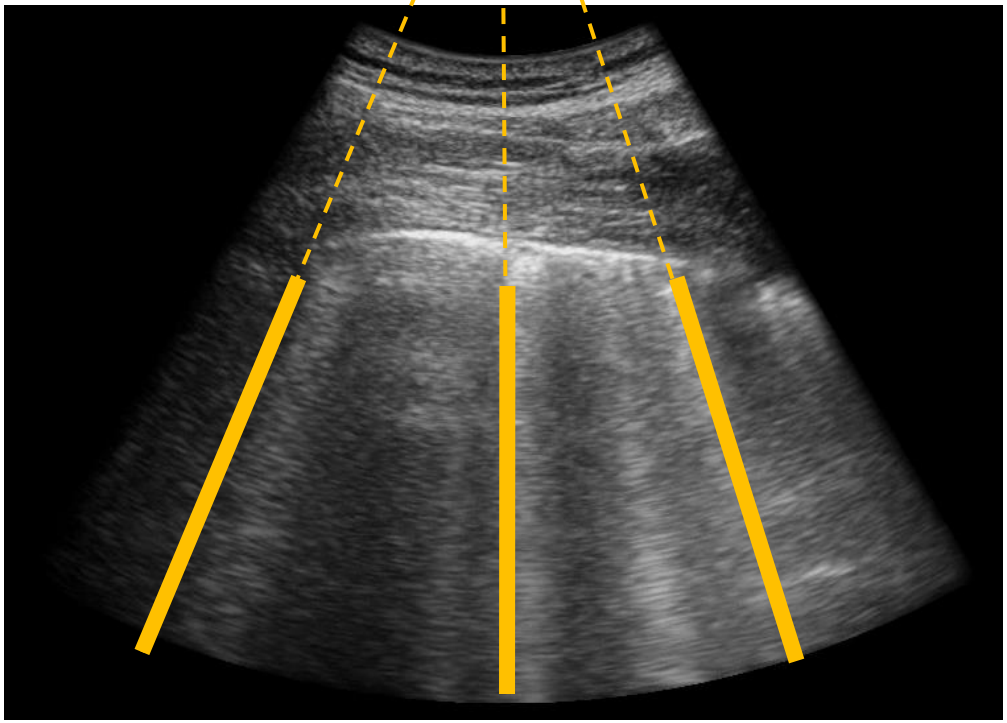

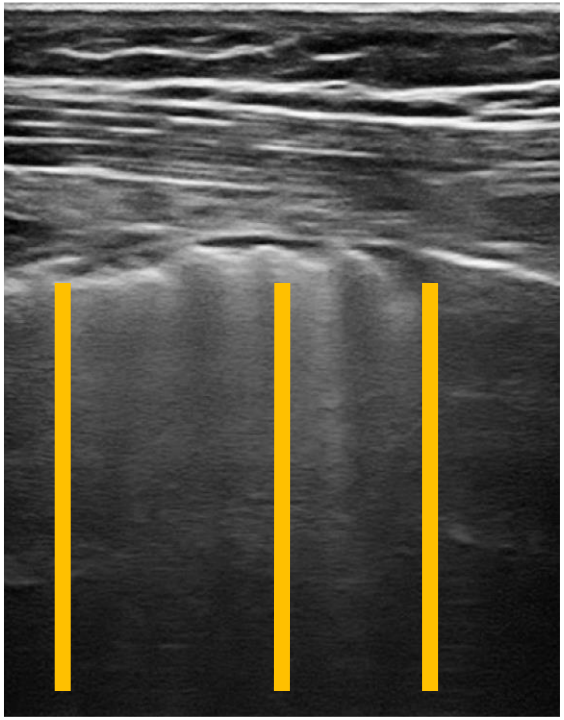

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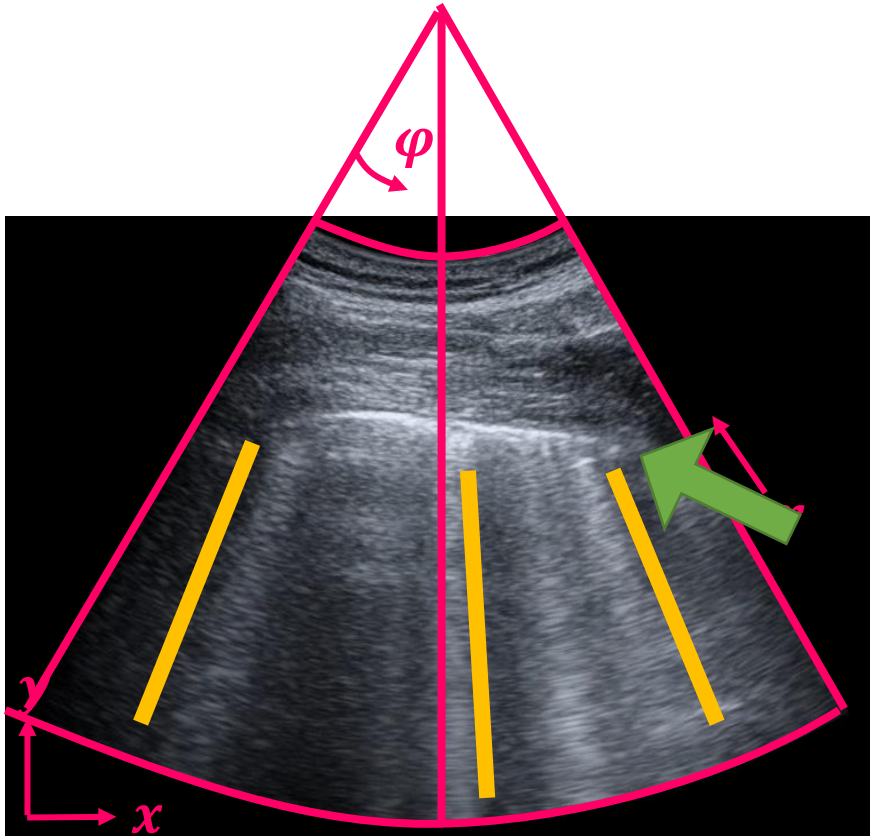
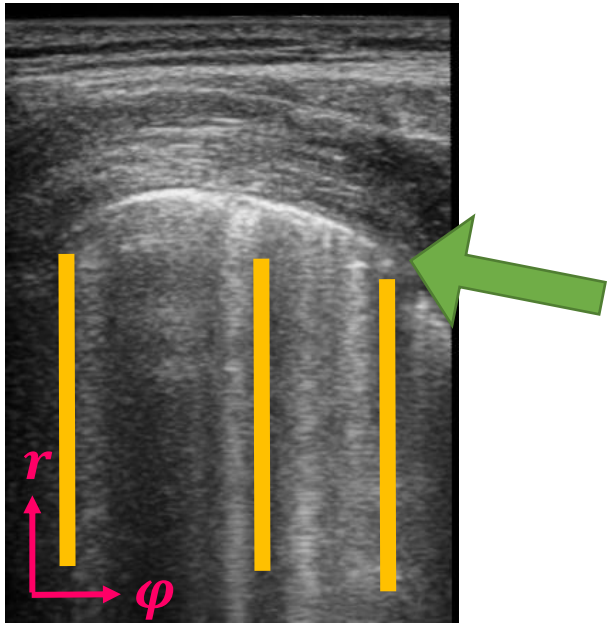
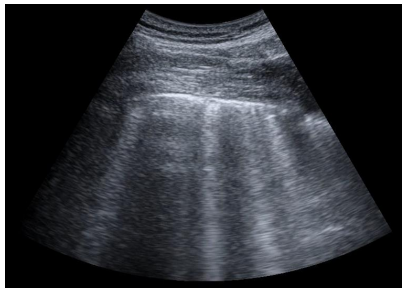




Grading COVID-19 Using LUS: Deep Model



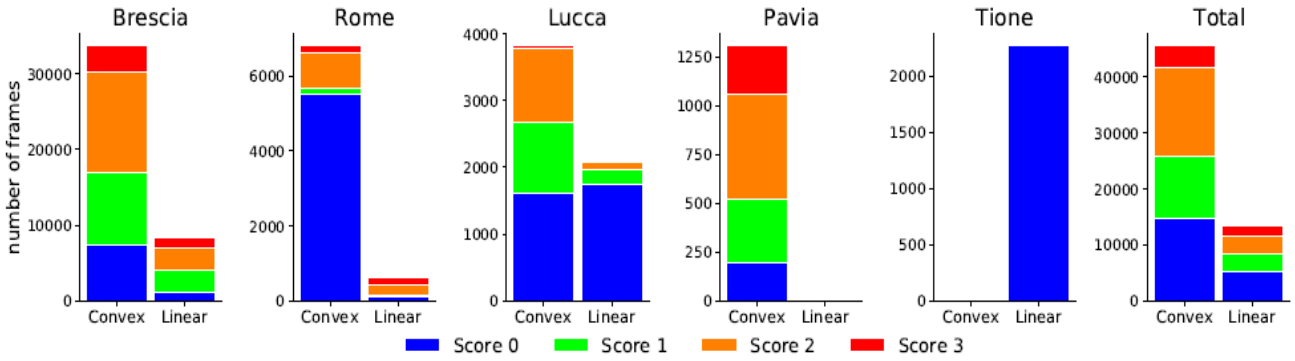
ResNet-18

ResNet-18

LUS prediction

Grading COVID-19 Using LUS

- ICLUS Dataset
  - 35 Patients from 5 hospitals
  - 277 LUS videos corresponding to 58,924 frames
- Annotations - “COVID-19 severity” score {0, ..., 3}



The distribution of the probes and the scores of frames grouped by hospital and overall statistics.

Roy, Subhankar, et al. "Deep learning for classification and localization of COVID-19 markers in point-of-care lung ultrasound." *IEEE Transactions on Medical Imaging* (2020).

Grading COVID-19 Using LUS: Classification

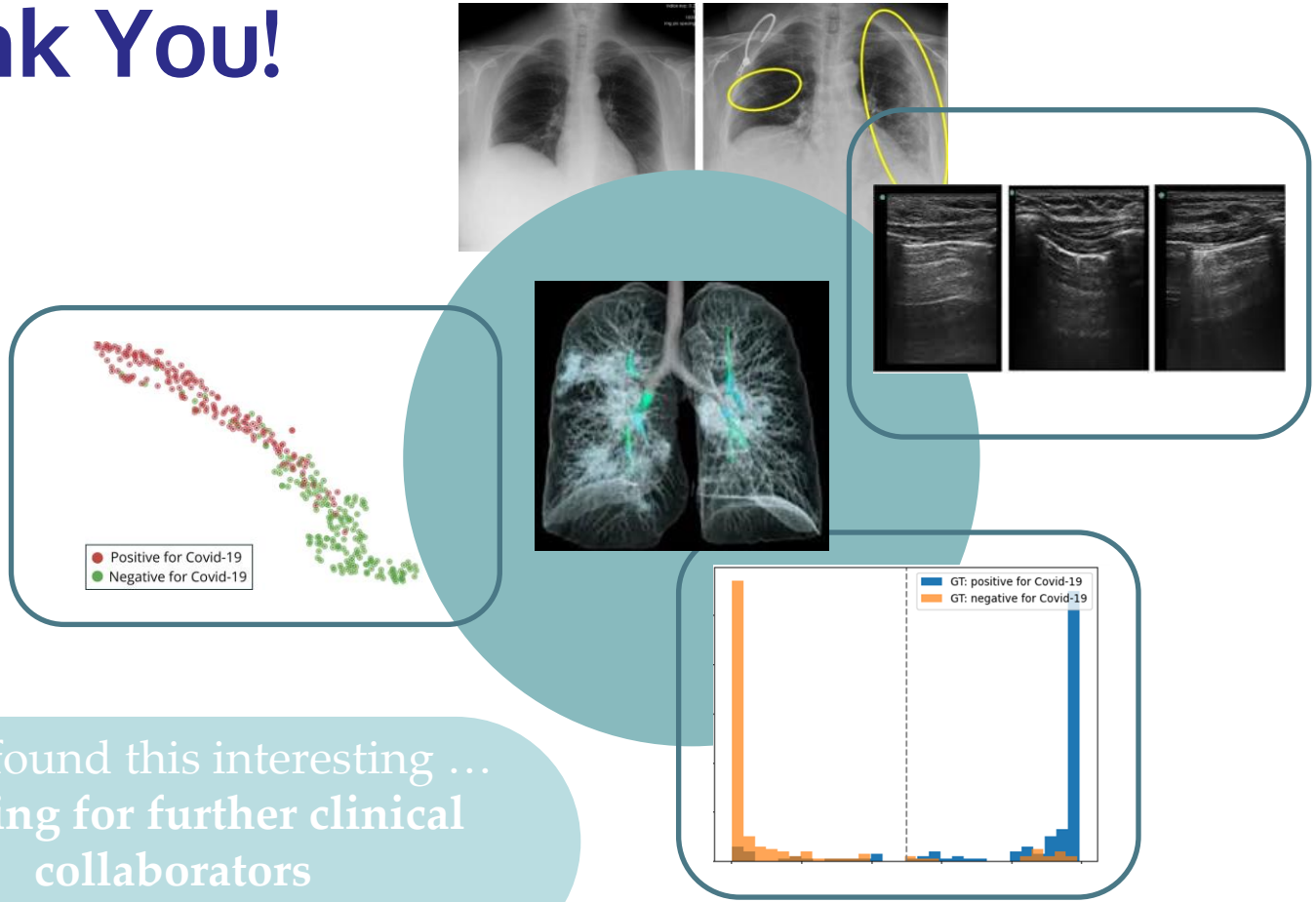
Model	Settings 1	Settings 2 Drop Transition Frames (K)			
	All Frames	K=1	K=3	K=5	K=7
ResNet-18 (Roy et al)	62.2	63.9	65.5	66.9	67.8
CNN-Reg-STN (Roy et al)	65.1	66.7	68.3	69.5	70.3
ResNet-18 (ours)	**68.7**	**70.0**	**72.1**	**73.9**	**75.3**

Summary: Bridging the Expert Gap

- Many opportunities for advanced AI methods in detection and monitoring of COVID-19 via imaging
- Very good results with relatively simple networks
- Data sets are a crucial part of the success
- Working on hospital deployment and will be made public to benefit the community

AI for COVID19 can pave the way to more pervasive use of ultrasound and Xray monitoring for lung patients more generally

Thank You!



If you found this interesting …
Looking for further clinical collaborators
Yonina.eldar@Weizmann.ac.il