Deep Learning ed ecografia toracica a supporto della gestione dei pazienti COVID-19

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Insitute of Clinical Physiology

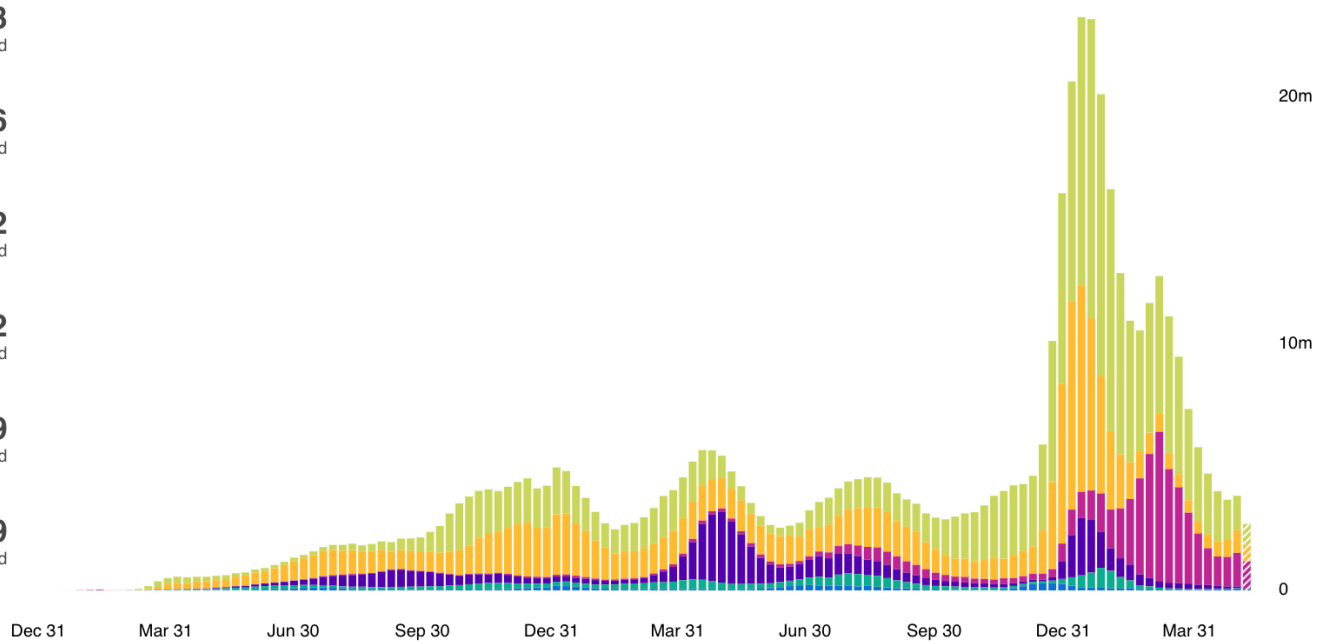National Research Council

Pisa, Italy

Le tecnologie per la salute all'epoca del COVID – Pisa – 23 Maggio 2022

Situation by WHO Region

Controls: line/curve toggle | Daily / **Weekly** | **Cases** / Deaths | Count ▾

Europe — 219.393.358 confirmed

Americas — 155.496.306 confirmed

Western Pacific — 58.291.292 confirmed

South-East Asia — 58.056.402 confirmed

Eastern Mediterranean — 21.746.779 confirmed

Africa — 8.935.659 confirmed

Source: World Health Organization

Data may be incomplete for the current day or week.

Chart y-axis: 0, 10m, 20m

Chart x-axis: Dec 31, Mar 31, Jun 30, Sep 30, Dec 31, Mar 31, Jun 30, Sep 30, Dec 31, Mar 31

Situation by WHO Region

Americas	2.736.277	deaths
Europe	2.006.475	deaths
South-East Asia	787.989	deaths
Eastern Mediterranean	342.687	deaths
Western Pacific	228.622	deaths
Africa	172.260	deaths

Source: World Health Organization

Data may be incomplete for the current day or week.

Daily Weekly

Cases Deaths

Count

100k

50k

0

Dec 31   Mar 31   Jun 30   Sep 30   Dec 31   Mar 31   Jun 30   Sep 30   Dec 31   Mar 31

The New York Times

The Coronavirus Outbreak › | LIVE Latest Updates Maps and Cases Vaccine Tracker Answers to Your Questions
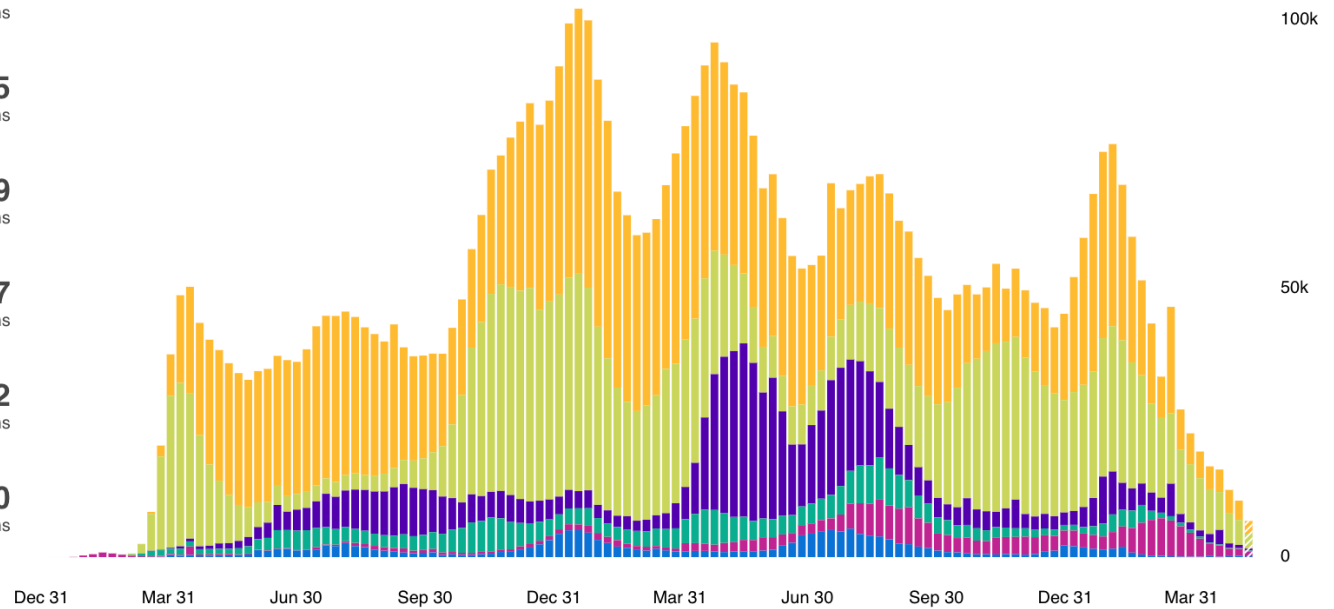
'At Capacity': Covid-19 Patients Push U.S. Hospitals to Brink

Utah officials issued urgent pleas and said they were planning to open a field hospital, which Wisconsin has already done. At least 14 states have a record number of coronavirus hospitalizations.

NEWS WEBSITE OF THE YEAR
The Telegraph Coronavirus News Politics Sport Business Money Opinion Tech Life Style Travel Culture

UK news World news Royals Health Defence Science Education Environment Investigations Gl

Hospitals could run short of oxygen 'within hours' as coronavirus escalates, specialists warn

'Overwhelmed' service also in danger of running out of medication and beds as expected

Search International edition
The Guardian

'On the brink': Covid pressure mounts at hospitals in Northern Ireland

Fears of looming disaster as ambulances forced to queue, with similar scenes in Wales

la Repubblica ABBONATI QUOTIDIANO R ACCEDI

The Local
ws@thelocal.se
thelocalsweden

Milano

CERCA

HOME CRONACA SPORT FOTO VIDEO TEMPO LIBERO ANNUNCI LOCALI CAMBIA EDIZIONE

Coronavirus a Milano, i pronto soccorso sono in crisi: attese fino a tre giorni per i ricoveri

di Alessandra Corica

(ansa)

Stockholm healthcare chief calls for help from public as ICUs reach 99 percent capacity

An intensive care worker in a Stockholm hospital. File photo: Staffan Löwstedt / SvD / TT

OPTIMISED - Aim of the project

- OPTIMISED aims to create a path for managing the flow of data resulting from blood and imaging biomarkers using new methods of statistical analysis and artificial intelligence (AI), in particular deep learning.

- The obtained results will aim to understand advantages and limitations of the different imaging methods in the risk stratification process, and how these techniques can be complemented with information from selected blood parameters available from the patient's diagnostic-prognostic pathway.

- The knowledge acquired during the project will lead to the creation of a prognostic model of risk stratification in patients with clinical and radiological features compatible with COVID-19; "recommendations" for health professionals will be also provided.

- The optimized path for COVID-19 patients will be smart and easily adaptable to other hospitals both in Tuscany and in other regions, with the aim of ensuring better management of the NHS resources in view of possible new peaks of COVID-19, but also in anticipation of other future pandemics

Overview of the project
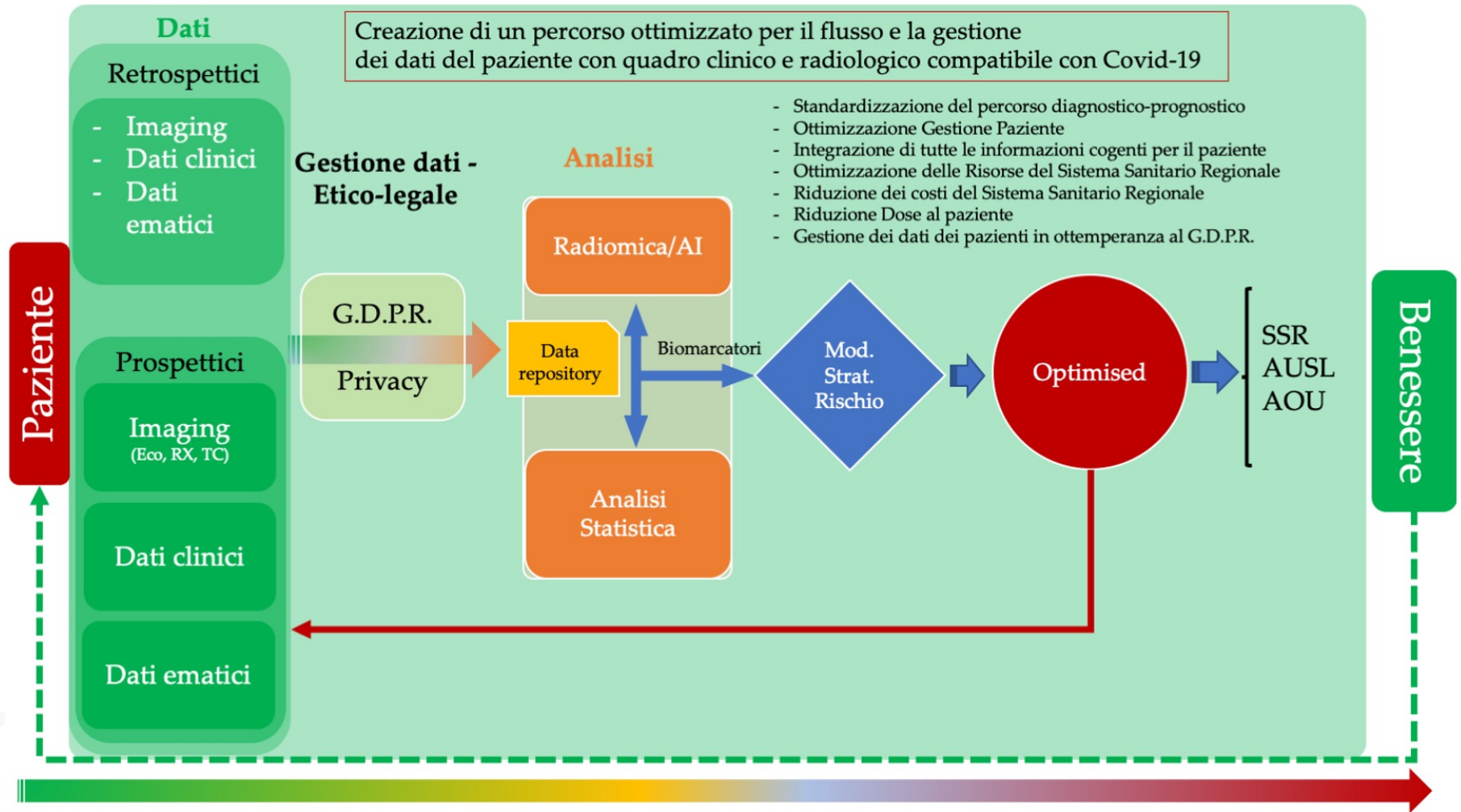
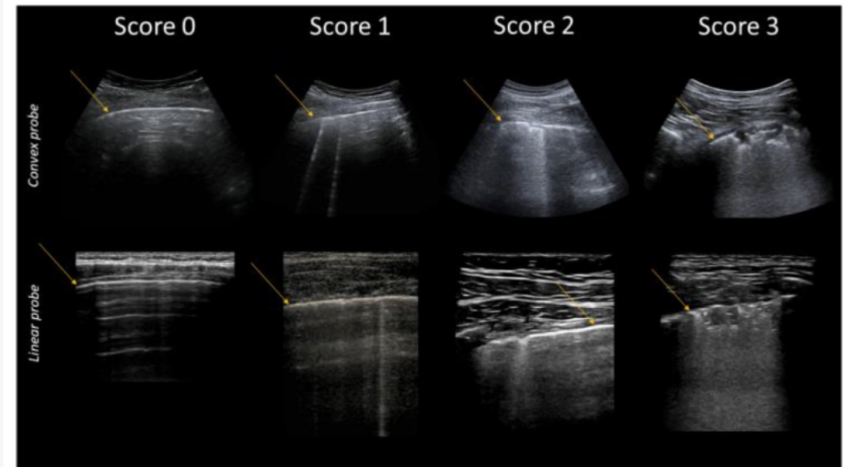# Lung Ultrasound in COVID-19 patients

Pro:

- Large availability (Point-of-care)

- Easy to use
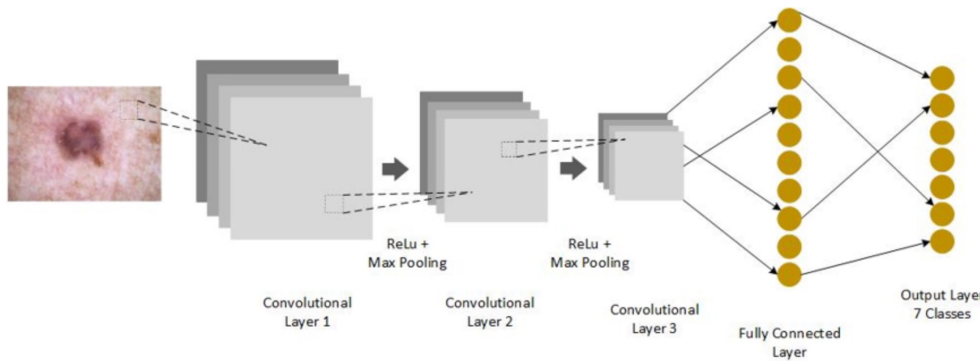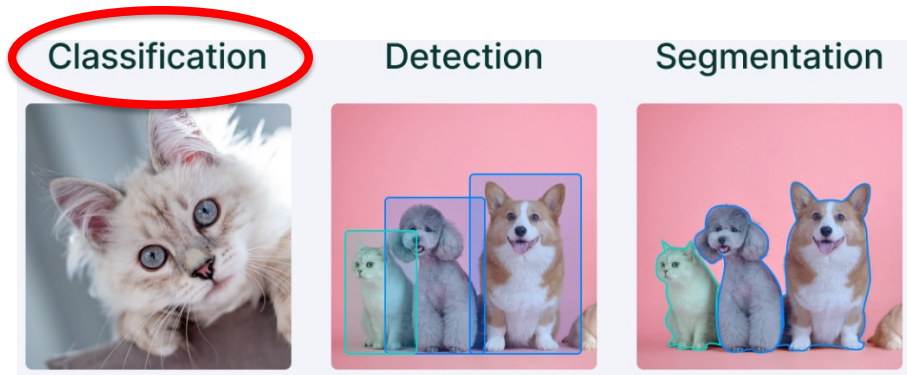
- Good sensitivity

Pro:

- Low specificity

- Operator dependency

- Lack of standard

Figure 4. Classification of pathological lung ultrasound findings in COVID-19 patients. Arrows indicate the pleural line. Top: convex probe. Bottom: linear probe.
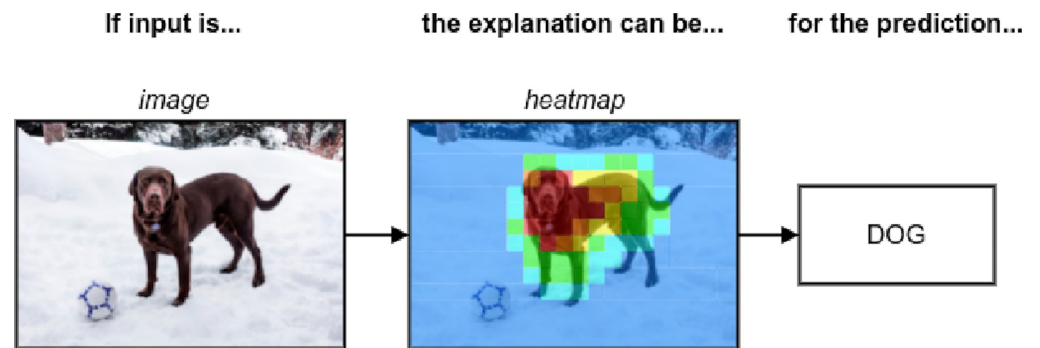
How AI can help?

Classification   Detection   Segmentation

Very low error on training data

But large error on test data

Overfitting

DL-based successful experiences

Avoiding black-box effect

If input is...   the explanation can be...   for the prediction...

image   heatmap   DOG

Convolutional Layer 1   Convolutional Layer 2   Convolutional Layer 3   Fully Connected Layer   Output Layer 7 Classes

ReLu + Max Pooling   ReLu + Max Pooling

State of the Art (LUNG US & COVID & AI/DL)

Single-frame/multi-frames or video based architecture

In the majority of the selected papers, DL architectures work with single frame images as input

Explainability

Among the selected articles, tools for interpreting the network output were provided in twelve studies (70.6%), whereas in the remaining five (29.4%) the DL algorithms' outcomes were proposed as black box
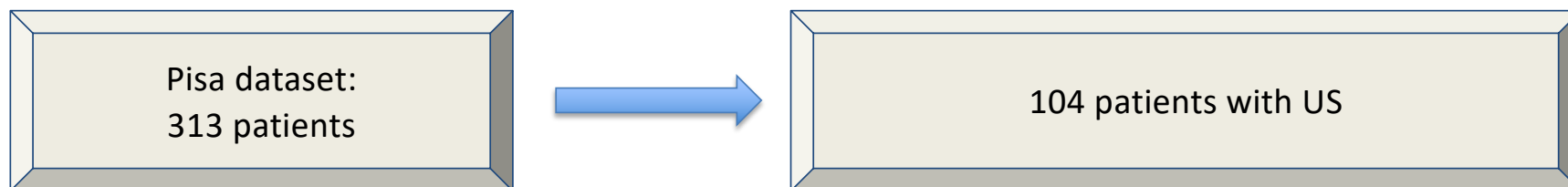
Clinical use

Most of the selected papers applied the AI system to diagnose COVID-19 and/or discriminate between COVID-19 and other lung diseases (such as bacterial pneumonia)[26-30,33,34,39,40]. The first approach

**Test strategy of DL models**

Sample size

Laura De Rosa, Serena L'Abbate, Claudia Kusmic, Francesco Faita

Deep Learning guided scoring of clinical ultrasound images

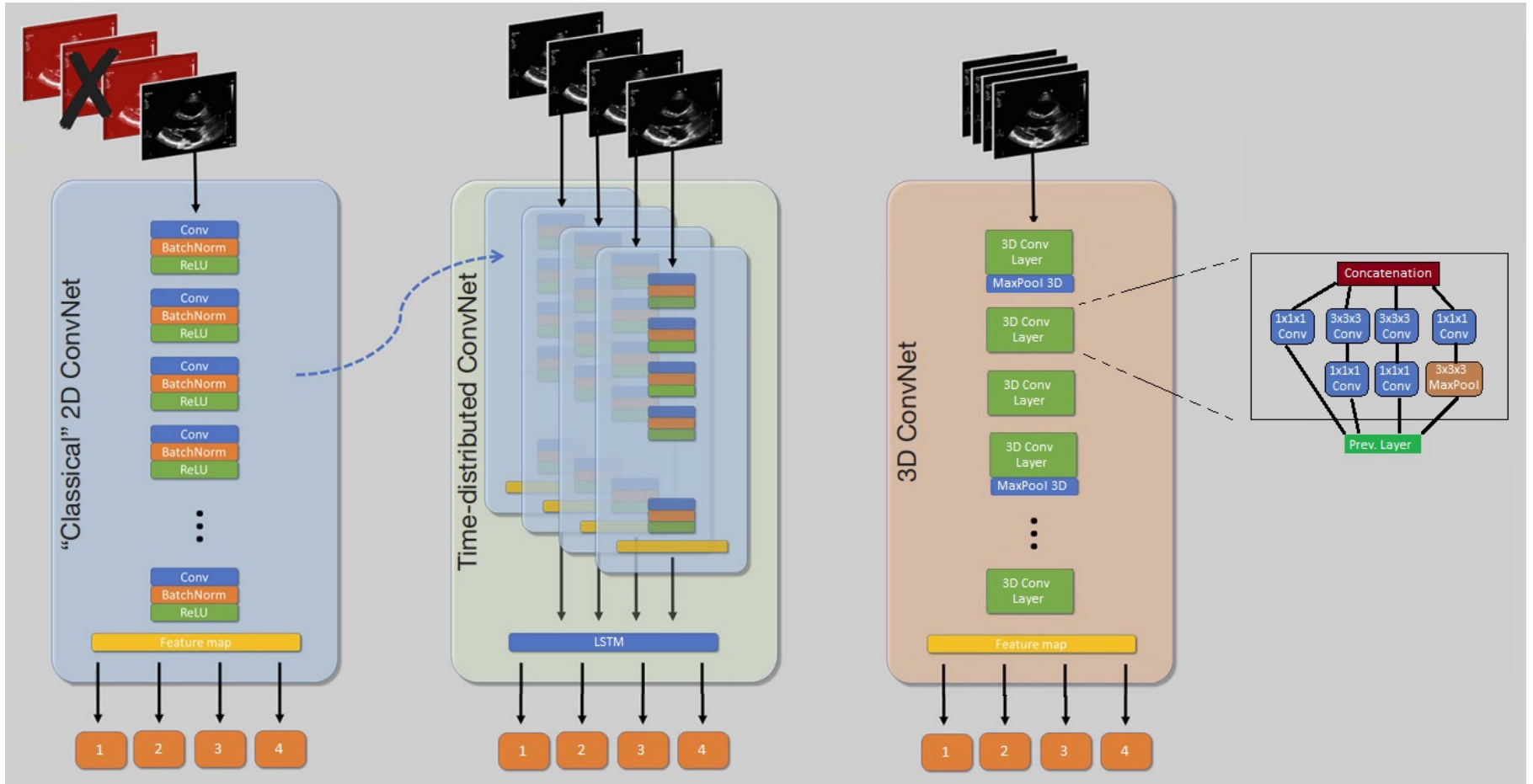Pisa dataset:
313 patients

→

104 patients with US

Dataset

- INITIALLY 1564 VIDEOS FROM 104 ULTRASOUND EXAMINATIONS.
- APPROXIMATELY 7000 LABELED VIDEOS AFTER AUGMENTATION.
- 224 X 224 X 3 X 20 (WIDTH X HEIGHT X CHANNELS X FRAMES) CLIP STRUCTURE.
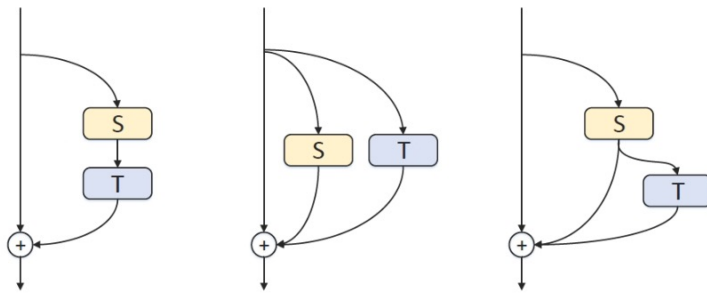- ONLY THE REGION OF INTEREST IS VISIBLE IN THE CLIP
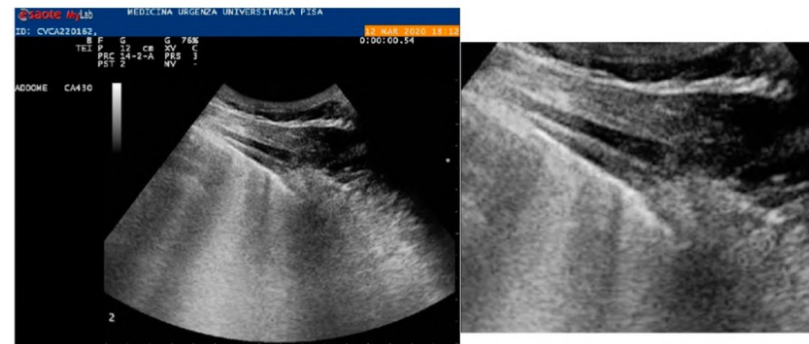
Deep Learning network (1)

Derived from ConvNet adding 3D structure and customized layers structure

Deep Learning network (2)
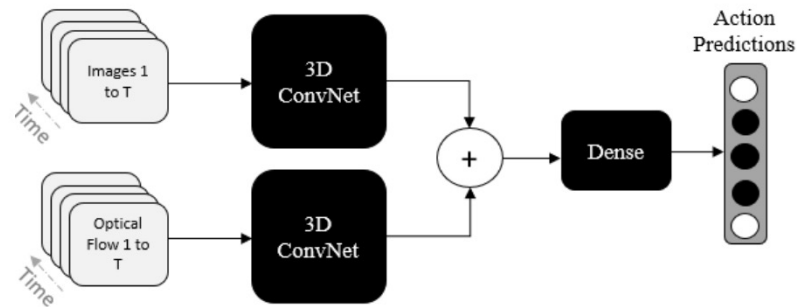
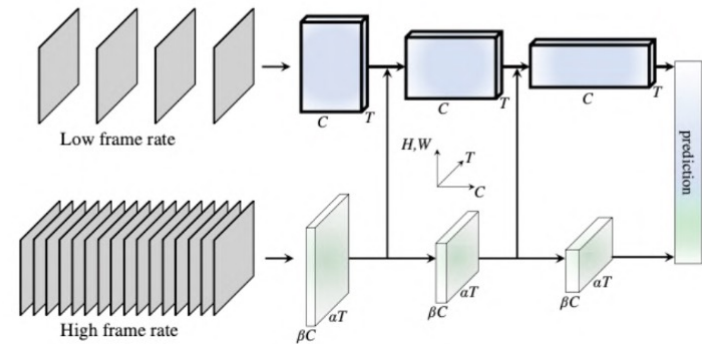## P3D - PSEUDO 3D RESIDUAL NETWORK
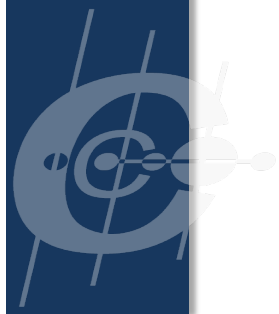

(a) P3D-A (b) P3D-B (c) P3D-C

I3D - INFLATED 3D NETWORK

SlowFast Network

Neural Network Performances (1)

Video evaluation

- RANDOM SPLIT
- 10% TESTING
- 72% TRAINING, 18% VALIDATION
- PREDICT SCORE 0-3 FOR SEVERITY

Video evaluation

Model	Training acc.%	Validation acc.%	Test acc.%
P3D not pretrained	95.9	74.5	57.3
I3D not pretrained	97.2	78.9	58.8
P3D	94.7	75.3	60.5
I3D	99.1	94.8	66.2
SlowFast not pretrained	97.1	64.9	63.7

Clinic evaluation
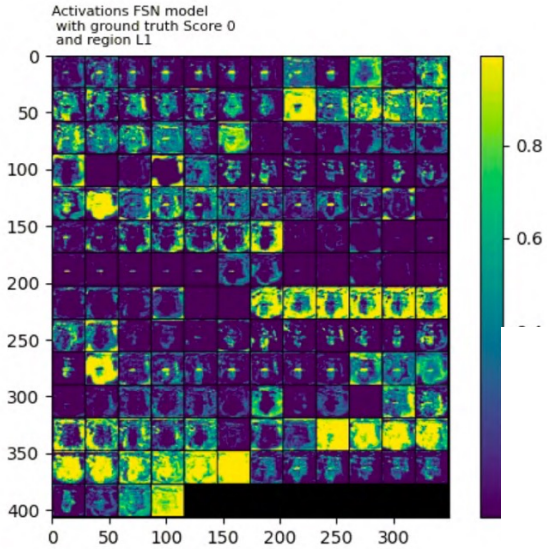
- SPLIT BASED ON PATIENT VIDEOS
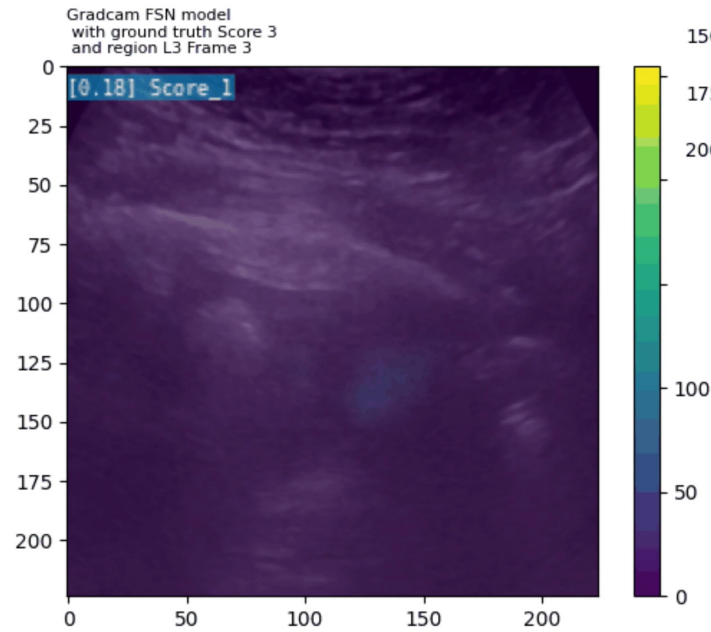- *REST SAME AS VIDEO EVALUATION

Clinic evaluation

Model	Training acc.%	Validation acc.%	Test acc.%
P3D	71.5	70.6	67.2
I3D	75.2	66.7	70.4
SlowFast not pretrained	67.6	64.1	62.4

Feature Maps

Neural Network Explainability

Activations FSN model
with ground truth Score 0
and region L1

Gradcam FSN model
with ground truth Score 3
and region L3 Frame 3

[0.18] Score_1

Experiment video: CVAG271136_0704-m8.avi

Gradcam FSN model
with ground truth Score 3
and region L7 Frame 14

[1.85] Score_2
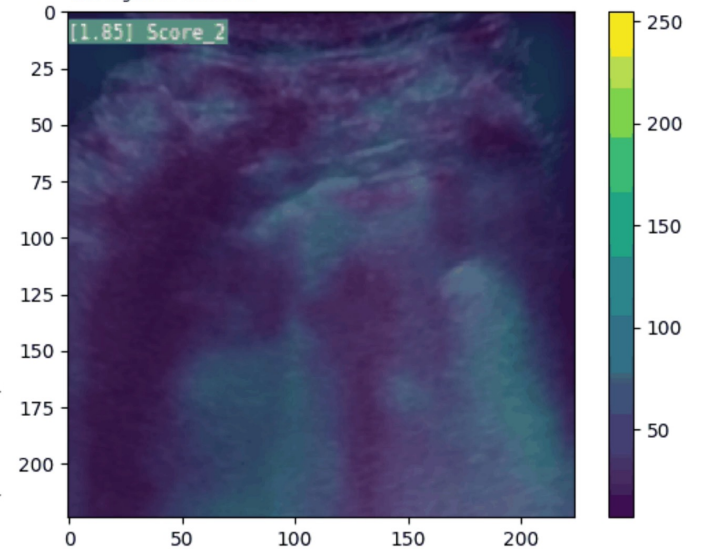
Experiment video: CVOB050341_0604-m15.avi

Research Teams

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Thanks for you attention and time !

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