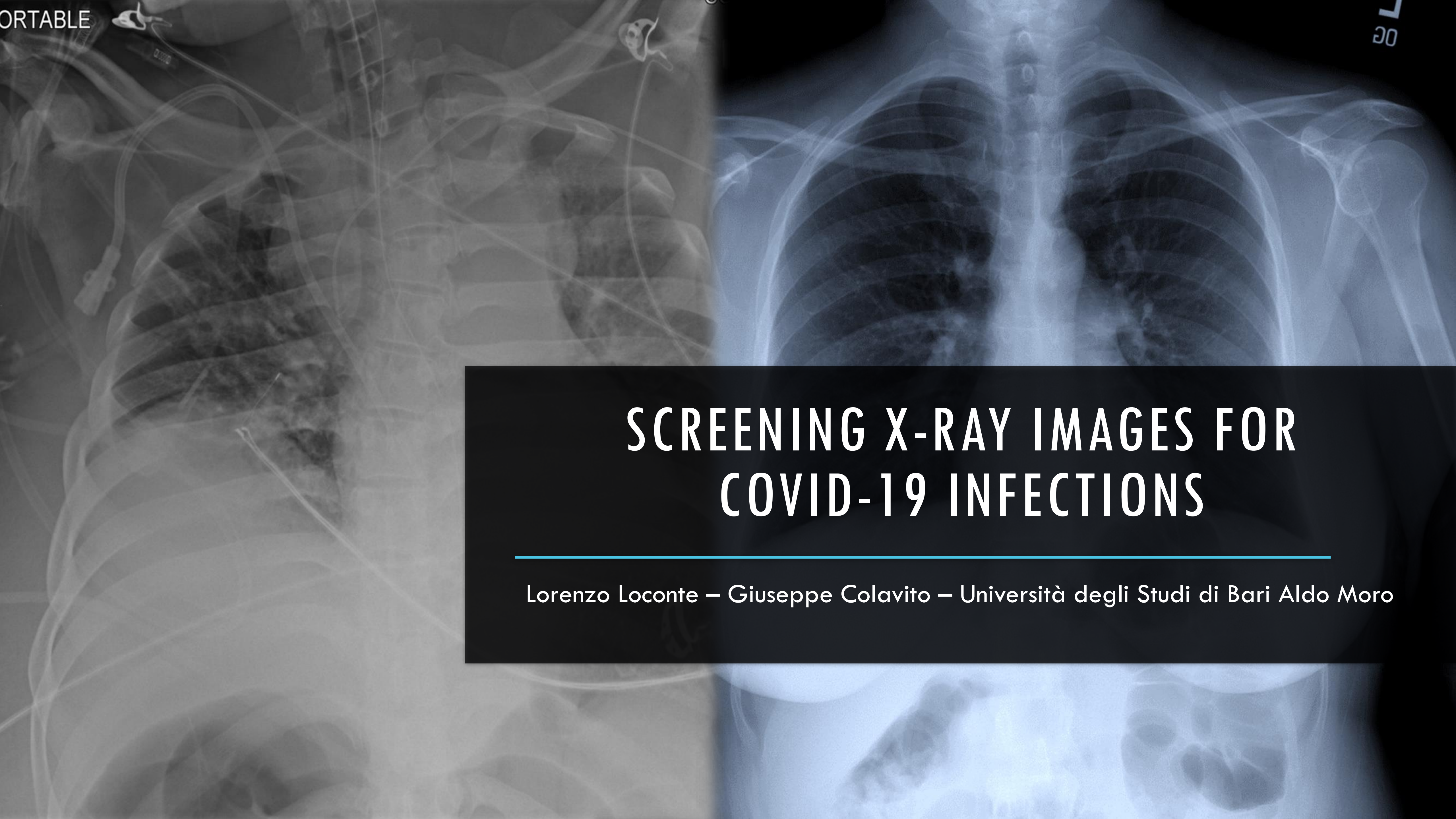

SCREENING X-RAY IMAGES FOR COVID-19 INFECTIONS

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TASK

Goal : understand if a patient has a COVID-19 infection

Data : X-ray image of the chest

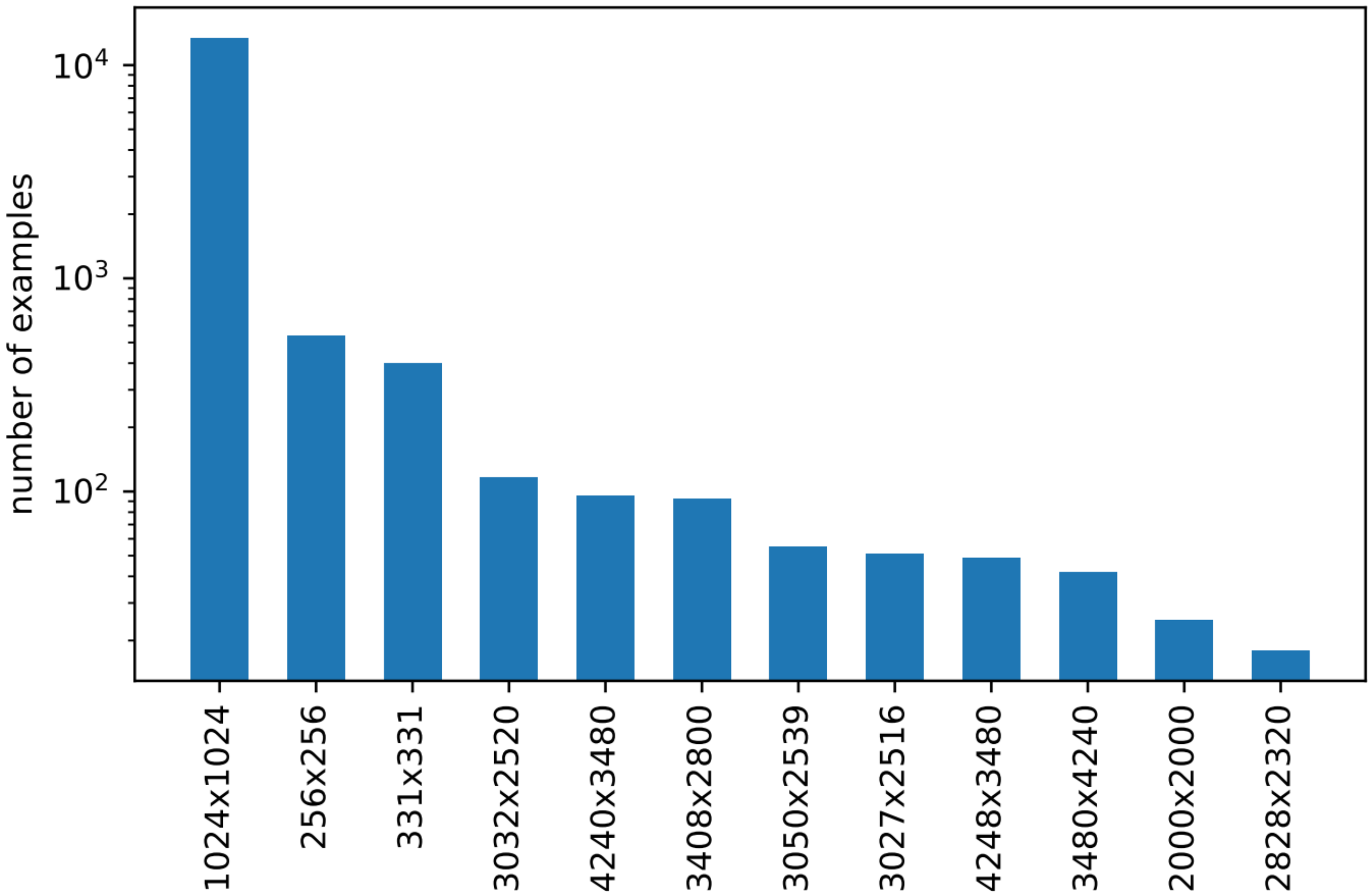
Task : binary classification task with an unbalanced dataset

DATASET

	Train Set	Test Set
Positive	2,158 (14%)	200 (50%)
Negative	13,793 (86%)	200 (50%)
Total	15,951	400

The COVIDx CXR-2 dataset

DATASET



The dataset is not uniform in terms of size of the images.

All the images are resized to 224x224

PREPROCESSING

Before training, the images are preprocessed.

Since some images contain writings on the upper part, the images are cropped (8% of the top-part)

PREPROCESSING

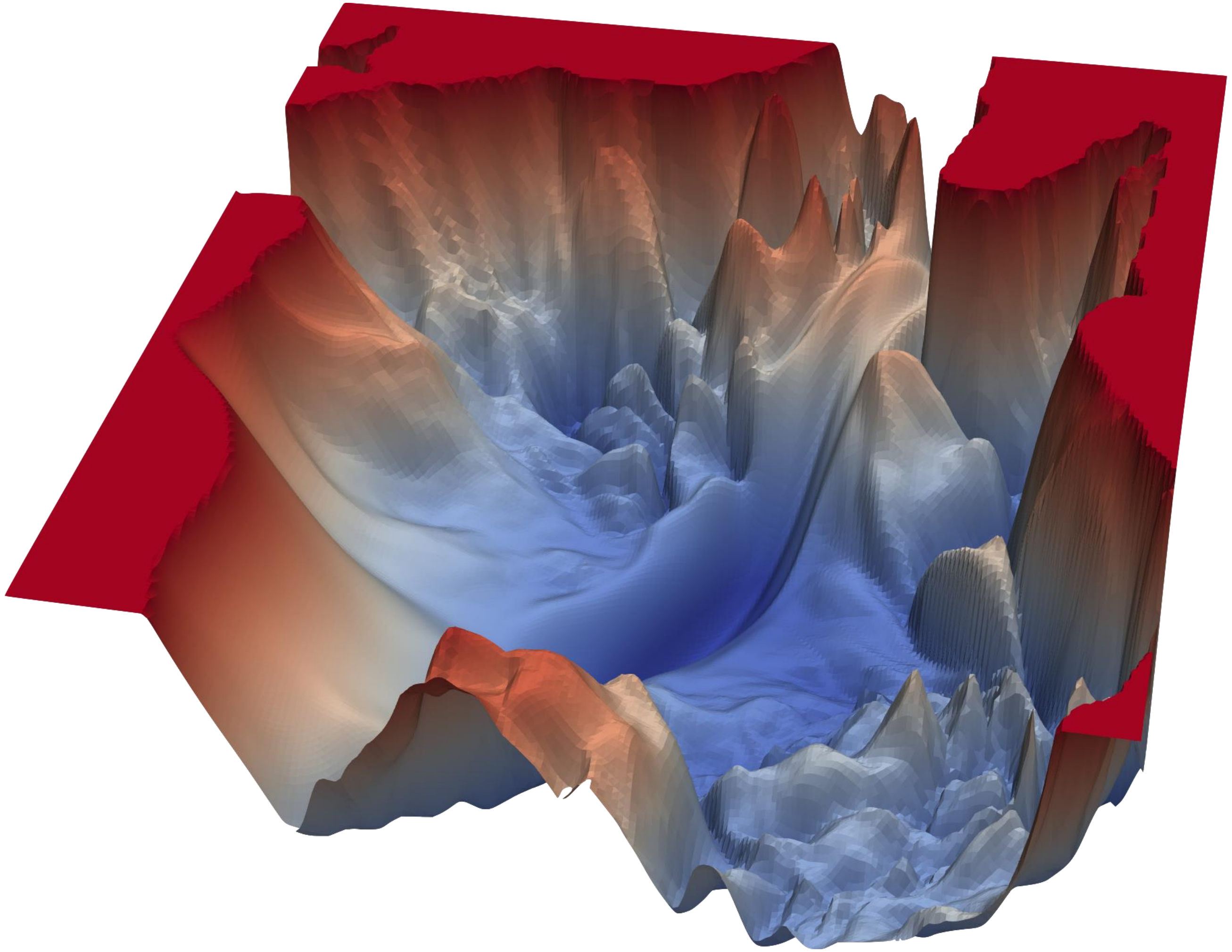
We are interested only on the chest, so we center crop the image to remove useless parts

PREPROCESSING

We investigated the use of histogram-equalization to enhance the quality of the images

NEURAL NETWORKS

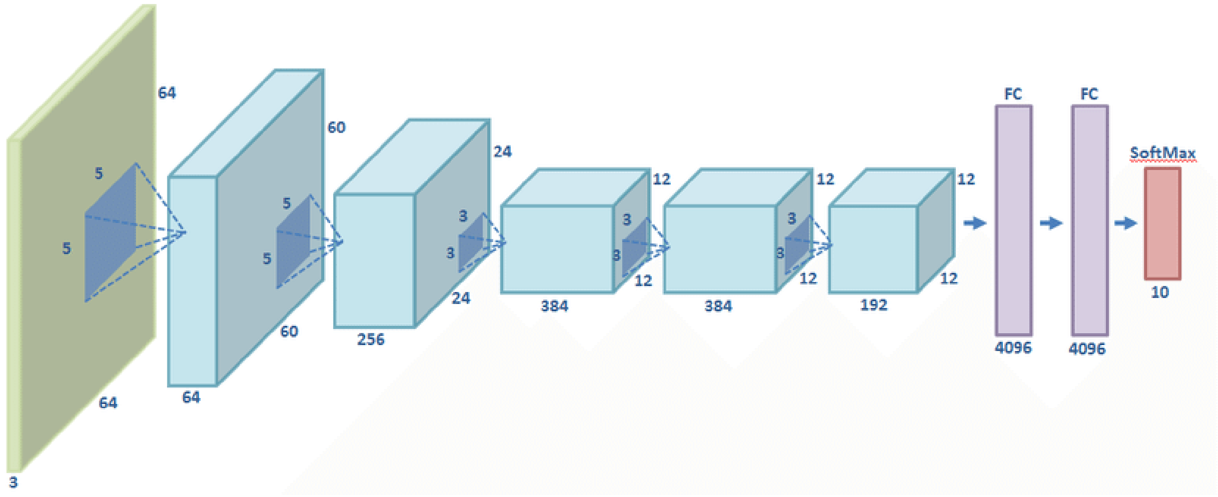
- AlexNet
- VGG16
- ResNet50
- DenseNet121
- InceptionV3



NEURAL NETWORKS

AlexNet:

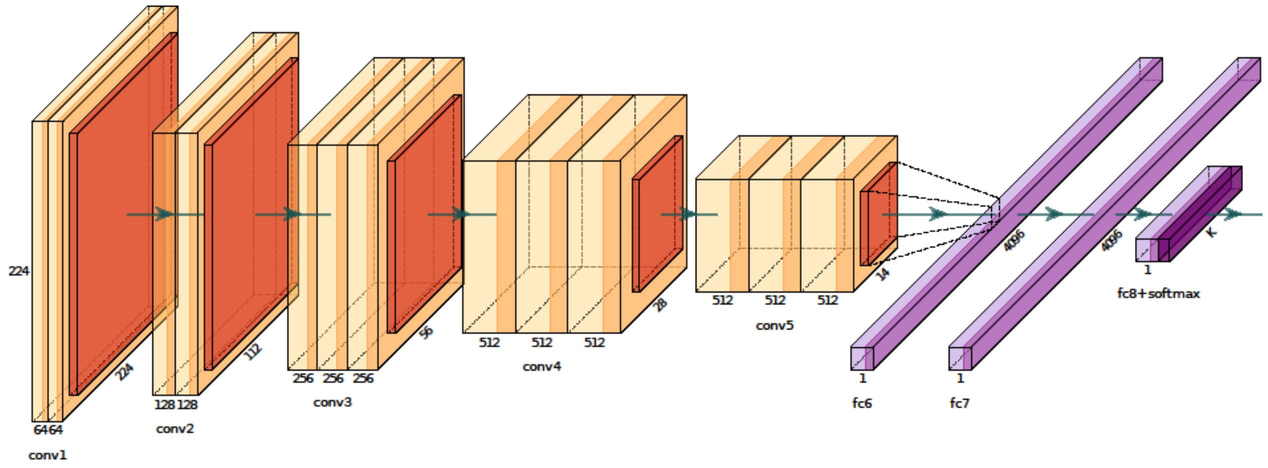
- convolutional neural network (CNN)
- no skip connections
- ReLU activation functions
- dropout



NEURAL NETWORKS

VGG:

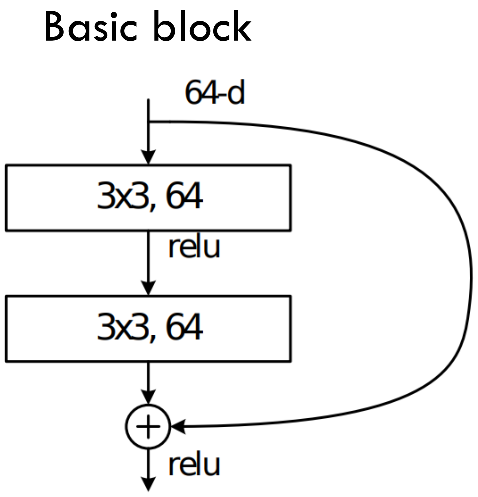
- convolutional neural network (CNN)
- stacks of 3x3 and 1x1 convolutions
- ReLU activation functions

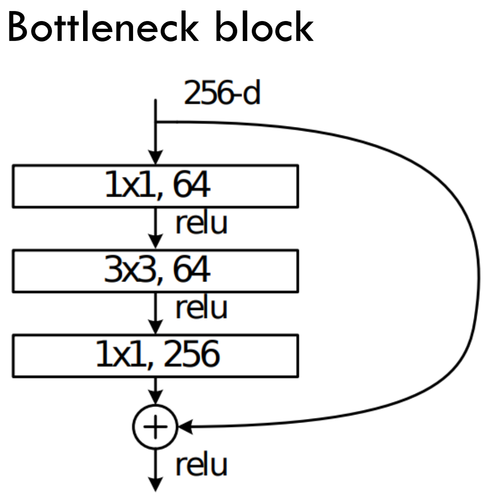


NEURAL NETWORKS

ResNet:

- convolutional neural network (CNN)
- skip-connections
- residual convolutional blocks (basic/bottleneck)
- improves convergence rate $\longrightarrow$ higher learning rate
- batch normalization

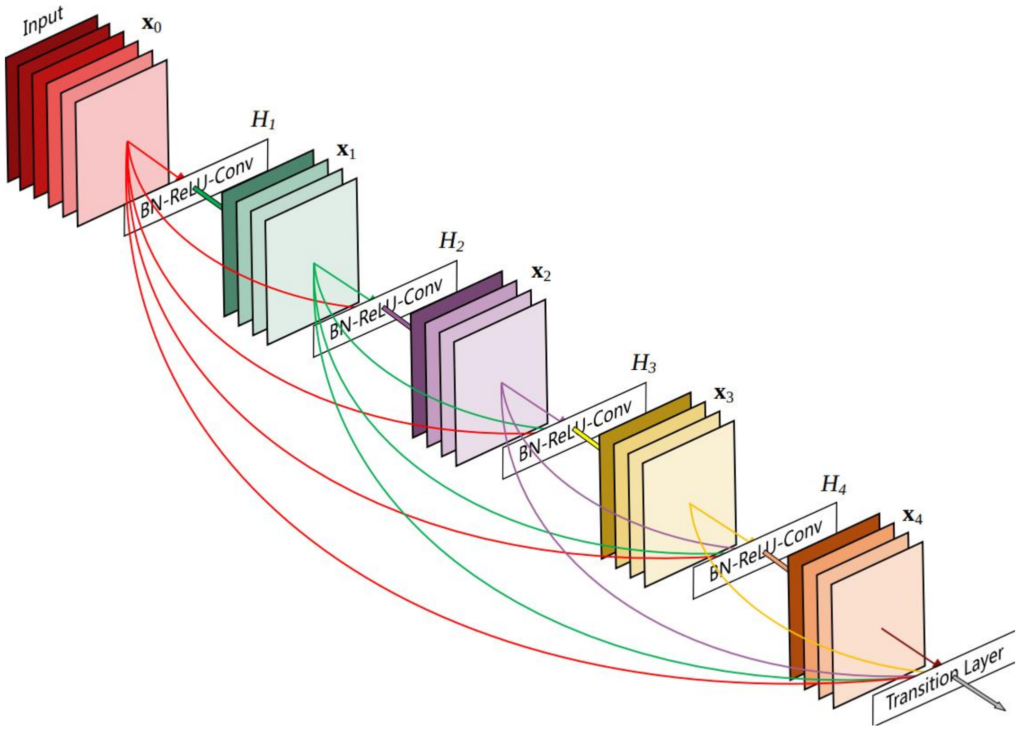




NEURAL NETWORKS

DenseNet:

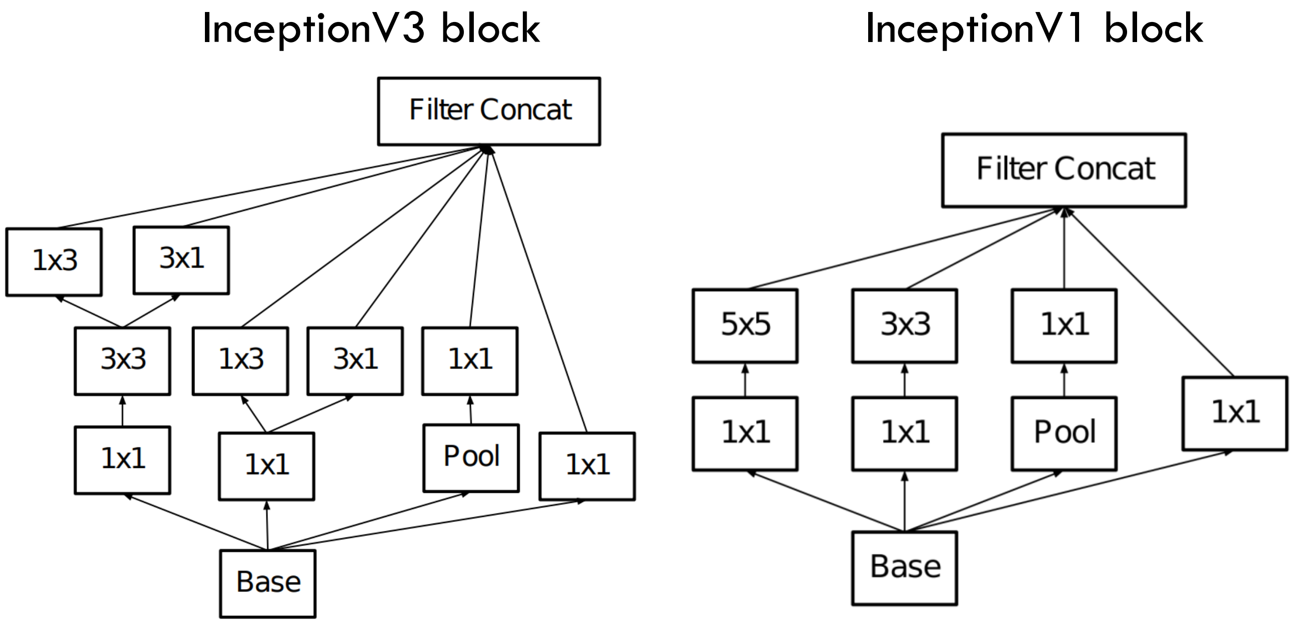
- convolutional neural network (CNN)
- direct connections to all subsequent layers (dense block)
- transition layers (convolution and pooling)
- ReLU activation functions
- batch normalization



NEURAL NETWORKS

InceptionV3:

- convolutional neural network (CNN)
- inception modules (parallel convolutions)
- auxiliary classifiers
- factorized convolutions
- ReLU activation functions
- batch normalization



METHODOLOGY

- Data augmentation
  - random scaling (10%)
  - random translation (10%)
  - random rotation (10°)
  - histogram-equalization (optional)
- Adam optimizer
  - learning rate 1×10^{-4} for AlexNet and VGG16
  - learning rate 1×10^{-3} for the others

METHODOLOGY

- Note for InceptionV3
  - input size 299x299
  - auxiliary classifier with cross-entropy loss weighted by a factor of 0.3
- Batch size 32
- No L2 regularization
- 100 epochs with early stopping (20 patience)
- Binary cross entropy weighted by taking into account dataset unbalance.

TOOLS AND HARDWARE

- Python 3.9
- PyTorch library
- GoogleColab
- Nvidia GTX-1660
- Intel 4460 quad-core 3.4 GHz

EVALUATION

	With Histogram Equalization			Without Histogram Equalization		
Architecture	**Precision**	**Recall**	**F1**	**Precision**	**Recall**	**F1**
AlexNet	0.918	0.905	0.904	0.932	0.923	0.922
VGG16	0.890	0.863	0.860	0.876	0.835	0.830
ResNet50	**0.953**	**0.952**	**0.952**	**0.949**	**0.945**	**0.945**
DenseNet121	**0.955**	**0.955**	**0.955**	0.919	0.905	0.904
InceptionV3	0.933	0.925	0.925	**0.975**	**0.975**	**0.975**

Metrics are macro averaged over the two classes

EVALUATION

Architecture	# params (M)	CPU Time (ms)	GPU Time (ms)
AlexNet	57.0	21.5	2.6
VGG16	134.3	171.0	12.7
ResNet50	23.5	95.1	11.0
DenseNet121	7.0	84.1	21.5
InceptionV3	21.8	116.4	18.3

Number of parameters and inference time for each model

EVALUATION

Architecture	Input size	Precision	Recall	Accuracy
ResNet50	224 x 224	0.941	0.965	0.952
DenseNet121	224 x 224	0.955	0.955	0.955
InceptionV3	299 x 299	0.975	0.975	0.975
COVID-Net CXR-2	480 x 480	0.970	0.955	0.963

Comparison with state of the art

FUTURE WORK

- Explore more sophisticated preprocessing algorithm to further enhance images
- Explainability and predictions visualization

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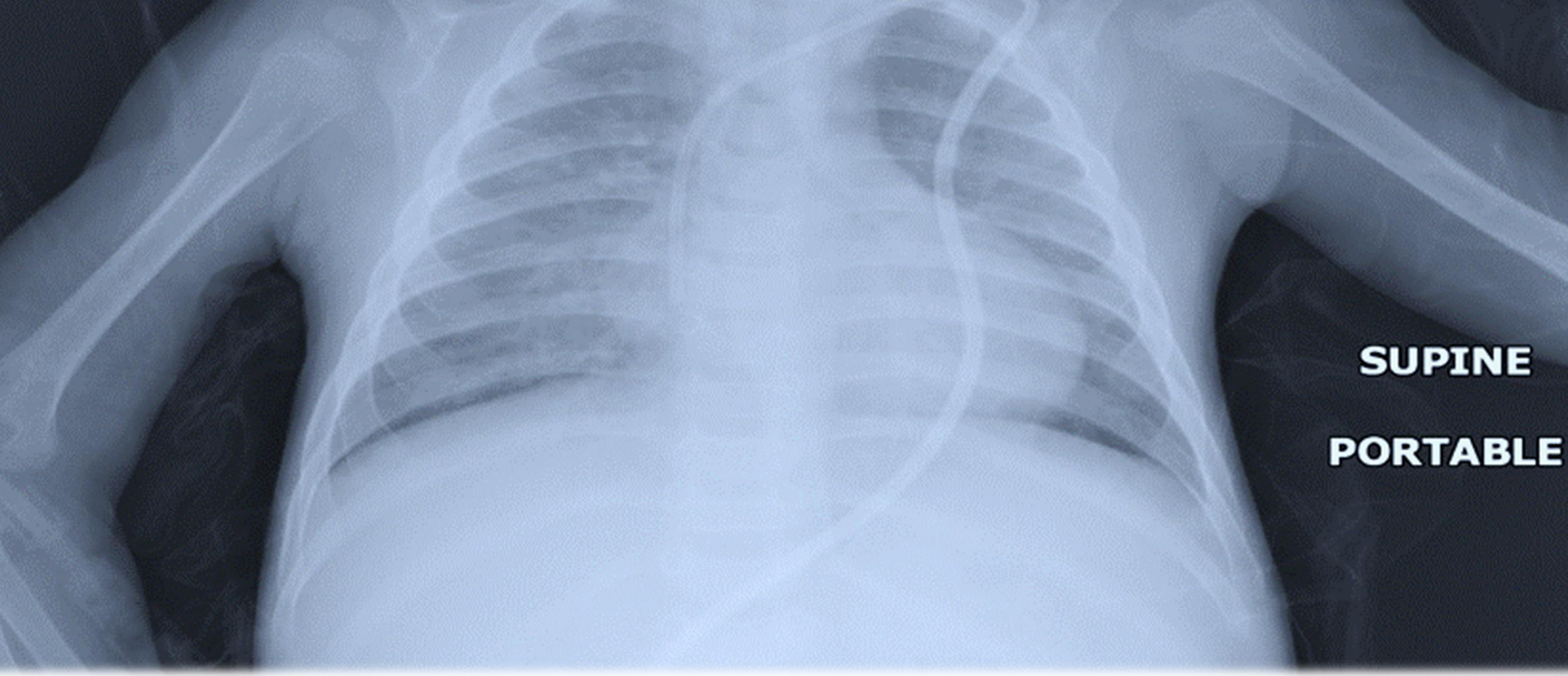

GRAZIE PER L'ATTENZIONE