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Pneumonia detection using Deep Learning

BIG DATA FOR OFFICIAL STATISTICS 2019/2020

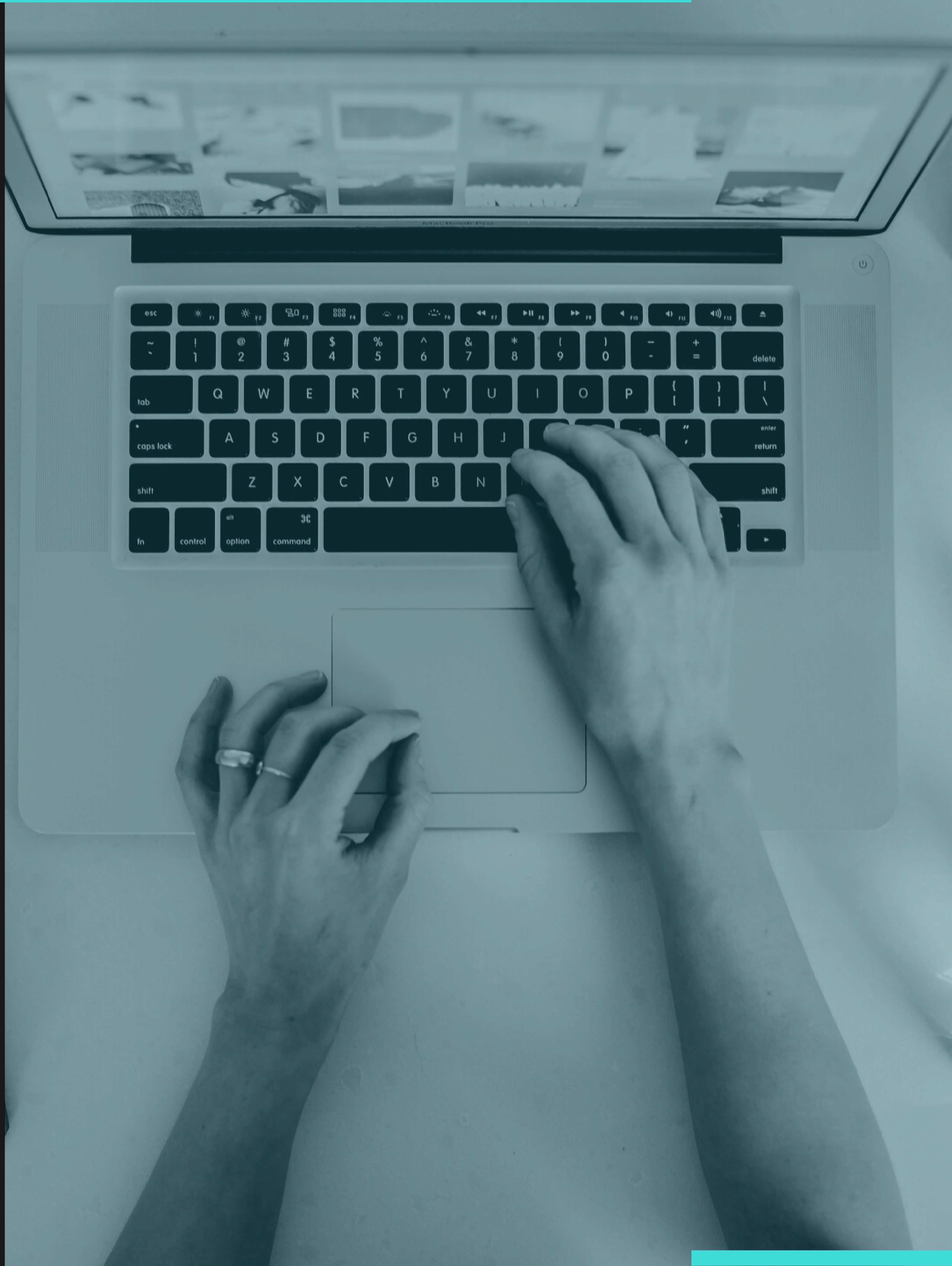
INTRODUCTION

Task:

Build an algorithm in order to detect whether a patient has Pneumonia or not using chest radiographs

Source from Mendeley:

https://data.mendeley.com/datasets/rscbjbr9sj/2



PROCESS DESCRIPTION

1

INPUT DATA

2

DATA MANIPULATION

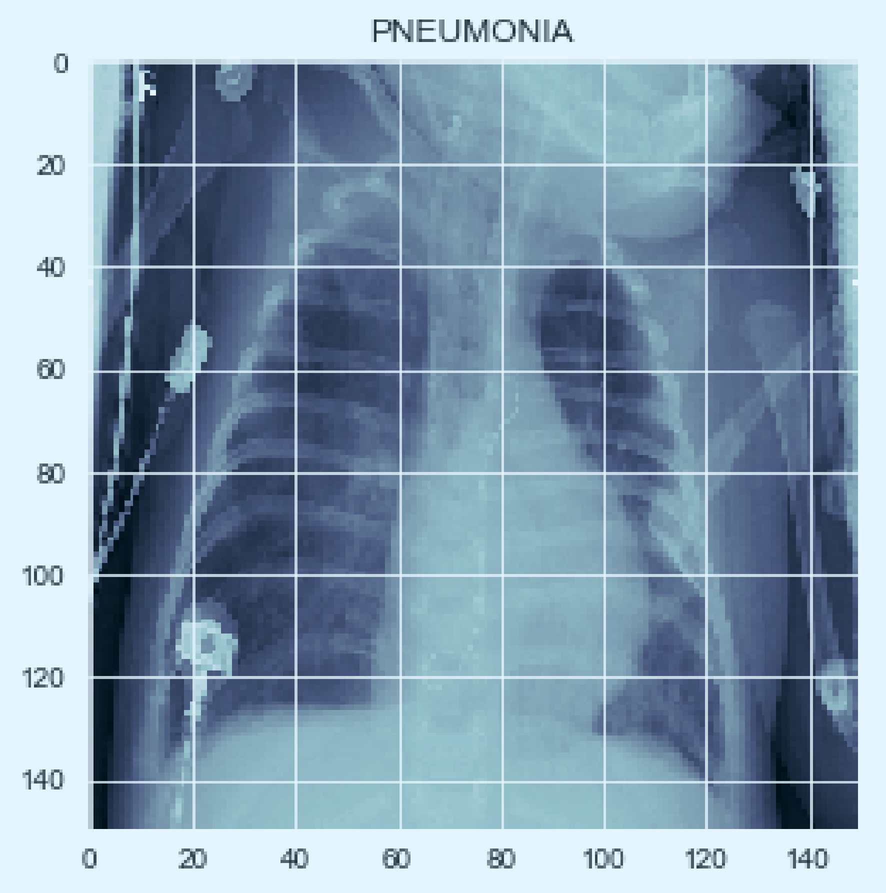
3

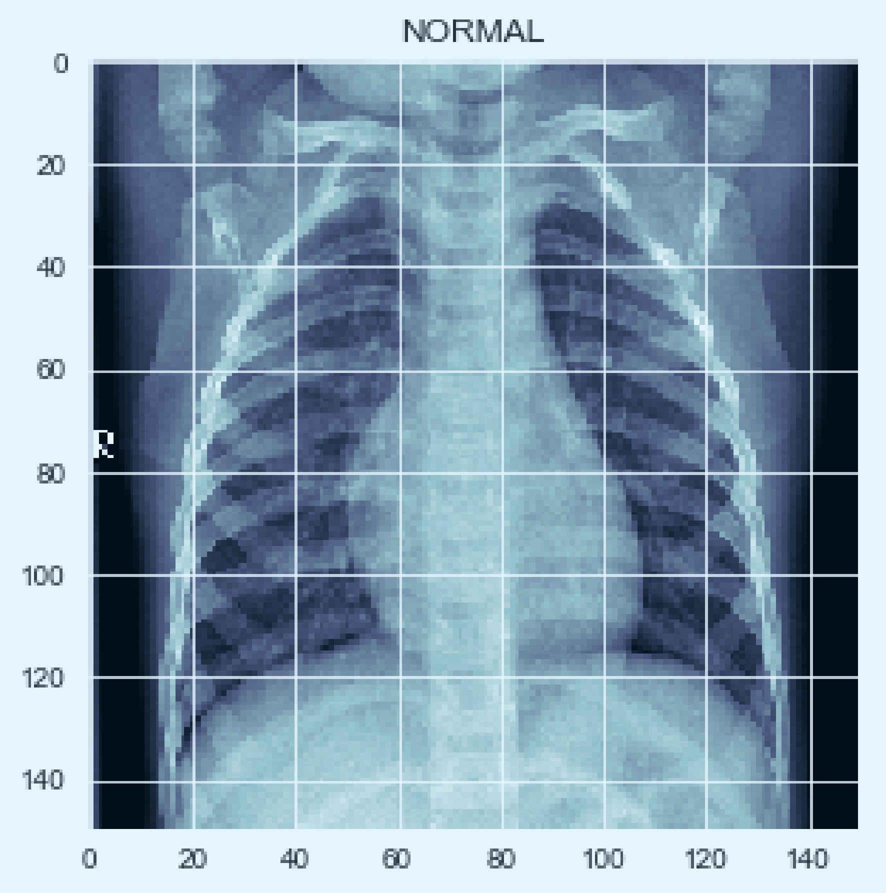
MODEL DEFINITION

4

EVALUATION

1. INPUT DATA





Number of images

	TRAIN SET	TEST SET	VALIDATION SET
PNEUMONIA Class 0	3875	390	8
NORMAL Class 1	1341	234	8

DATA DESCRIPTION

5856 Chest X-ray images of pediatric patients of one to five years old

LABELS

The images show whether a patient has Pneumonia (Class 0) or not (Normal - Class 1)

DATASET ORGANIZATION

- **Train set:** training data/images for teaching our model
- **Test set**: data to test the model once it has learned the relationships between the images and their label
- **Validation set:** data to validate the model in order to prevent overfitting

2. DATA MANIPULATION

1. PREPROCESSING

- Each pixel represents a value
- Converting imagine into matrix to which is assigned the belonging class
- Separate features (matrix) from the label
- Normalization of each pixel matrix in [0, 1]
- Reshaping

2. DATA AUGMENTATION

- Prevent overfitting
- Handle the imbalance of labels
- Make existing dataset larger altering the training data with small transformations (30° rotation, 10% vertical and horizontal shift, 20% zoom)

3. METHODOLOGIES - MODEL DEFINITION

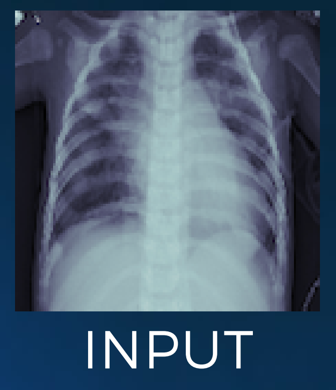
Convolutional Neural Newtork

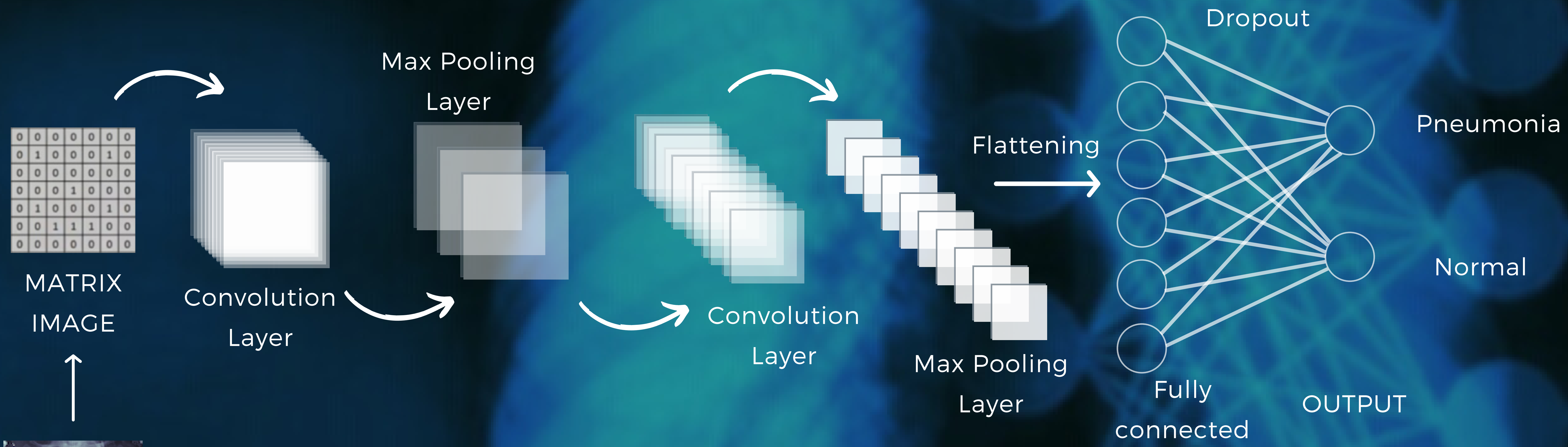
CNN is a special type of an Artificial Intelligence implementation which uses a special mathematical matrix manipulation called the convolution operation to process data from the images.

It works as follow:

1. It takes the x-ray image as input, and slides a filter (or kernel) over the image matrix to create a feature map describing the image.
2. It puts together all the feature maps as the final output of the convolutional layer.
3. It passes the output of this layer through a non-linear activation function.
4. It reduces the dimensionality using a Pooling layer

CONVOLUTIONAL NEURAL NETWORK





The model has been compiled using **Adam Optimizer** in order to update the network weights iterative based in training data

MODEL DESCRIPTION

Layers

- **3x3 Filters**: 32, 64, 128, 256
- **5 Convolutional Layers** with **stride** 1 and **padding**
- After each convolutional layer 2x2 **Max Pool** Layer with **stride** 2 and **padding**
- **2 Fully connected Layers**
- **Dropout** after the first FCL, that is random neurons are ignored during training

Activation Function

- **Relu** is the non-linear activation function used y=x for positive x, y=0 for negative x.

- For the second FCL the activation function is **sigmoid [0,1],** used when there is to predict the probability as an output

CONVOLUTION PROCESS

In the convolution operation, each matrix is scanned by a filter, that starts to shift inside the image matrix.
In every shift step, it performs a matrix multiplication between the kernel and the portion of the image over which the kernel is hovering.

$$39\times1 + 31\times0 + 30\times-1 + 15\times2 + 43\times0 + 46\times-2 + 0\times1 + 18\times0 + 16\times-1 = \mathbf{-69}$$

39	31	30	36	7
15	43	46	28	35
0	18	16	14	26
33	2	10	12	9
42	40	8	48	38

*

1	0	-1
2	0	-2
1	0	-1

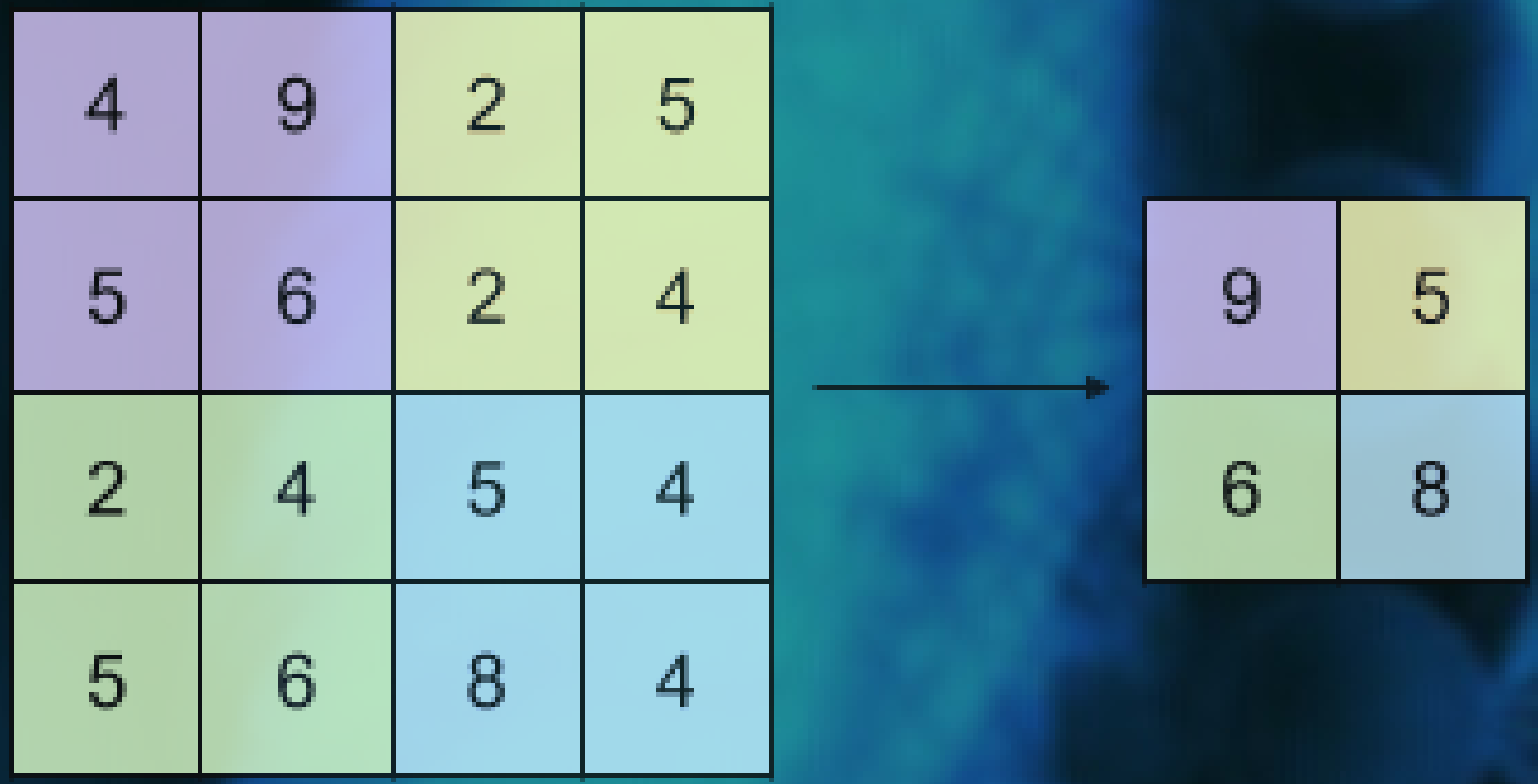
3x3 Kernel

-69		

Stride 1: the filter will slide 1 pixel after each covolution operation

Padding: zero value pixels that surround the input image. It is used to protect the loss of any valuable information.

MAX POOLING



Max Pooling takes the maximum value in the window created by a 2x2 filter with stride 2. This significantly reduces the training time and preserves significant information.

4. EVALUATION

- CONFUSION MATRIX
  - ACCURACY
  - PRECISION
  - RECALL
  - F-1 SCORE

CONFUSION MATRIX

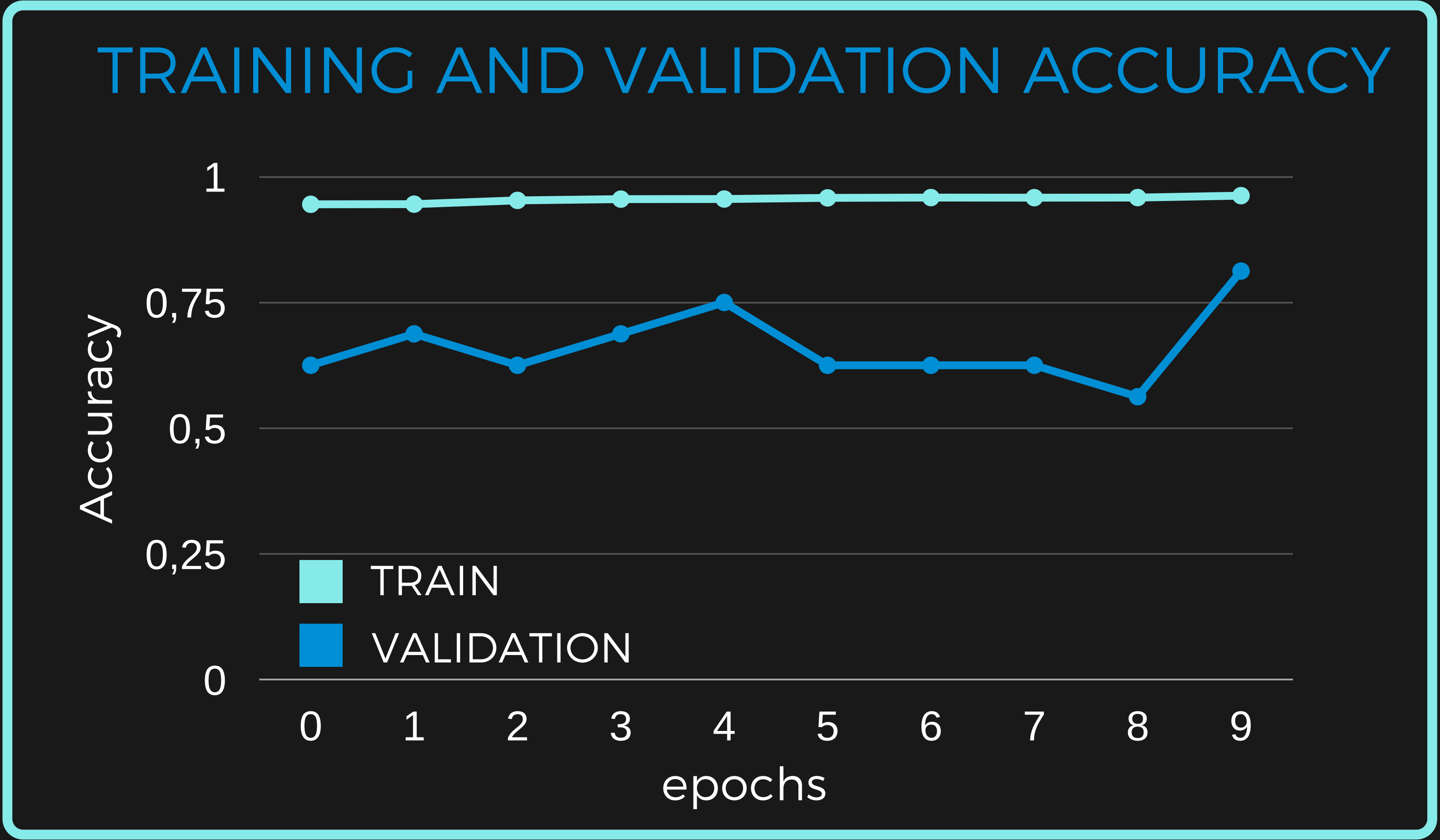
Each row of the matrix represents the instances in a predicted class while each column represents the instances in an actual class

	Pneumonia	Normal
Pneumonia	383 TP	7 FN
Normal	35 FP	199 TN

ACCURACY

Description of systematic **errors**, a measure of statistical bias; low accuracy causes a high difference between a result and a "true" value. However, high accuracy is not enough, in fact it is significant only when the amount of false positive and false negative are almost the same.

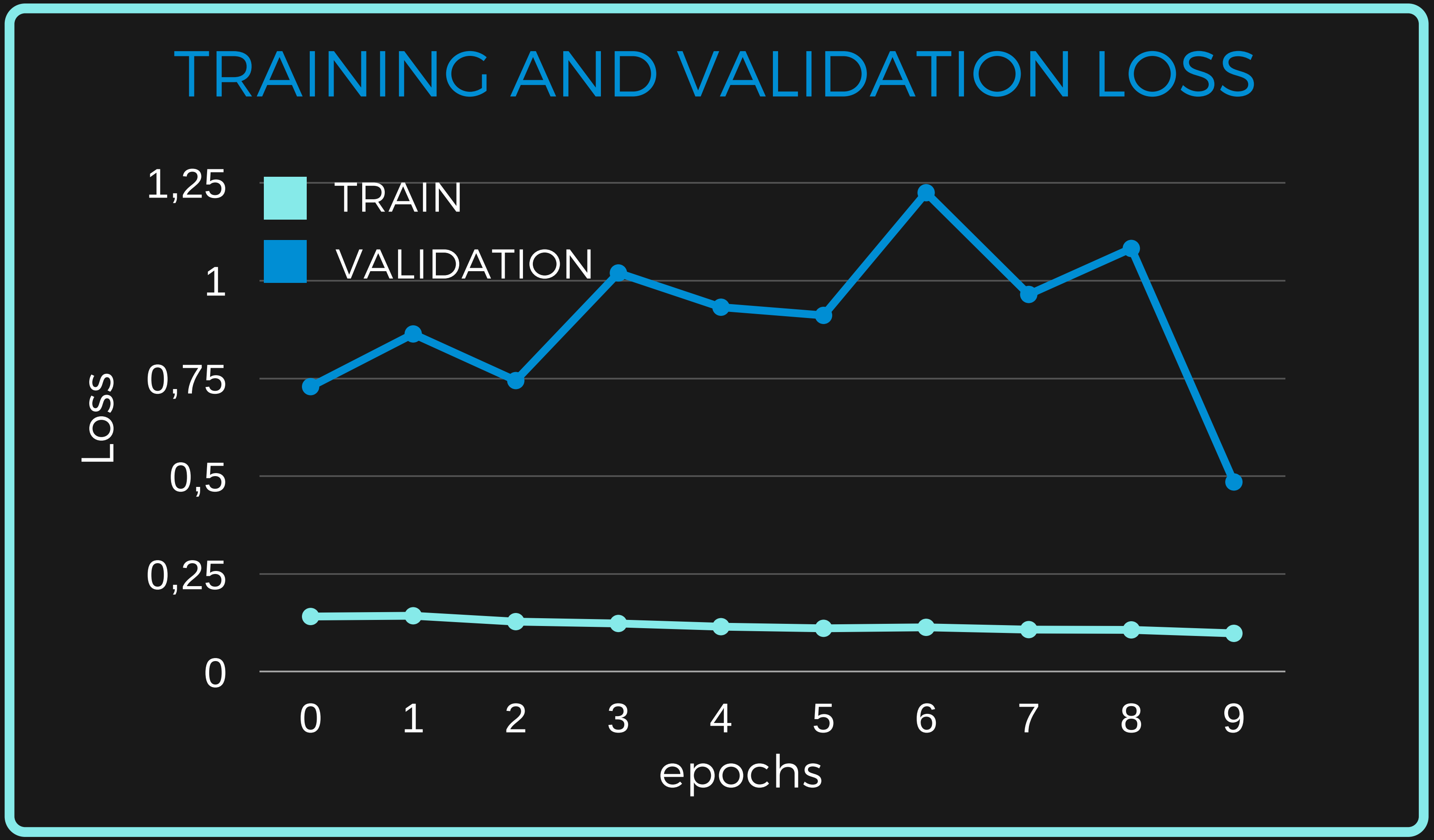
$$ACC = \frac{TP + TN}{TP + TN + FP + FN}$$



OUR MODEL
93.27 %

LOSS FUNCTION

Function representing the price paid for inaccuracy of predictions that has to be minimized. The most common is the **binary cross entropy**.



OUR MODEL
31 %

PRECISION

Also known as positive predictive value, precision is the ratio of the correct positive results over all positive results:

$$PPV = \frac{TP}{TP + FP}$$

RECALL

Also known as Sensitivity of true positive rate, it is the ratio of correct positive results over all relevant samples (all samples that should have been identified as positive):

$$TPR = \frac{TP}{TP + FN}$$

F-1 SCORE

It is the harmonic mean of the precision and recall and it gives a better measure of the incorrectly classified cases. In fact it reaches its best value at 1

$$F\text{-}1 = 2 * \frac{PPV * TPR}{PPV + TPR}$$

Classification Report

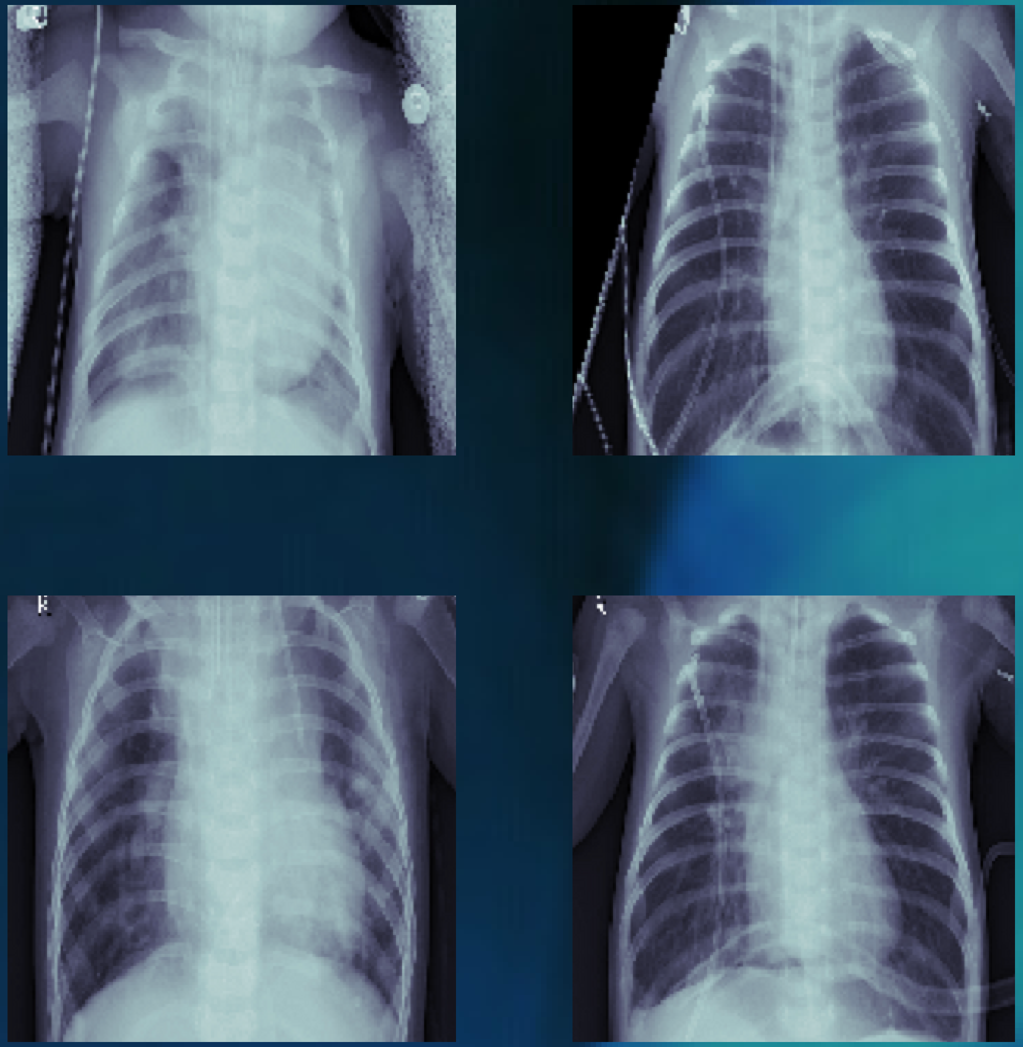
	precision	recall	f1-score	support
Pneumonia (Class 0)	0.92	0.98	0.95	390
Normal (Class 1)	0.97	0.85	0.90	234
accuracy			0.93	624
macro avg	0.94	0.92	0.93	624
weighted avg	0.93	0.93	0.93	624

- **Macro average:** average of the unweighted mean per class;
- **Weighted average:** average of the support-weighted mean per class.

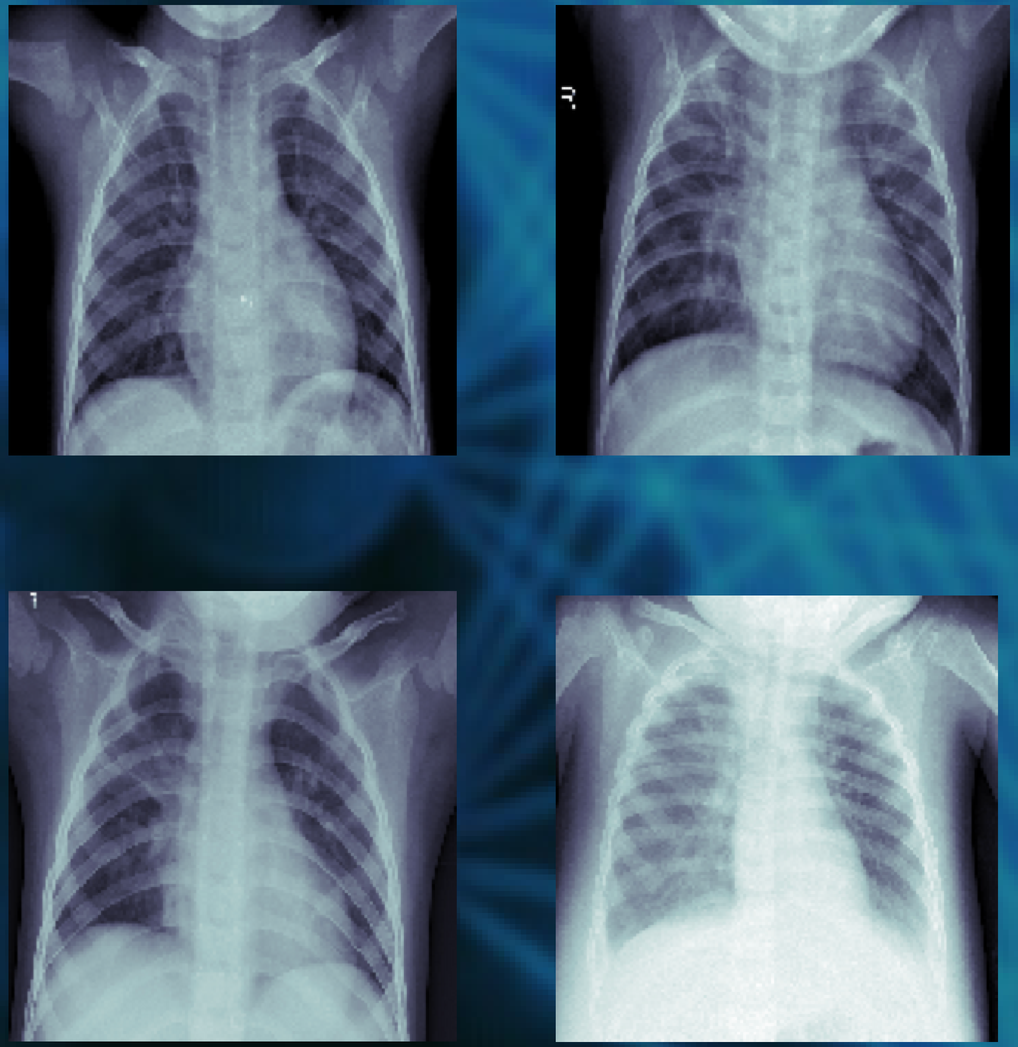
Predicted Classes vs Actual Classes

examples

Predicted Class Pneumonia
Actual Class Pneumonia



Predicted Class Normal
Actual Class Pneumonia



CONCLUSION

1

AIM

Classify Pneumonia disease using convolutional neural network.

2

DISCUSSION

Since the low amount of x-ray images without Pneumonia, a good direction is to improve the CNN classifier's performance on normal image, adding more normal chest x ray images to the dataset. Moreover, it would be a good idea to train the algorithm to first detect areas that are dramatically different between normal and pneumonia images, and then focus on analyzing those areas instead of the whole image.

3

ADVANTAGES

- Improve the efficiency of radiologists
- It can guarantee timely access to treatment and save time and money.
- potential for generalized high-impact application in biomedical imaging

4

APPLICATION

Produce deep learning models that can classify whether a patient has a condition or not, that can determine which particular condition the patient has, and that can determine the severity of the condition.

Thanks for your attention!