# Deep Learning Project № 2

DM873 / DS809, Fall 2022 11/11/2022

To do this project, you will use Python 3 and the following packages:

- TensorFlow. The used backend used for Keras.
- Keras. Good front-end package for easier integration of neural networks.
- Matplotlib. This package allows you to graph your data and data transformations.

These can all be installed using pip, the python package manager. You are not strictly forced to use these packages, but it is highly recommended. Feel free to use other packages you think are necessary.

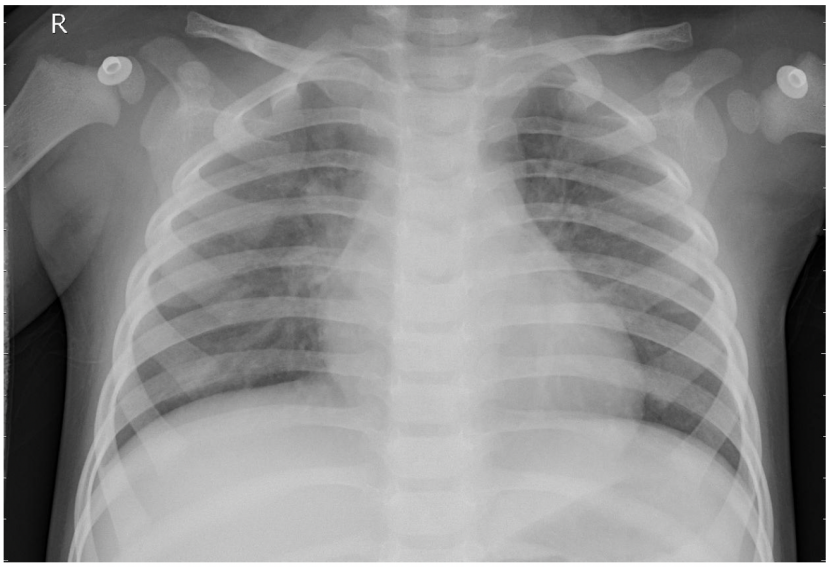
## Installations

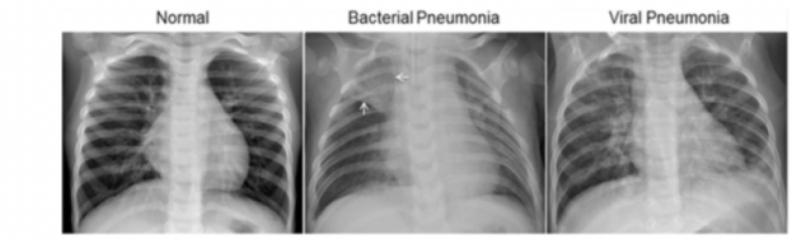
Run the following commands on terminal if not installed;

Listing 1: Installations of required Python packages

```
1 pip install tensorflow
2 pip install matplotlib
```

## Project Details




In this project, we will apply all our knowledge we have collected in the course so far. You will implement your own layer and seek to get the best possible performance. The dataset you will be given is of quite some relevance: In light of the recent COVID-19 pandemic, we will take a look at one of the severe symptoms of the disease, pneumonia. According to the mayoclinic.org[1], "Pneumonia is an infection that inflames the air sacs in one or both lungs. The air sacs may fill with fluid or pus, causing cough with phlegm or pus, fever, chills, and difficulty breathing. A variety of organisms, including bacteria, viruses and fungi, can cause pneumonia."

It is crucial that a pneumonia is detected as early as possible to advert the most severe, life threatening symptoms. The primary tool for detection of pneumonia are x-ray images of the lung. Therefore, you will be given a dataset comprised of lung x-ray images of patients with pneumonia and of health lungs. Your classification task will be the detection of those patients suffering from pneumonia vs. the healthy group.

Additionally, you must implement your own convolutional layer, your own dense layer, and your own pooling layer. Furthermore, you must evaluate your model on data in a different format than your training dataset. Here you must write your own custom Keras generator to read the new format. Apply all techniques at your disposal to get the model with the highest possible performance.

[1] https://www.mayoclinic.org/diseases-conditions/pneumonia/symptoms-causes/syc-20354204

### When to submit

You need to submit before Friday 16-12-2022 at 23.59.

### What to submit

The hand-in must include a short report. In the report you must include what you've done, the reasoning behind, your results, and a short explanation of your results. You are welcome to include screenshots of your networks training. You must also submit your code, as well as an HDF5 file for your trained network.

### How to submit

You should create a directory at this[2] drive folder, and submit your project here. Name the directory according to the members in the group.

### Notes

You should form groups of 4 people to do this assignment. As training your networks can take a long time, remember to start early on this assignment! Please read through the entire project description and feel free to send any questions you might have about the tasks to Tobias (greisager@imada.sdu.dk) If you think you cannot pass this project, please hand in what you have anyway.

## The Project

### The Dataset

All images are x-ray images taken in the chest region to get a view of the lungs. There are 1341 images of healthy humans, as well as 1341 images of people with pneumonia. The image format is jpeg, and there are 3 color channels. The dataset was created by taking x-ray images of children aged 1-5 from the Guangzhou Women and Children's Medical Center. You can find the training dataset on the same google drive[2] where you also have to submit your project.

### Task 1 - Layers

To create your model, you will need different layers. You are not allowed to use the built in dense, convolution, and pooling layers. Instead, you must implement these 3 layers on your own. A good place to start off is always the Keras documentation. You can find a good documentation for creating your own layers here[3]. Carefully read through the documentation, it help help tremendously with creating your own layers.

[2] https://drive.google.com/drive/folders/1-b1-fZfTMHVjl8YqfHWQInWYFFzdkQUd?usp=share_link
[3] https://keras.io/guides/making_new_layers_and_models_via_subclassing/

You must present three classes, performing the operations of a Dense, Convolution2D, and Pooling layer. You can add additional parameters to these layers as you might need them, such as stride, kernel size, different types of pooling such as average pooling, max pooling, etc. You are allowed to use all backend functions like $\mathrm{K.dot(x,\ y)}$ or $\mathrm{K.conv2d(x,\ kernel)}$ etc.

### Task 2 - Model

You must now build your model. To do this, use your own layers, as well as the other layers from the Keras library except the three forbidden layers (Dense, Convolution2D, pooling). This means you can use for example Flatten from the Keras library.

Try to make your model as good as possible. A quick (and not exhaustive) list of things you could try:

- Adding different kinds of regularization
- Adding different kinds of data augmentation
- Varying your model parameters such as kernel size, amount of units, activation functions
- The structure of your model. Make it deeper and slimmer, make it more shallow but wider

Especially the last suggestion can give large gains. Here is a couple papers you can read, if you want to know what tricks state-of-the-art networks emply, for instance InceptionV3[4] or DenseNet[5].

It is important that you resize your images to 224x224, in order for your network to work for task 3.

### Task 3 - Model

For this last task, you're given a new dataset that you must evaluate your model on. The new dataset is different from the one you've been training on. You can find the test dataset on the same google drive[2] where you also have to submit your project.

The new dataset consists of 30 normal cases, and 21 pneumonia cases. This time, they're not in a jpeg format, but are simple txt files. Each file contains a 224x224 matrix of the pixel values of an image. As the matrix is 2D, we only have 1 color channel, i.e. we have grey-scale images.

If your model was trained on 3 color channels, you must convert this monochrome 1-channel data to a 3-channel RGB similar to your training data. To do this, you are required to write a custom Keras generator class. Once again, I recommend you check the docs describing the sequence base class here[6].

[4] https://arxiv.org/abs/1512.00567
[5] https://arxiv.org/abs/1608.06993
[6] https://keras.io/api/utils/python_utils/#sequence-class