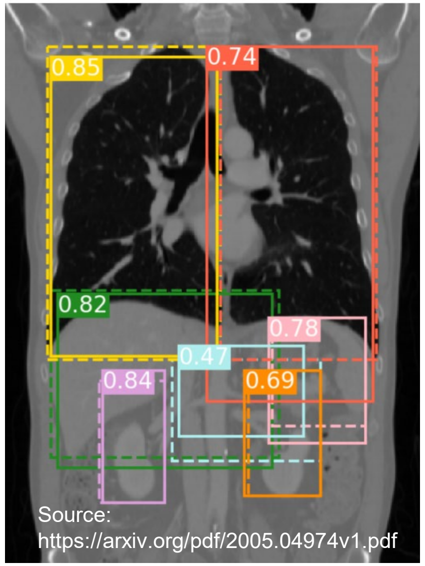
Technical Project Tutorial

Data Science Online Summer School
04/08/2021

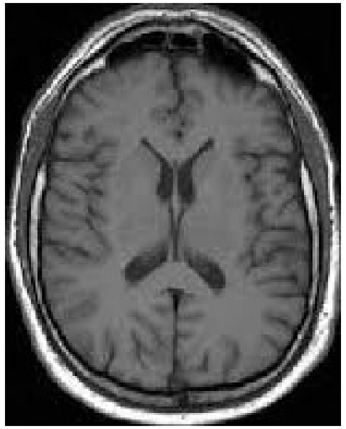
Common Medical Image Analysis Tasks

Localisation



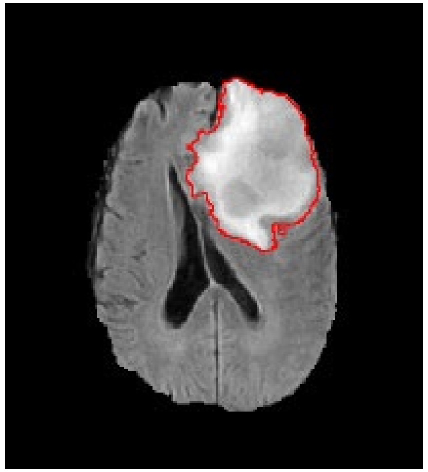
Output: bounding boxes

Classification



Output: tumour/no tumour

Semantic Segmentation



Output: segmentation map

Example: classification

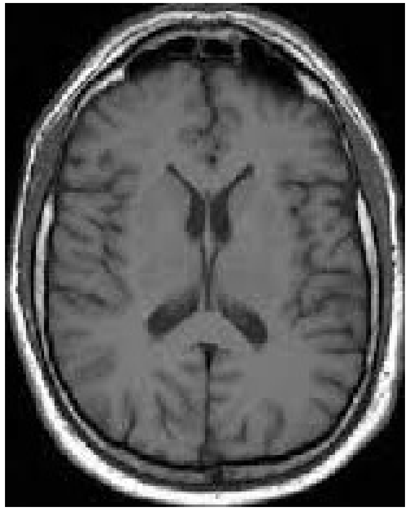
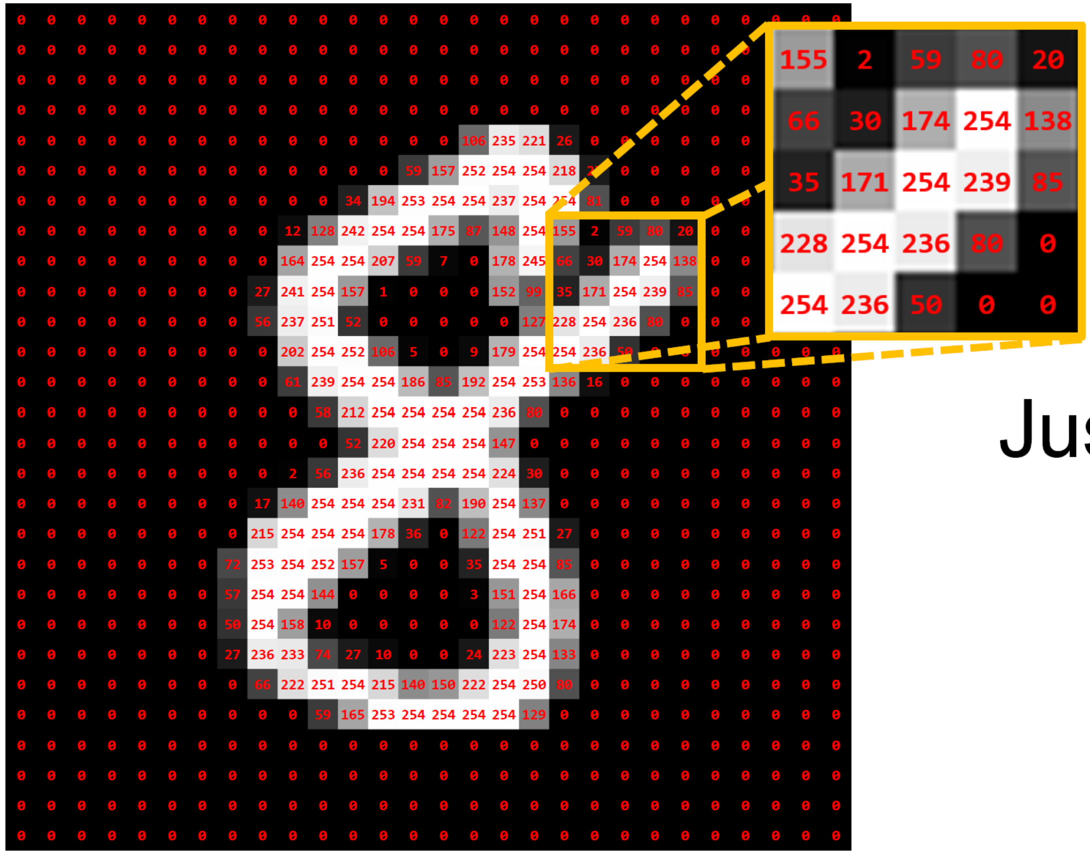


Image Classification Algorithms

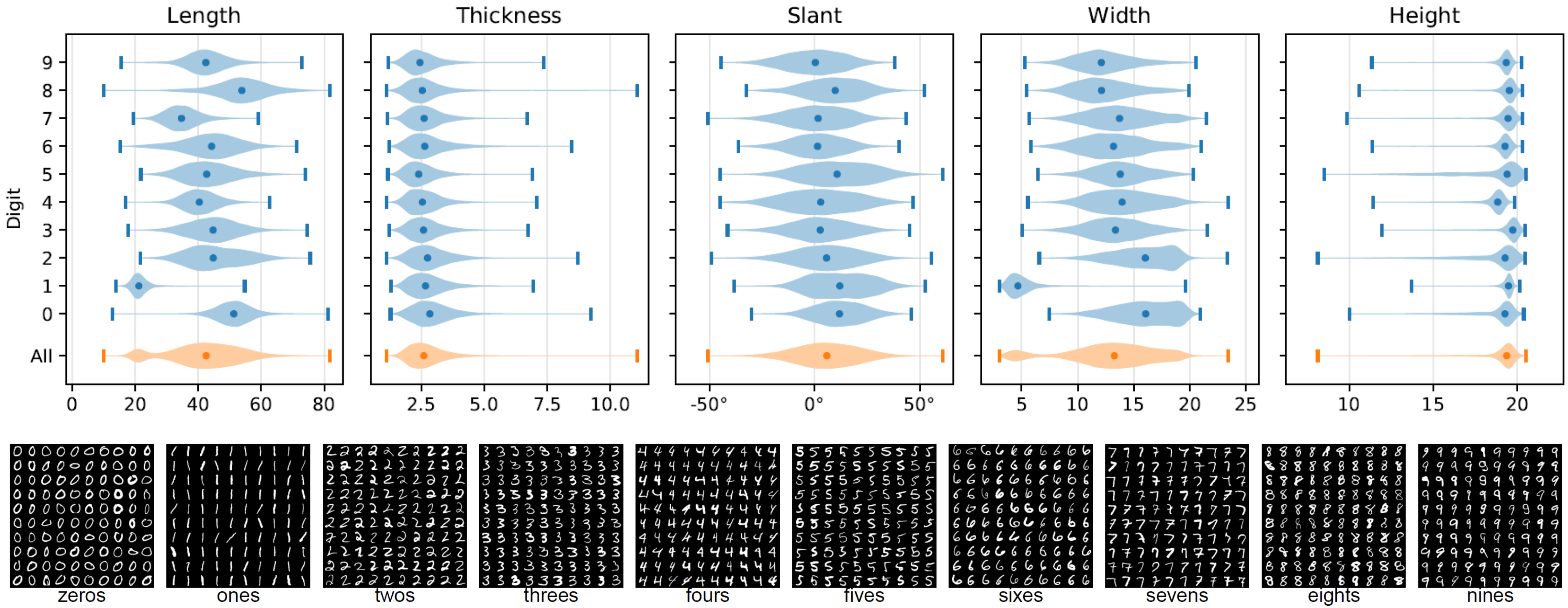
With/without tumour

Classification



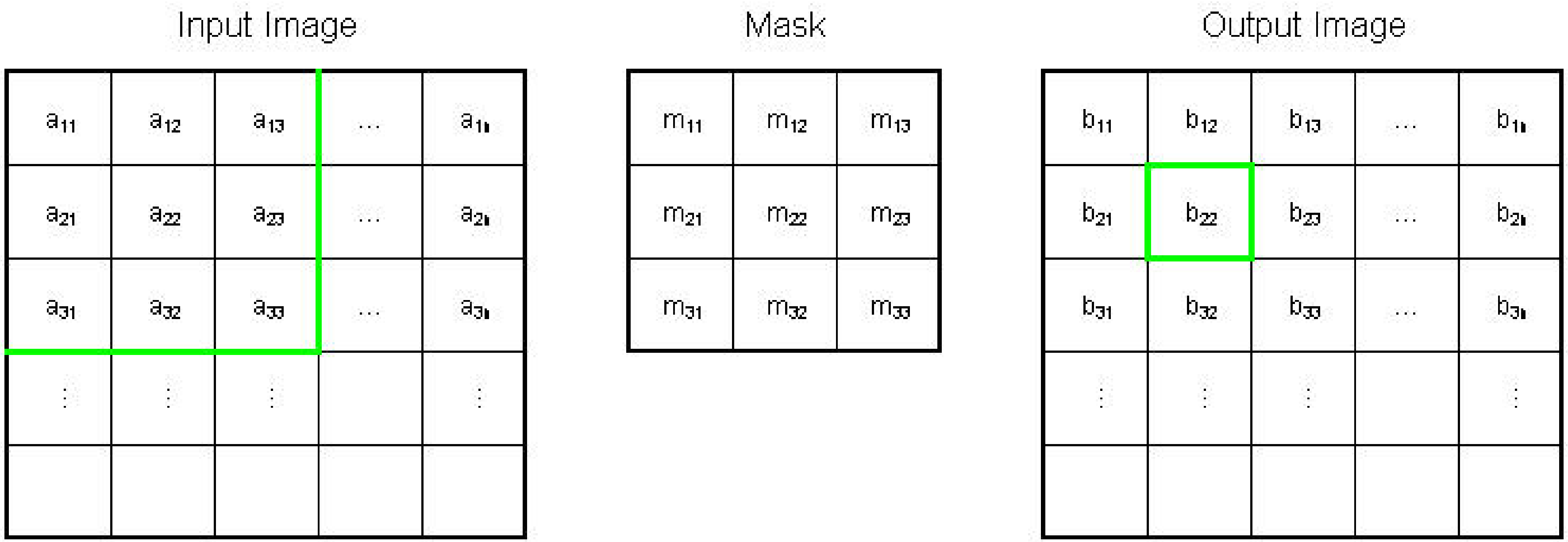
Just an array of numbers

Classification



Source: Castro et al. 2018. https://arxiv.org/abs/1809.10780

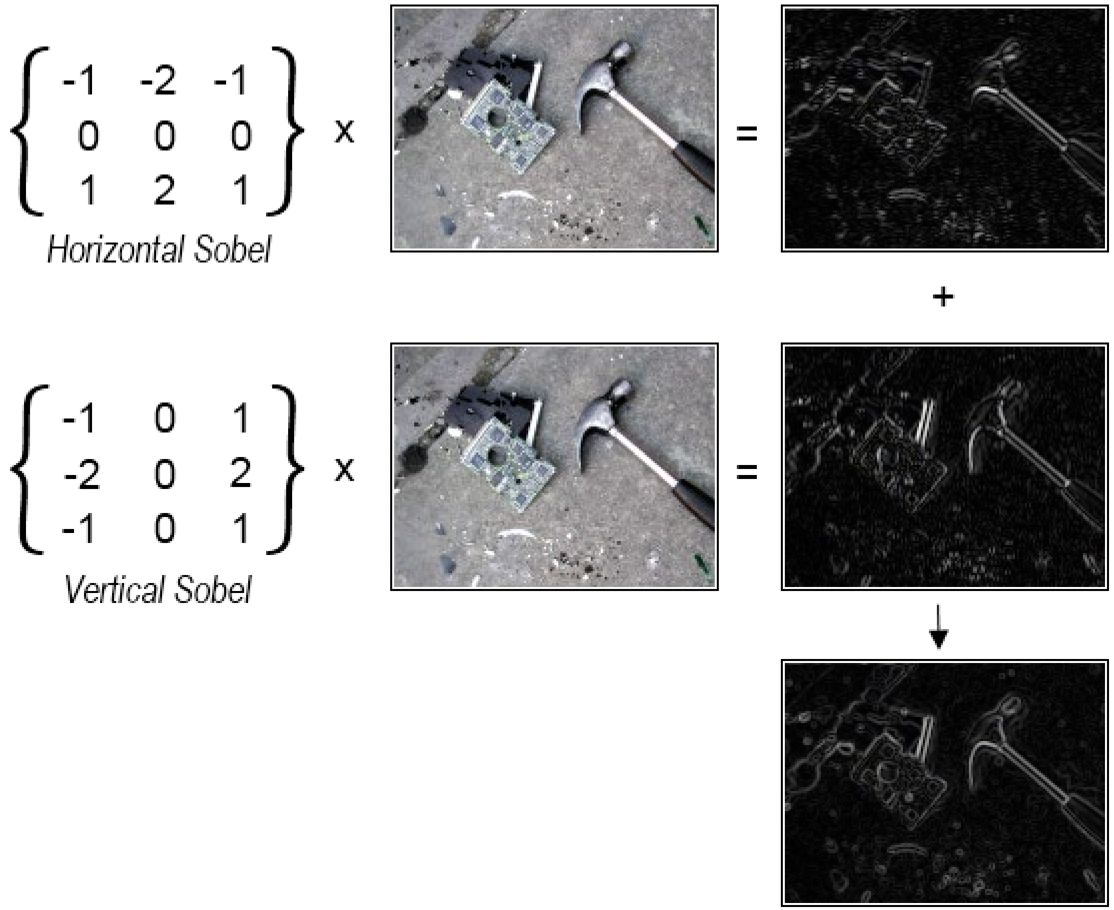
Convolution



$$b_{22} = (a_{11}*m_{11}) + (a_{12}*m_{12}) + (a_{13}*m_{13}) + (a_{21}*m_{21}) + (a_{21}*m_{21}) + (a22*m_{22}) + (a_{23}*m_{23}) + (a_{31}*m_{31}) + (a_{32}*m_{32}) + (a_{33}*m_{33})$$

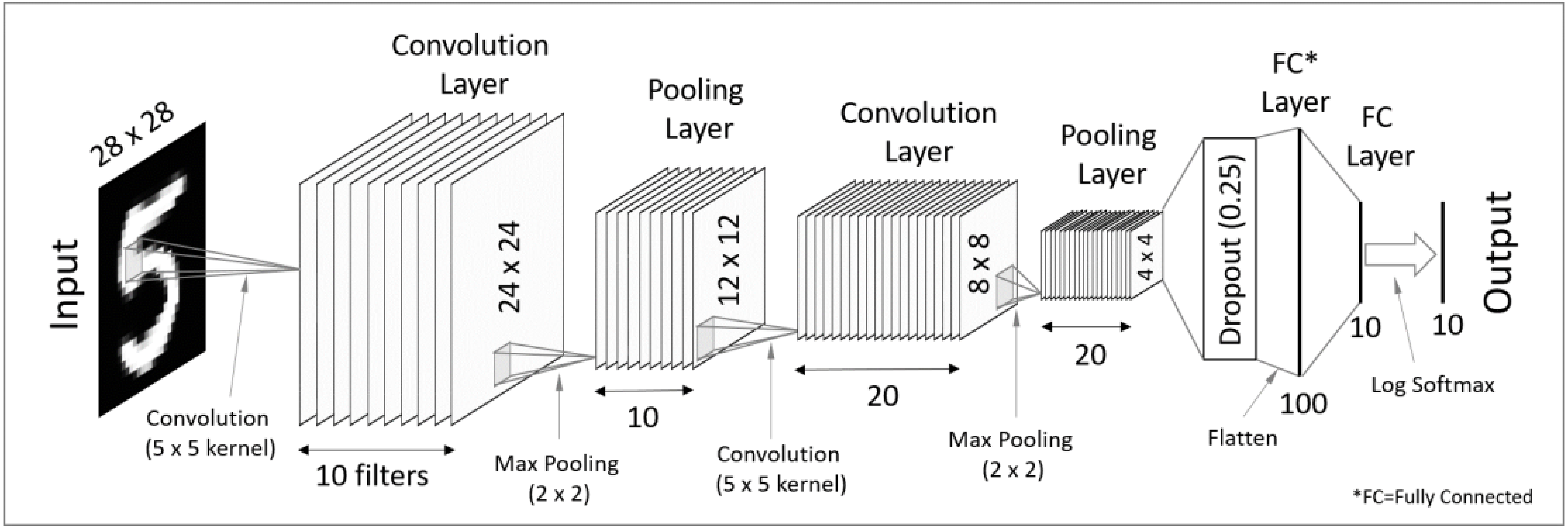
Convolution

Convolution



Sobel filter

Classification



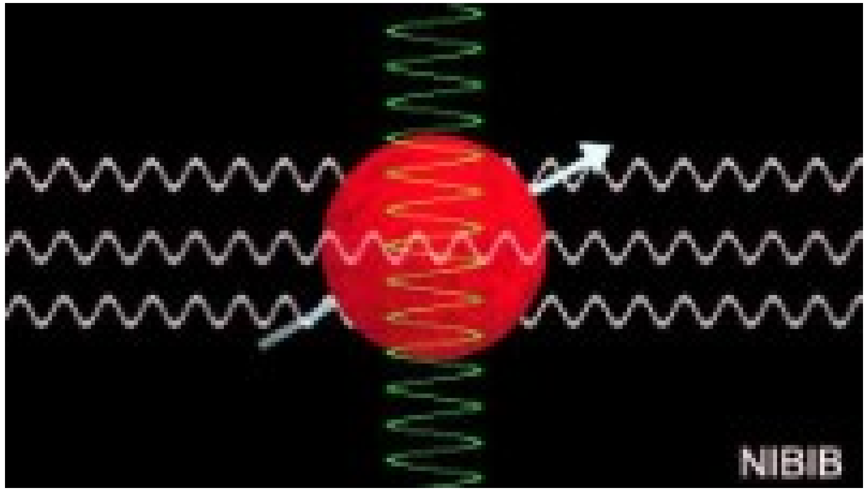
CNN model

Project Workflow

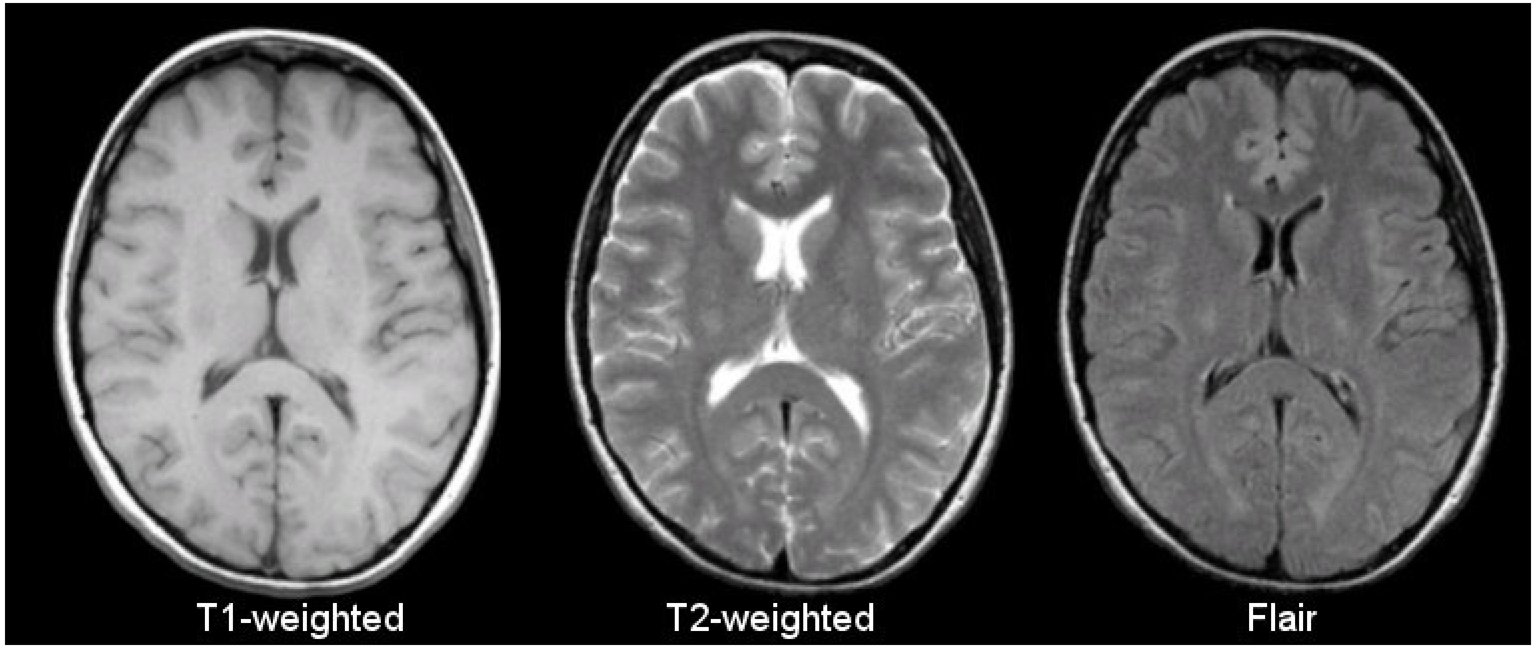
- Understand and preprocess your dataset
- Build the model
- Train the model
- Find the optimal hyperparameters
- Evaluation

Brain MRI

- Non-invasive imaging technology
- Produce three dimensional detailed anatomical images
- Used for disease detection, diagnosis, and treatment monitoring



Brain MR Images

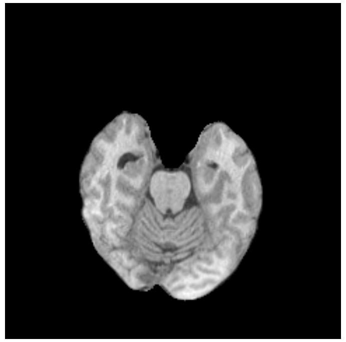


Different MRI sequences

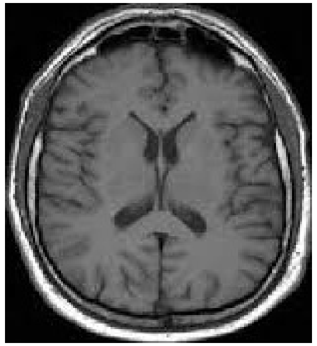
Classification Dataset

- 5391 images are given to you for training and testing the model.

- All the images have been preprocessed for you for better training result.



Brain image with tumour

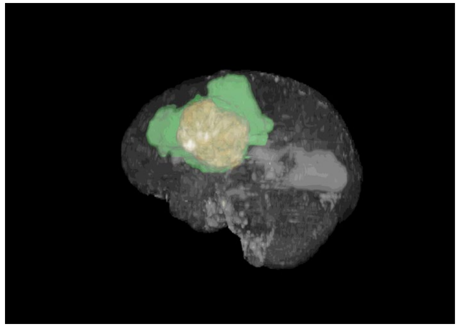


Brain image without tumour

Segmentation Dataset

- 251 MRI volumes and segmentation maps are given to you for training the model. Around 100 volumes will be given to you on 19th August for testing your model.

- All the MRI volumes have not been preprocessed.

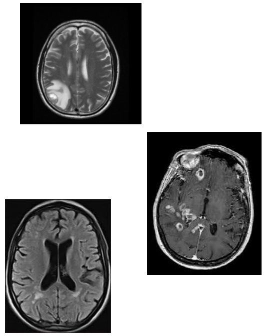


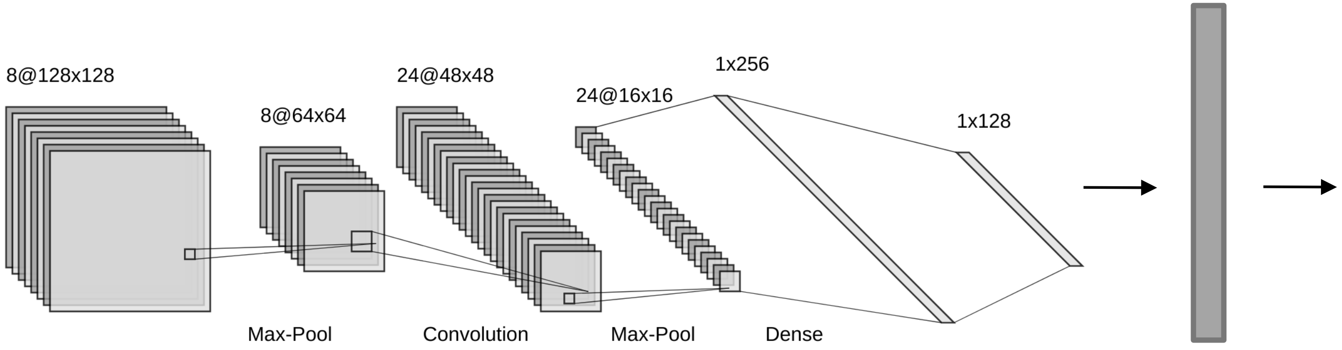
Brain tumour in 3D

Data preprocessing

- Denoise
- Standardise images (resize, normalisation, etc)
- Data augmentation (rotation, sheer, scale, etc)

Build the classification model





Probability
$p \in (0,1)$

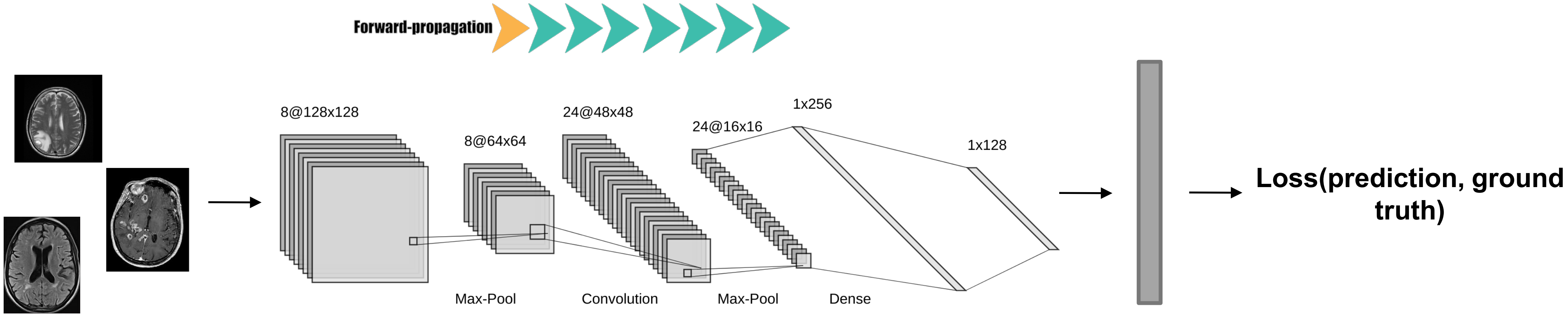
Preprocessed dataset

CNN-based backbone model for feature extraction (VGG16, AlexNet, ResNet, etc)

Classifier

Output

Train the classification model



Preprocessed dataset

CNN-based backbone model for feature extraction (VGG16, AlexNet, ResNet, etc)

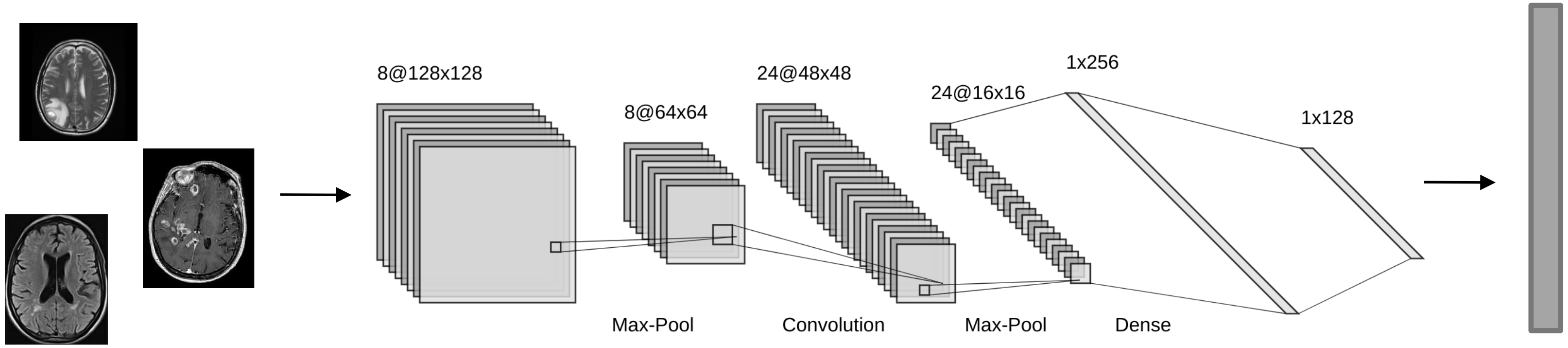
Classifier

Training loss

Improve the accuracy of the prediction

- Choose the right augmentation methods to tackle the overfitting problem;
- Find the best backbone model;
- Choose to finetune the model or train it from the scratch;
- Set the number of epochs to train the model and early stopping criteria;
- Tune other hyperparameters to achieve the best performance.

Test the classification model



With tumour (1)
or
without tumour (0)

Test data

CNN-based backbone model for feature extraction (VGG16, AlexNet, ResNet, etc)

Classifier

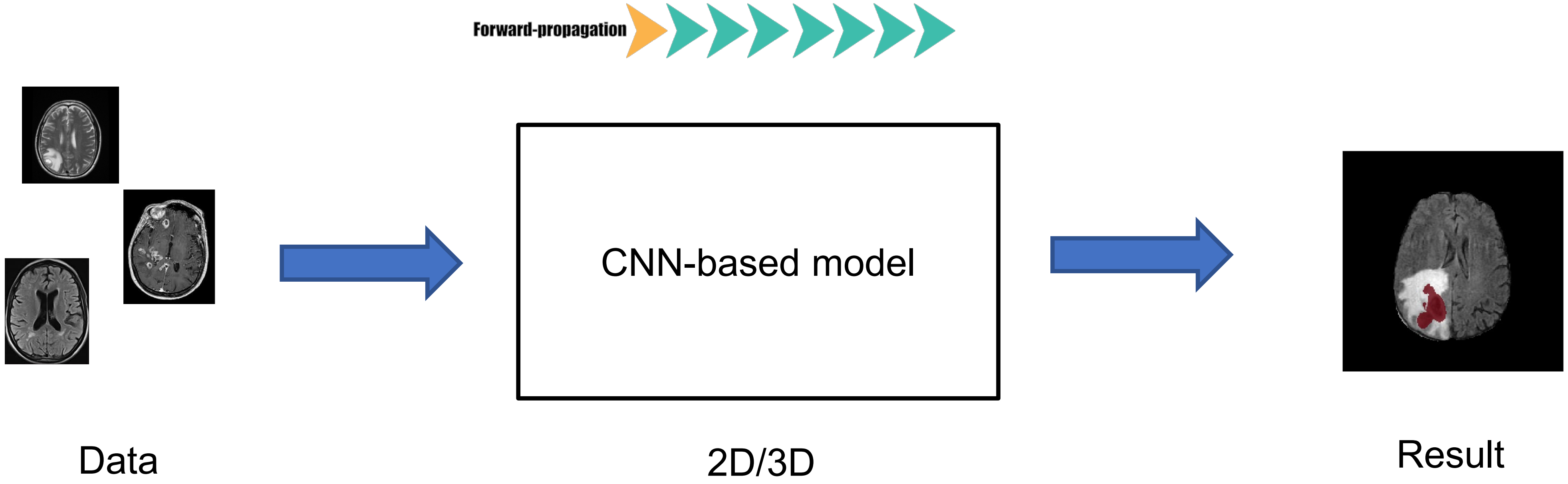
Result

Result evaluation

Accuracy is used to evaluate the performance of your classification model, which is defined as

$$Accuracy = \frac{Number\ of\ correctly\ classified\ images}{Number\ of\ total\ images} \times 100\%$$

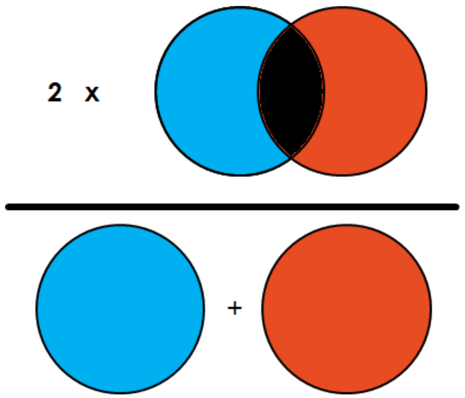
Segmentation model



Result evaluation

Dice score is used to evaluate the performance of your segmentation model, which is defined as

*Dice score = (2 * Area of Overlap)/(total pixels combined)*



Blue: Ground Truth
Red: Prediction

Source: https://towardsdatascience.com/metrics-to-evaluate-your-semantic-segmentation-model-6bcb99639aa2

Agony of choice

- Model architecture: depth, width, scales, residuals,…
- Loss function: (weighted) cross-entropy, IoU, Dice,...
- Sampling strategy: equally per class, fore/background, uniform,...
- Optimization: optimizer, learning rate, momentum, regularization,…
- Data normalization/standardisation: z-score, bias field correction, histogram matching,...

Setting Up Python Development Environment

Anaconda Installation (2020.02)
https://repo.anaconda.com/archive/

For using Nvidia GPU
https://github.com/antoniosehk/keras-tensorflow-windows-installation

Packages:
Tensorflow
Scikit-learn
SimpleITK