OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

INF

FAKULTÄT FÜR INFORMATIK

Scientific Team Project:

COVID-19 prediction on Chest X-Rays using Interpretable Machine Learning

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Introduction, Background and Motivation

- The COVID-19 or the SARS-CoV-2 originated from the district of Wuhan, China has transpired to be a pandemic worldwide [1].
- Due to shortage and limited efficiency of testing mechanism through RT-PCR test kits [2], it motivated the possibility of diagnosing patient being COVID-19 positive or negative based on Chest X-Rays (CXRs) and CT-Scans.
- This is also a highly active topic among artificial intelligence community and this motivated to involve Machine Learning and Computer Vision methodologies in application.

Problem Statement

- Our research experiment, tries to predict COVID-19 on CXRs with Interpretable Machine Learning Models and tries to explain the predictions.

  - How well could classifiers perform on Chest X-Rays?

  - Although state-of-the-art approaches extensively works with Neural Networks (Black-Box Model) to classify, Can simple and intrinsically explainable classifiers achieve a base Accuracy, F1-Score and AUC similar to state-of-the-art using CXR?

  - Can we come up with explanation of our model's decision and prediction?

  ➢ We aim to build a pipeline that on given CXRs predicts whether the image is a COVID-19 +or- based on 14 radiological features [3 , 4] and explains it based on it's contribution to prediction.

State-of-the-art literature review

Reference	Image Type	Machine Learning Techniques Used
Brunese, Luca, et al.	CXRs	VGG16, GradCam
Wang, Linda, et al.	CXRs	COVIDNet, VGG19, ResNet15
Zhang, Jianpeng, et al.	CXRs	DeepCNN, Anomaly Detection
Wu, Yu-Huan, et al.	CT	VGG16, Unet, DSS, EGNet, PoolNet
Kassani, Sara Hosseinzadeh, et al.	CXRs and CT	CNN Deep Features with Decision Tree, Random forests, XGBoost, AdaBoost, Bagging Classifier, LightGBM
Pereira et al.	CXRs	Multi-class classification using k-Nearest Neighbots (kNN); Support Vectors Machine (SVM); Multilayer Perceptrons (MLP); Dicision Trees (DT); and Random Forests (RF)
Chatterjee, Soumick, et al.	CXRs and CT	Techniques Surveyed: ResNet18, ResNet34, InceptionV3, InceptionResNetV2, DenseNet161

Table 1. State-of-the-art literature-review: Similar approaches

Previous Approach : Pipeline

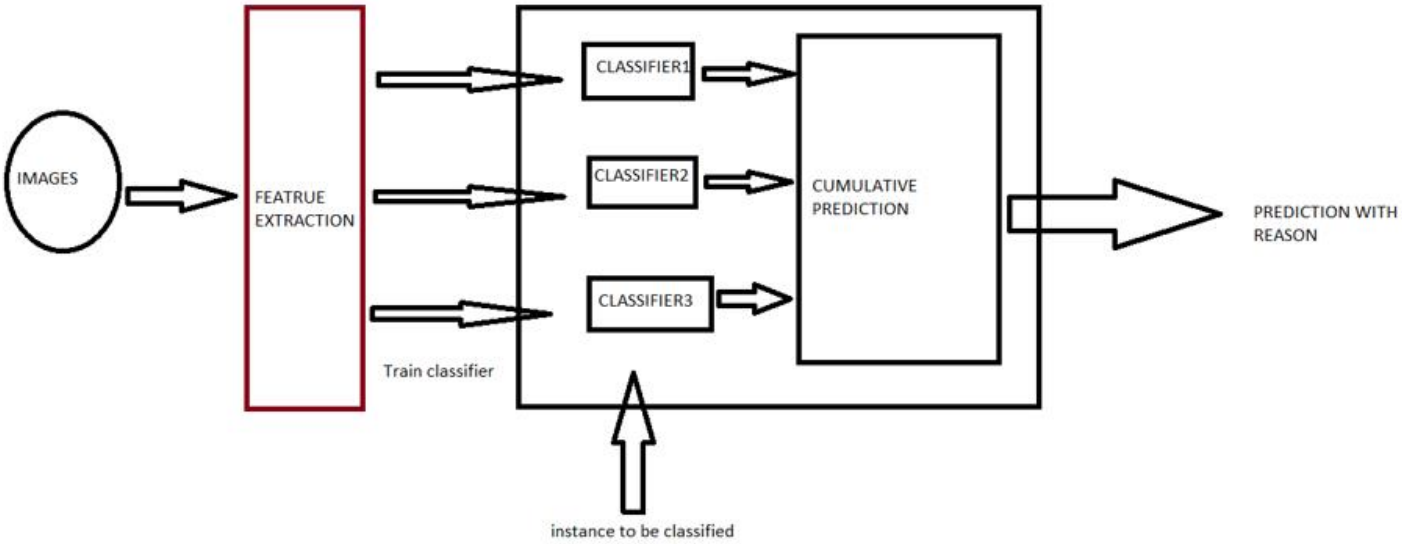


Figure 1 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

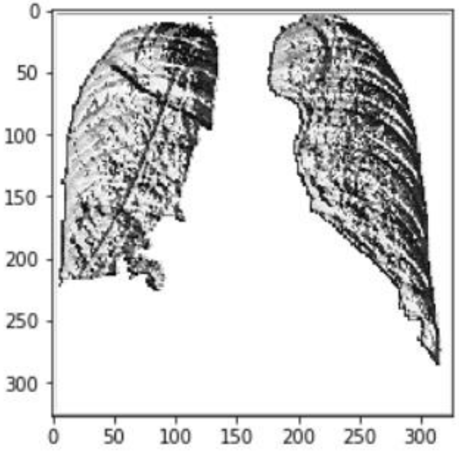
Previous Approach: Pre-processing

Region of Interest: Masking and Segmentation of Lungs

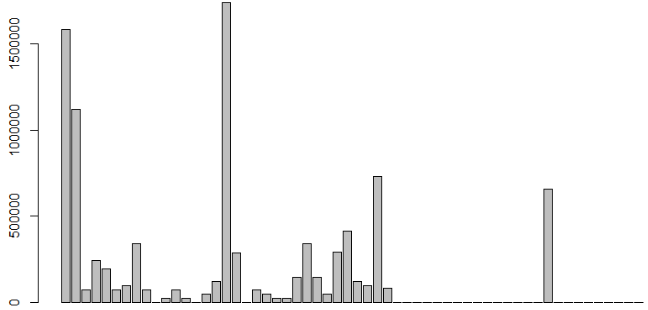
Figure 2 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

Feature Extraction: Local Binary Patterns

X-Ray Image



LBP Image



LBP Histogram

Figure 3 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

Previous Approach: Benchmark Comparison

Study	Type Of Image	No. Of Cases	Method Used and Settin	Accuracy
Sethy and Behra	Chest X-ray	25 COVID-19(+) 25 COVID-19 (−)	ResNet50+ SVM	95.38
Hemdan et al.	Chest X-ray	25 COVID-19(+) 25 Normal	COVIDX-Net	90.0
Narin et al.	Chest X-ray	50 COVID-19(+) 50 COVID-19 (−)	Deep CNN ResNet-50	98.0
Ying et al.	Chest CT	777 COVID-19(+) 708 Healthy	DRE-Net	86.0
Wang et al.	Chest CT	195 COVID-19(+) 258 COVID-19(−)	M-Inception	82.9
Zheng et al.	Chest CT	313 COVID-19(+) 229 COVID-19(−)	UNet+3D Deep Network	90.8
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Decision Tree with RAW Data	90.03
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Decision Tree with Oversampled Data	69.05
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Random Forest with RAW Data	91.69
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Random Forest with Oversampled Data	79.17
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	kNN with RAW Data	90.62
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Logistic Regression with RAW Data	90.34
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	Naive Bayes with RAW Data	87.0
Our Study	Chest X-ray	1000 COVID-19(-) 201 COVID-19(+)	SVM with Oversampled Data	54.73

Figure 4 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

Previous Approach: Explanation using LIME

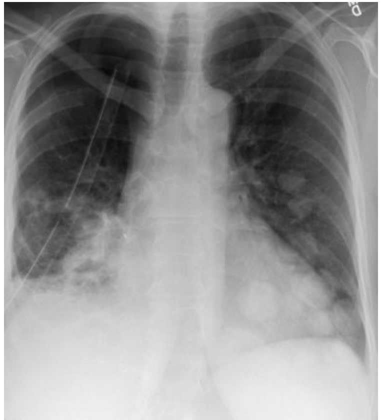


Figure 5 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

New Approach

- Research Questions:
  - Comparison Study of Radiological features, with respect to Local Binary Pattern based approach as baseline.
  - Interpretability study based on the SHAP approach.

New Approach: Dataset

- Our Dataset consists of 1000 COVID negatives and 313 COVID positives

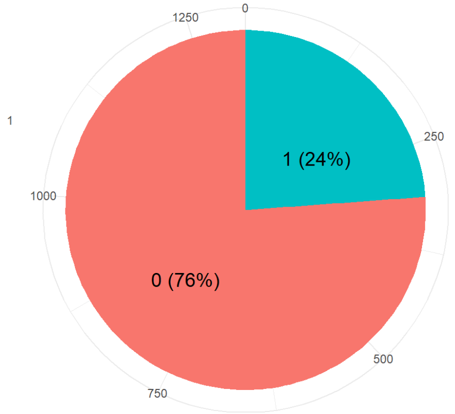


Figure 6 Source: https://jalajvora.github.io/COVID-19-predictions-on-Chest-X-Rays-using-Interpretable-Machine-Learning/

New Approach: Assumption

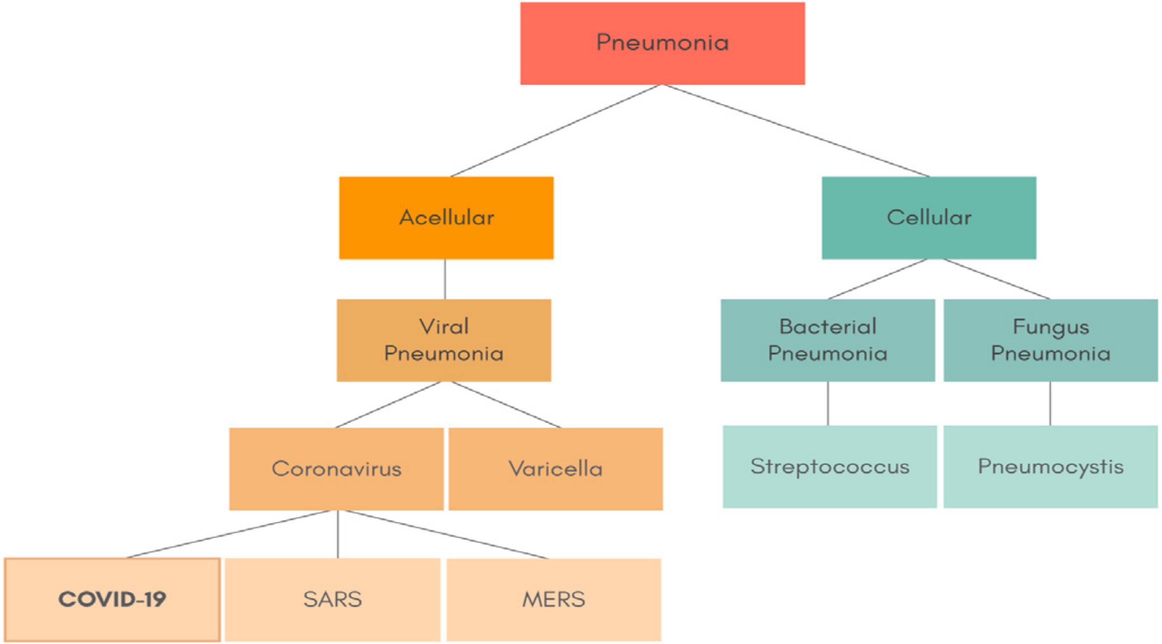


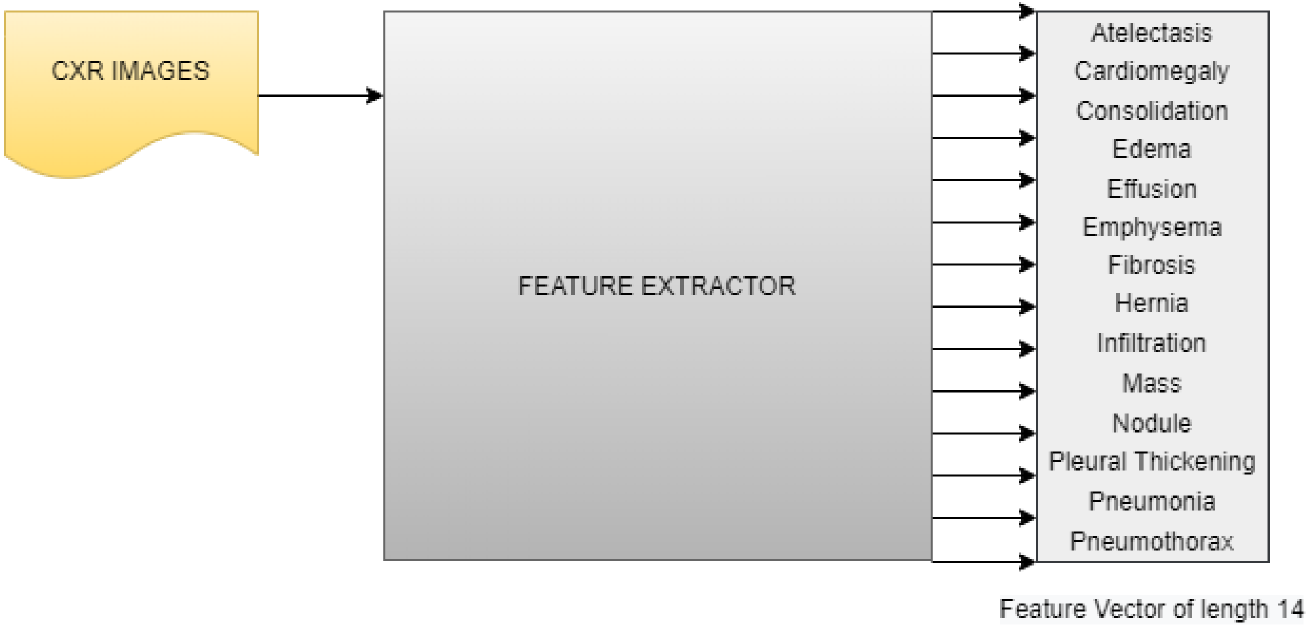
Figure 7 Source: Peirara et. Al. [20]

New Approach: Radiological Features

These 14 radiological features are namely:

- Atelectasis
- Cardiomegaly
- Consolidation
- Edema
- Effusion
- Emphysema
- Fibrosis
- Hernia
- Infiltration
- Mass
- Nodule
- Pleural Thickening
- Pneumonia
- Pneumothorax

New Approach: Pipeline



New Approach: State-of-the-art literature review - Feature Extraction

Reference	Image Type	Machine Learning Techniques Used
Nanni et al.	Neonatal facial, fluorescence microscope and smear cells images	LBP, LPQ, EQP, LTP, EBP, ILBP CSLBP and SVM
Parveen and Sthik	CXR	DWT, WFT, WPT and fuzzy C-means clustering
Scalco and Rizzi	CT, PET and MR	Grey-level histogram, GLCM, NGTDM, GLRLM and GLSZM
Zhou et al.	CT	YOLOv3, VGGNet and AlexNet
Narin et al.	CT	ResNet50, InceptionV3 and Inception-ResNetV2
Wang and Wong	CXR	COVID-Net a deep neural network created to detect NCP
Khan et al.	CXR	CoroNet a CNN created to detect NCP
Ozturk et al.	CXR	DarkNet and YOLO

Table 2 State-of-the-art-literature-review: Feature Extraction

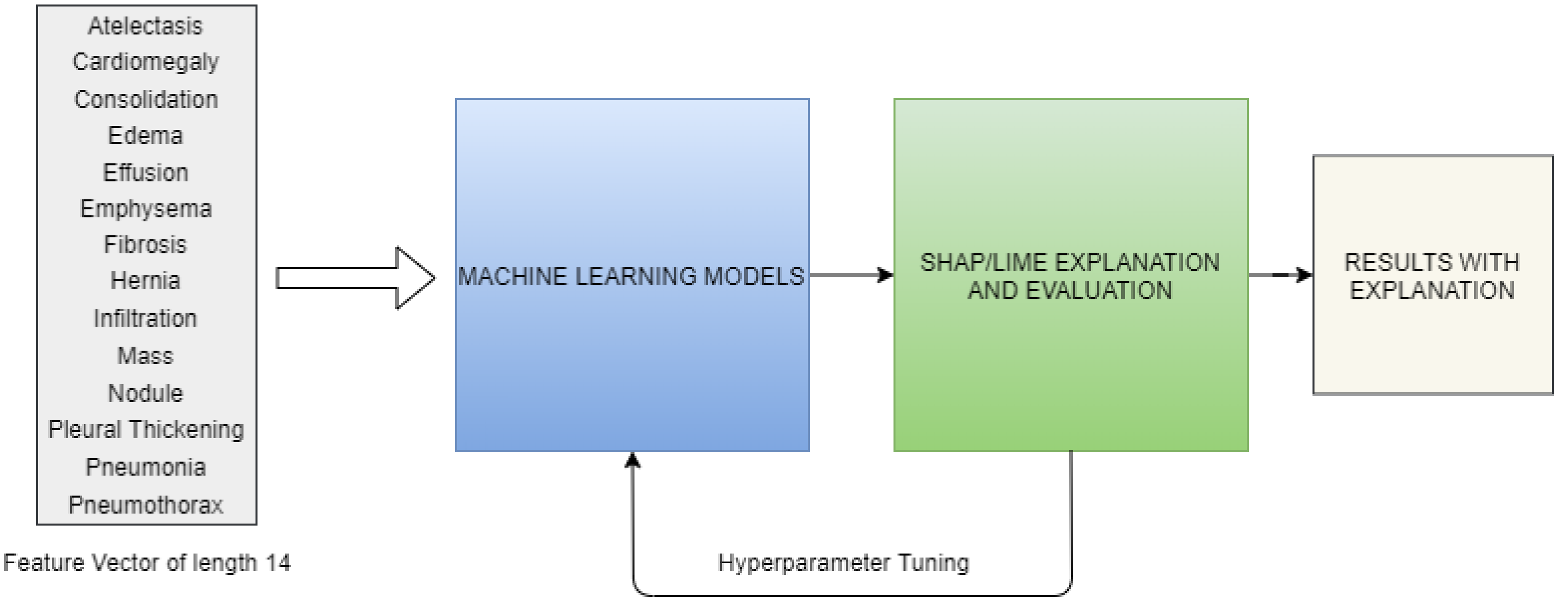
New Approach: Feature Extraction - Observations

- More emphasis on automatic learning of features represented as features via hidden layer representation (Narin et. al.)

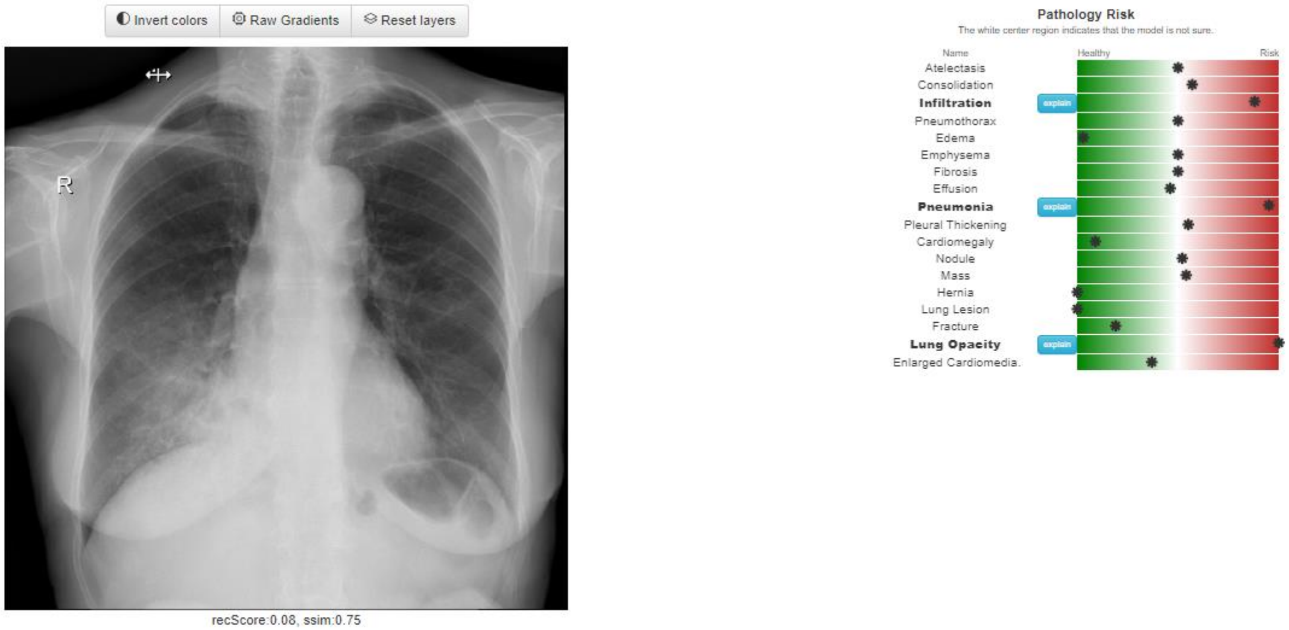
- In case of handcrafted features, (for example used in Nanni et. al.) more than one kind of descriptor is used with core aim of classification (and Not Explanation).

- Radiological feature extraction and usage of such explicitly for learning is rarely studied in the community. The added advantage is that, the same helps in explanation to medical domain personnel.

New Approach: Architecture



New Approach: UI/UX Design (tentative)

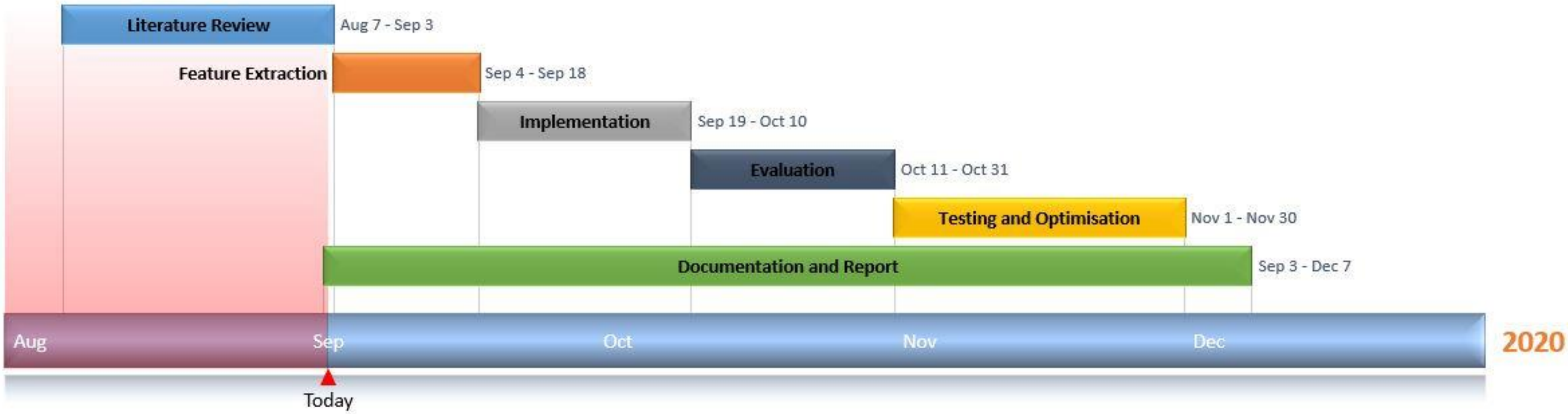


Evaluation

Factors based on which performance of models would be determined:

- F1-Score
- AUC/ROC
- Accuracy

Project Timeline



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Thank You!

Questions?