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COVID-19 Detection from Imbalanced CT scans dataset using RESNET50 & XCEPTION CNN Models

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Abstract:With the advent of the global corona virus pandemic induced by the "novel SARS-CoV-2 (severe acute respiratory syndrome corona virus 2)", detection of COVID 19 become one of the prime challenges in order to mitigate the adverse effects. Recent studies reveal that a Radiological examination is an effective approach for detecting COVID 19. CT scans of patients can be analyzed using convolution neural network models to discover covid-19.Almost majority of the datasets available today suffer from Class imbalance where the instances of one class are predominant over the other classes. Sufficient sample is required for the model to run. In our proposed system methodology, The Class imbalance problem is identified and addressed in this aspect and their results are compared with the Class Weighted Approach models. Prebuilt CNN Architectures namely, RESNET50 and XCEPTION Models are employed and their accuracies are found to be 85.71 and 74.12 respectively. These models are further employed with Class weighted approach to reduce the class imbalance between COVID and NON-COVID files and their accuracies are increased to 87.06 and 81.67 respectively.

Index Terms **– COVID-19, Convolution neural networks (CNN), RESNET50, XCEPTION, CLASS WEIGTED APPROACH,Computed-Tomography (CT) scan.**

I. INTRODUCTION

The world is undergoing tremendous changes under this new normal. Right from education to administration, Health of people to the Wealth of the economy all underwent huge losses. It is said that "Health is Wealth." Following the same, this project contributes to the theme of predicting and detecting COVID-19, infectious disease that is caused by the virus, SARS-CoV-2. The outburst of the corona virus in early December 2019 in the China has grown worldwide. This pandemic challenges clinical systems globally in multiple views that include sharp rise in requirement for beds in hospital and equipment shortage, while most medical persons are infected. Thus, the efficient usage of medical resources is vital. An effective screening approach enables a fast and optimized COVID-19 detection and can reduce the additional demand on healthcare systems.As a need of the hour, we focus on predicting and detecting COVID-19 using the practices of Machine learning like CNN (Convolution Neural Networks)

1.1 MACHINE LEARNING

This is a view of teaching robots to learn and build their own programs in order to make their behavior and decisions more human-like. This is done with as little human interaction as possible, i.e., no human intervention is necessary. It is one of the part in Artificial Intelligence. Based on how robots' experiences, the learning process is automated and improved over time. To build or construct machine-learning models, the computers are given high-quality data and several methodologies. The type of data and the job to be automated dictate the algorithm to utilize.

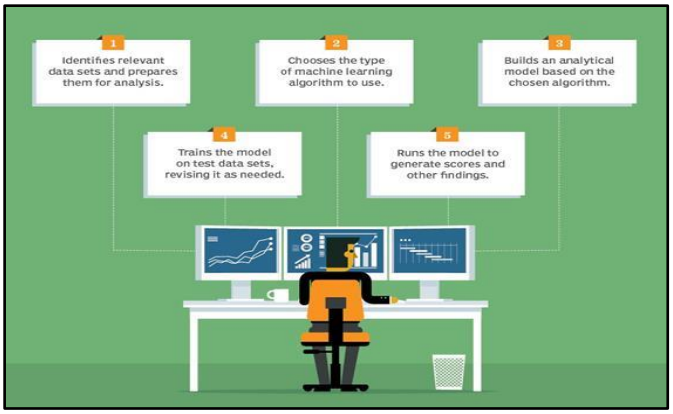


Fig-1: Machine learning

1.2 TYPES OF MACHINE LEARNING

1.2.1 SUPERVISED LEARNING

It is a variation of machine learning where computers train to give outcomes using labeled training data. As evidenced by the labels, a portion of the input has already been given the appropriate output. In supervised learning, the training data provided to the computers functions as a supervisor, teaching the machines on predicting the outputs correctly. It operates in the similar way that a student taught under the assistance of a tutor. Models were taught by usage of labeled data in the supervised learning, and the model reads about every single category in the input. The model is evaluated using test data, which is a part of the training dataset, and it estimates the outcome once the training phase is done.

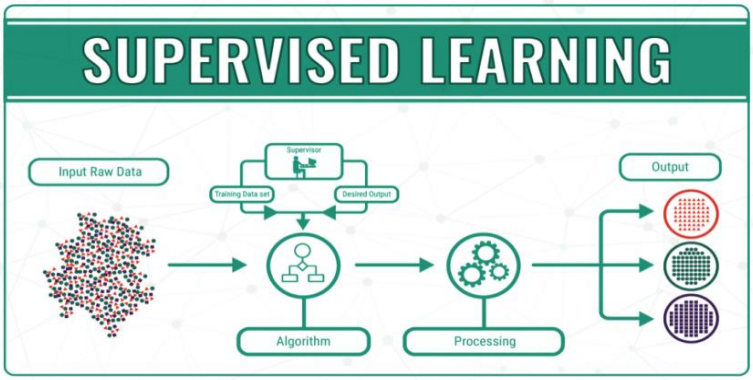


Fig-2: Supervised machine learning

1.2.2 UNSUPERVISED LEARNING

Unsupervised learning is also a part of ML where the models were trained on unlabeled data and permitted to operate on it with no guidance. The ability to deal with unlabeled data benefits unsupervised machine learning. When none of human inference was wanted for doing the dataset machine readable, computer may handle remarkably bigger dataset. The supervised learning, labels will help the algorithm to determine the essence of any link that exists between two data points. Besides, unsupervised learning has shortage of labels, leading the format of the hidden structures. The application detects connections between the data points abstractly, without help of human. Unsupervised learning algorithms may dynamically alter the data modifying remote systems in place of predetermined and a fixed problem statement.

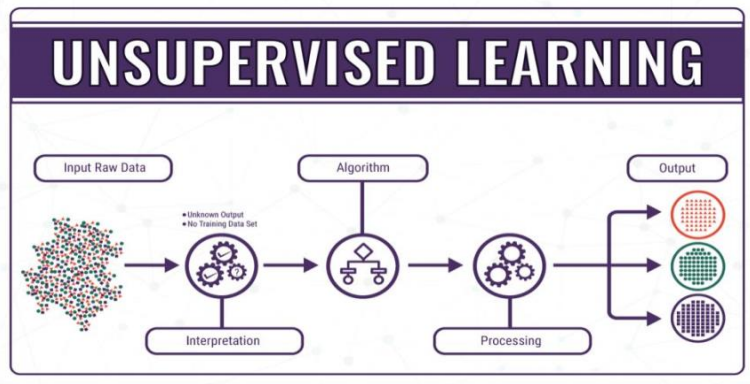


Fig-3: Unsupervised machine learning

1.2.3 REINFORCEMENT LEARNING

It's subsection to machine learning. It was about getting suitable actions for maximizing the raise in whichever situation. Number of applications and machines utilize for figuring out the finest in a particular situation of a viable action or path. Reinforcement learning differs with supervised learning within this supervised learning contains the required key, enabling its system is also being taught by the true answer, whereas the reinforcement learning will not, relying rather on the reinforcement agent for choosing how to complete the work. The absence with this training dataset, it is designed for learning from its own mistakes. Reinforcement learning is based on cognitive idea of conditioning and involves implementing the algorithm in a work-environment, complete with an interpreter and a reward system.

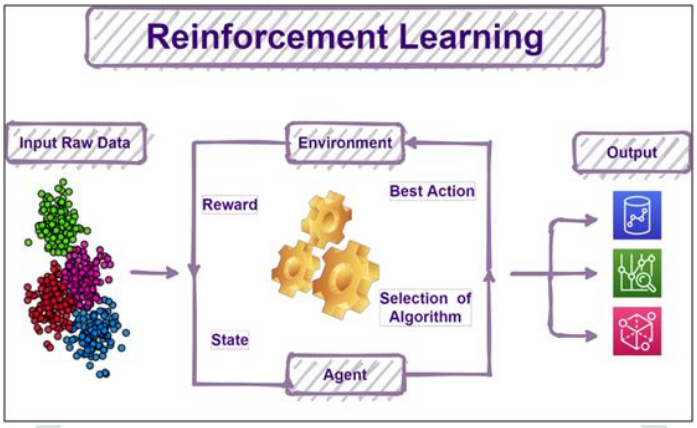


Fig-4: Reinforcement machine learning

1.3 NEURAL NETWORKS

Neural networks were systems which resembles neural networks of biological. Without any job rules, these systems learn to do tasks by being exposed to various datasets and examples. The concept is that instead of being programmed with a pre-coded understanding of these datasets, the system derives identifying traits from the data it is given.

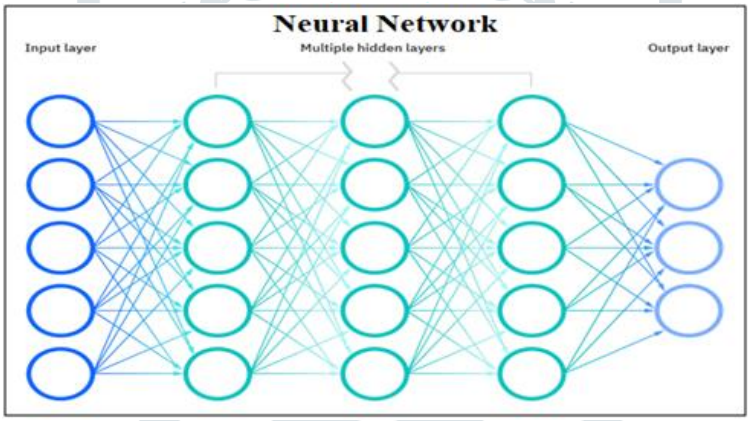
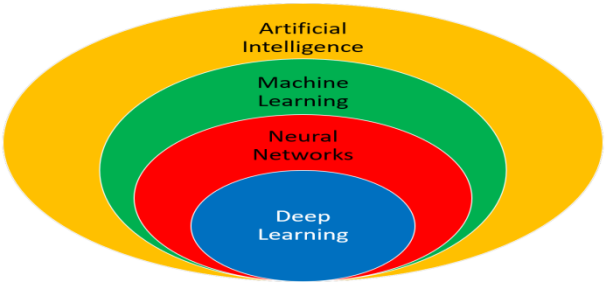


Fig-5: Neural Network

A node layer in ANN is made up of input layer, one or more hidden layers, and an output layer. Each-and every node is connected for others and has its own weight and threshold. When a node's output reaches a certain level, it will activate and the data will be sent for following one in network. Other than none of the data will be directed for the network's next layer. In deep learning models, artificial neurons were nodes which allow information as well as operations to pass over them. They are fed one or more signals. These input signals might originate from a previous neural net layer's raw data collection of neurons

1.4 DEEP LEARNING

Deep learning is a branch under neural networks. The neural networks try to emulate functions done by a brain through corresponding the capacity for getting taught by massive data. Whereas single layer neural networks can make predictions by addition of more than one hidden layer that helps to increase accuracy.



Deep learning techniques improves with more dataset is collected However empty learning type of approach. Algorithms of Machine Learning that plateau as given standard of the presentation when many instance and training datasets were combined with network is **Fig-6**: Deep Learning

Called as learning empty. Data in a structured format is required by most machine learning algorithms. In contrast, Deep Learning models can operate with both organized and unstructured data because they depend on the artificial neural network layers. A deep learning model's problem-solving method differs from that of a machine learning model in that it accepts input for a problem and creates the final result. Hence it follows the end-to-end approach.

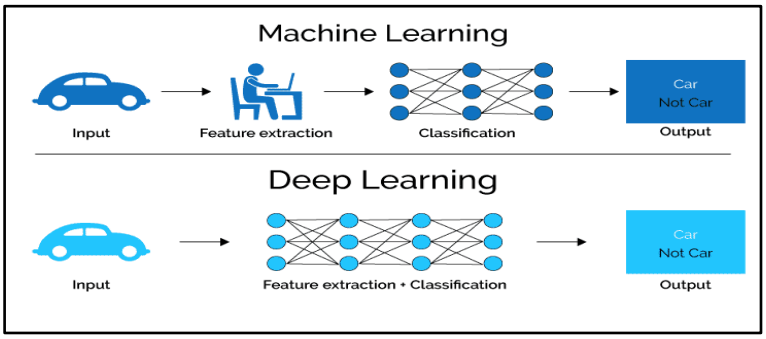


Fig-7: Machine & Deep Learning

Deep learning is one of the few methods for solving feature extraction issues. This is because, with little input from the programmer, deep learning models may learn to focus on the excellent features. Deep learning, in essence, works in the same manner that the human brain does. That is, it learns from experience. As like the brain is built up of billions of neurons that allow doing unique tasks.

As a result, Deep Learning overcomes Machine Learning's disadvantage by concluding a data set.

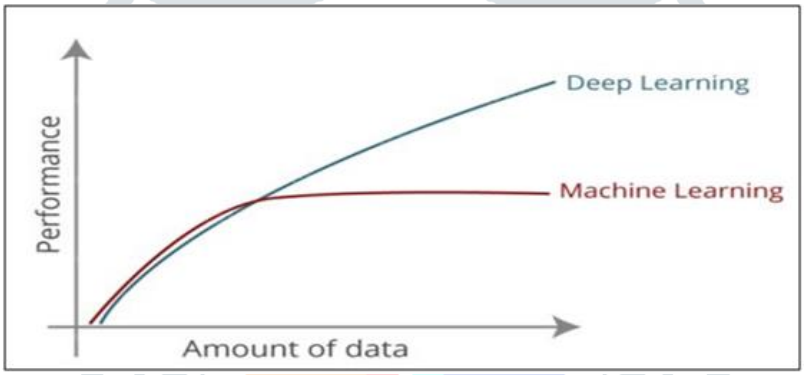


Fig-8: Machine & Deep Learning

1.5 CONVOLUTIONAL NEURAL NETWORKS

A convolution neural network (CNN) is a kind of artificial neural network employed in deep learning for evaluating visual information. CNNs are excellent at detecting design elements in input images, such as gradients, lines, circles, and even eyes, ears and faces. Because of this feature of convolutional neural networks, they are so effective in the field of image analysis. CNN does not require any preprocessing and may run straight on an underdone image. CNN comprises of multiple convolutional layers piled on top of each other, each capable of identifying increasingly complex structures. These are among the most commonly utilized varieties, particularly in image recognition. This particular neural network technique has been employed in many of the most advanced AI applications, such as facial recognition, text digitization, and natural language processing.

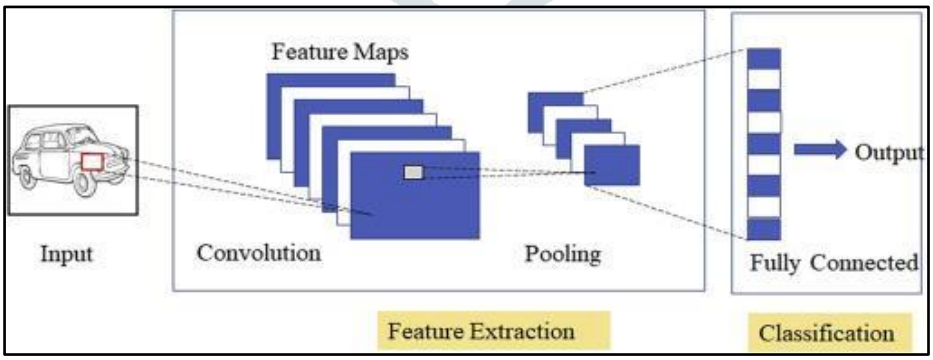


Fig-9: Convolutional Neural Networks

There are three Convolution Neural Networks layers used which are Convolution, Pooling and Flattening.

1.5.1 Convolution

It is a mathematical operation between the original picture / other feature map and a kernel. It is a process that helps the neural network to extract the features from data. Vital characteristics include kernel size and number of filters.

1.5.2 Pooling

Pooling layer is analogous to the convolutional layers and is frequently employed for dimensionality reduction. Various pooling functions include max pooling, min pooling and average pooling that take maximum, minimum and average respectively values in a specific kernel region.

1.5.3 Flattening

The 2-Dimensional arrays which are generated from feature maps after pooling are flattened into a long contiguous linear vector. To identify the picture, the flattened matrix is input to the fully connected layer.

1.6 CNN ARCHITECTURES

1.6.1 RESNET50

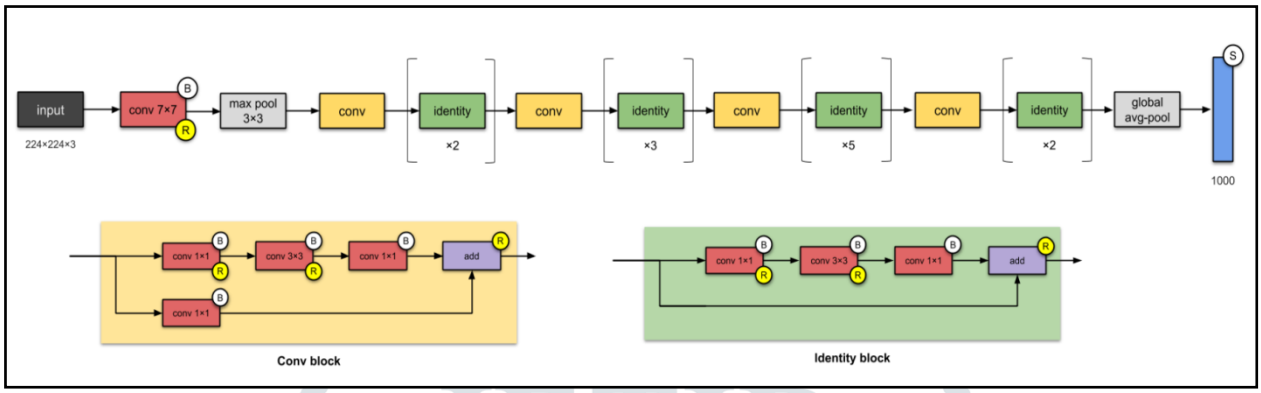


Fig-10: RESNET50 MODEL CNN ARCHITECTURE

RESNET50 is a Convolutional neural network that is 50 layers deep. This Variant of ResNet model has 48 Convolution layers along with 1 MaxPoolinglayer and 1 Average Pooling layer. It can load a pretrained version of the network trained on more than a million images from the ImageNetdatabase.A building block of a ResNet is called a residual block or identity block. A residual block is simply when the activation of a layer is fast-forwarded to a deeper layer in the neural network.

1.6.2 XCEPTION

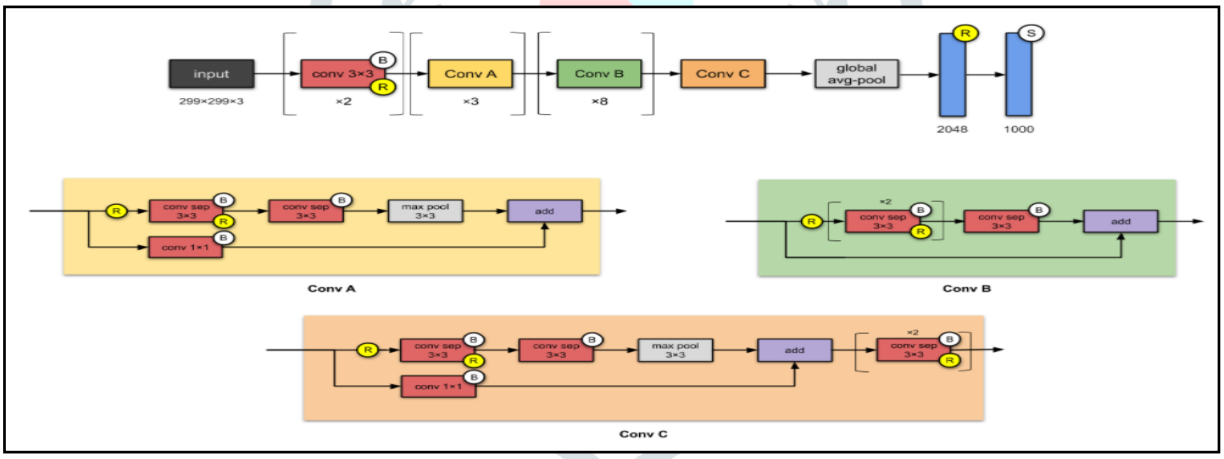


Fig-11: XCEPTION MODEL CNN ARCHITECTURE

XCEPTION is aConvolutional neural network that is 71 layers deep that has 36 Convolution layers along with 1 Average Pool layer. It Can load a pretrained version of the network trained on more than a million images from the ImageNet database.
It has linear stack of depthwiseseperable convolution layers with residual connections.

1.7 COVID-19

COVID 19 is caused by SARS-CoV-2, a severe acute respiratory syndrome corona virus 2 that was never detected in human beings before December 2019. SARS-CoV-2 is a worldwide unique contagious and fatal disease. Corona viruses get their name from their view: "corona" means "crown" in Spanish. Spike proteins cover the virus's outer layers, forming a crown around them.

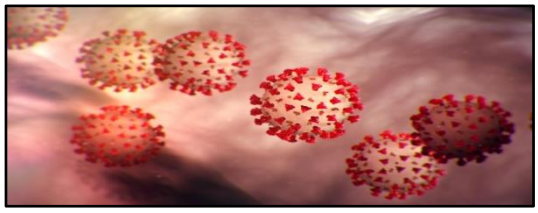


Fig-12: Corona Virus

The majority of people who get the covid virus will have mild to moderate respiratory symptoms and will recover on their own. Some people, though, will grow ill and require medical assistance. People over the age of 60, as well as those suffering from underlying medical conditions such as chronic lung disease, diabetes, or cancer are at a higher risk. COVID-19 has the potential to make anyone sick or kill them, regardless of their age. Mostly, infected people have mild respiratory symptoms and recover on their own. However, some people are infected chronic and require medical assistance.

1.7.1 COVID-19 VARIANTS

Viruses develop over time and will continue to evolve as they spread, such as SARS-CoV-2. Virus variants can appear from time to time. A variant is a virus that differs in at least one manner from the original virus.

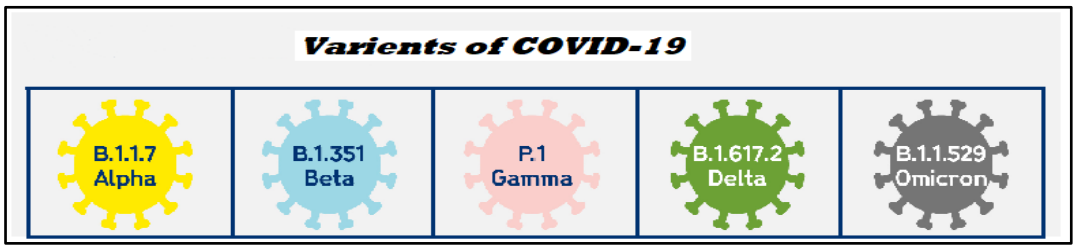


Fig-13: COVID-19 Variants

1. Alpha
2. Beta
3. Gamma
4. Delta
5. Omicron

1.7.2 HISTORY OF COVID-19

The Novel Corona Virus Disease outbreak, originated in seafood market in Wuhan city of the China, in the end of 2019. It has already spread to 215 nations, territories, and places globally. On 1 sty December 2019, the first COVID-19 case was identified, and the cause was a new coronavirus known as COVID. According to researches, SARS CoV2 might have initiated in animals and evolved as a human disease. Viruses that began in birds, pigs, bats, and other animals and spread to humans have been connected to a number of infectious disease epidemics. More sophisticated study is needed to identify how and why the coronavirus developed the ability to cause pandemic illness.

1.7.3 COVID-19 TRANSMISSION

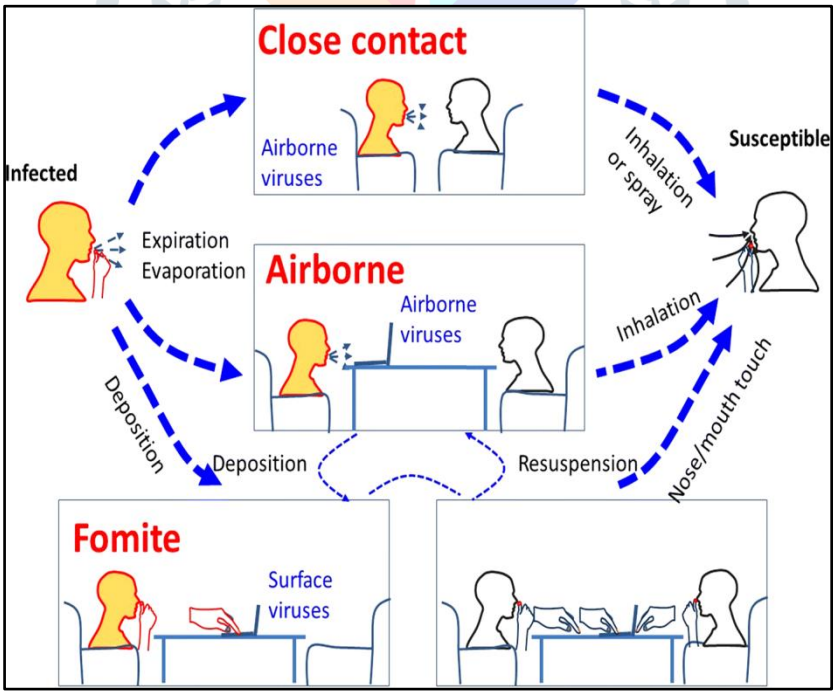


Fig-14: COVID-19 TRANSMISSION

1.8 CLASS IMBALANCE

In the dataset, we usually undergo scenarios where the number of observations belonging to one class is significantly higher than those belonging to the other classes.This scenario is referred as class imbalance or data imbalance. “Machine Learning Algorithms are usually designed to improve accuracy by reducing the error. Thus, they do not take into account the class distribution / proportion or balance of classes. Most Algorithms work best when the samples in each class are almost equal. Class imbalance might fail to capture the minority class due to the high number of observations in the dominant majority class. Thus model will have low prediction accuracy for the infrequent class.”It has a negative impact on the overall performance of the model.

The dataset contains 1252 COVID class files and 602 NON-COVID class files.Clearly there is a class imbalance and COVID class is the Majority class while NON-COVID class is the minority class.

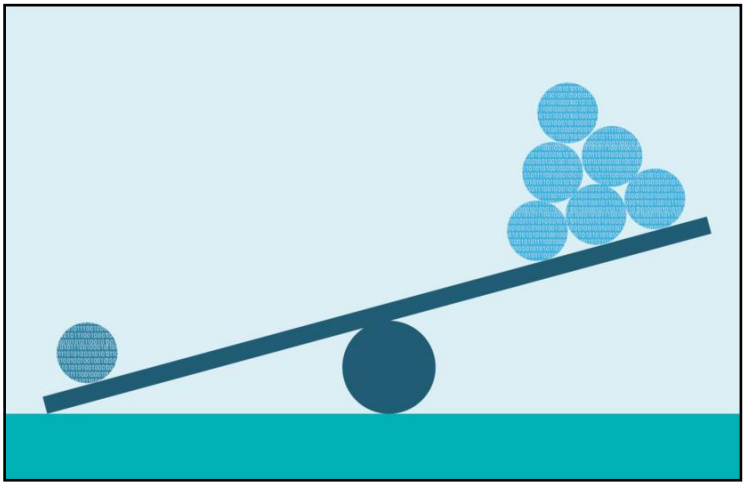


Fig-15: Class imbalance

1.9 CLASS WEIGHTED APPROACH

Anefficient way to overcome from the effects of Class imbalance problem.When confronted with skewed class data, most deep learning algorithms are useless. However, we may modify the current training technique to account for the skewed distribution of the classes. This may be performed by varying the weights assigned to the majority and minority groups. During the training phase, the weight discrepancy will influence class classification. The overarching purpose is to penalize the minority class for misclassification by increasing class weight while lowering class weight for the majority class.

The products with the number of classes and count of instances of each class are calculated and this product is used as a weight for training. Our dataset has two classes namely COVID and NON-COVID. So the number of classes is two. The number of instances in COVID and NON-COVID class are 1252 and 602 instances respectively. In this way class weighted approach is implemented by giving more weight to minority class and less weight to majority class.

$$W_{n,c} = \frac{1}{Number\ of\ Samples\ in\ Class\ c}$$

Fig-16: Weight Calculation in Class Weighted approach

II. PROPOSED METHODOLOGY

3.1SYSTEM ARCHITECTURE

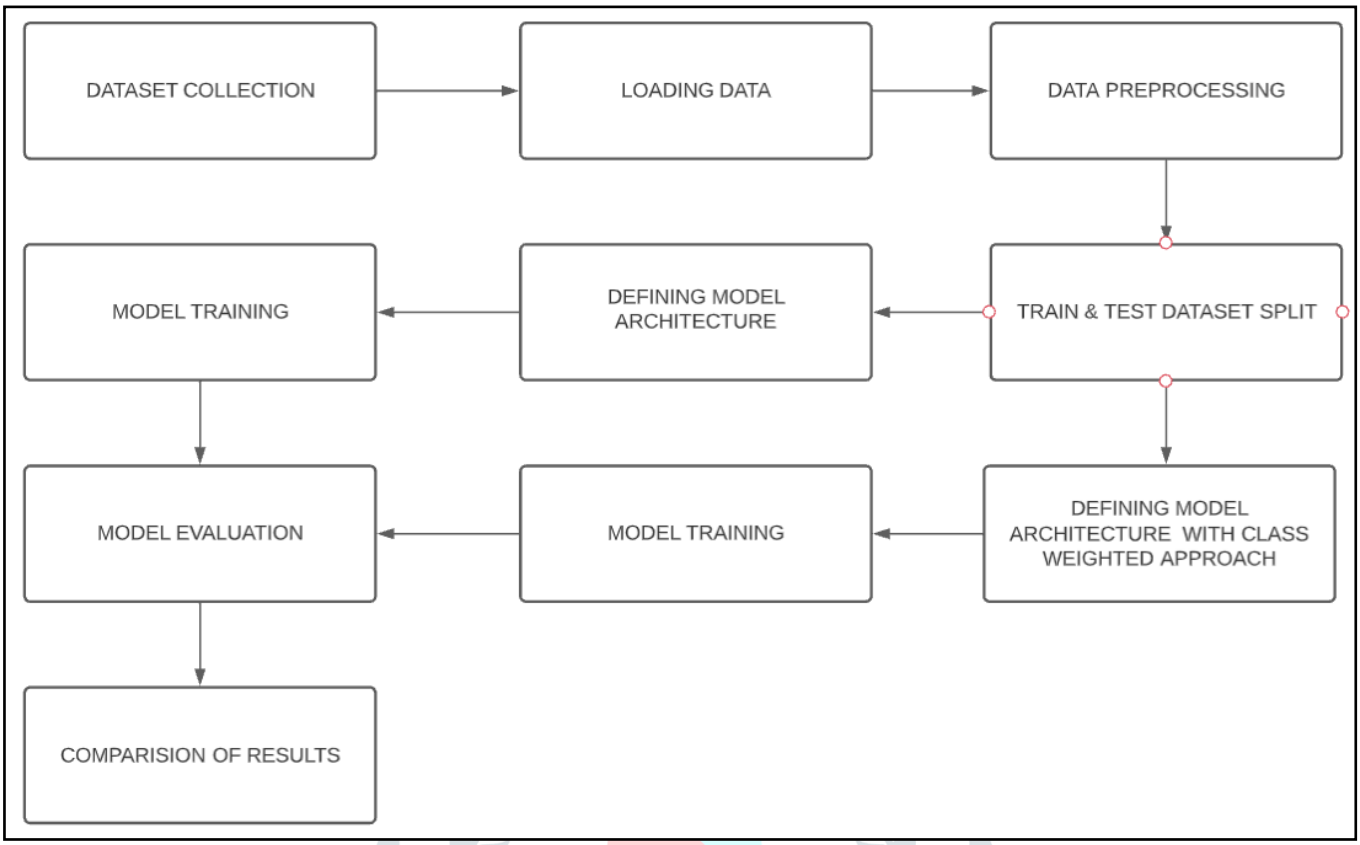


Fig-16: System Architecture

Firstly we collected the dataset and through inspection we found that there is class imbalance in the dataset. We loaded and preprocessed the data and then divided the data in training and testing datasets. The model architectures for RESNET50 and XCEPTION are then defined after train and test dataset split. The models are evaluated. The Models are then trained with the class weighted approach and the models are evaluated. The results of the model on the raw dataset and the models with Class weighted approach are compared.

III. RESULTS AND DISCUSSION

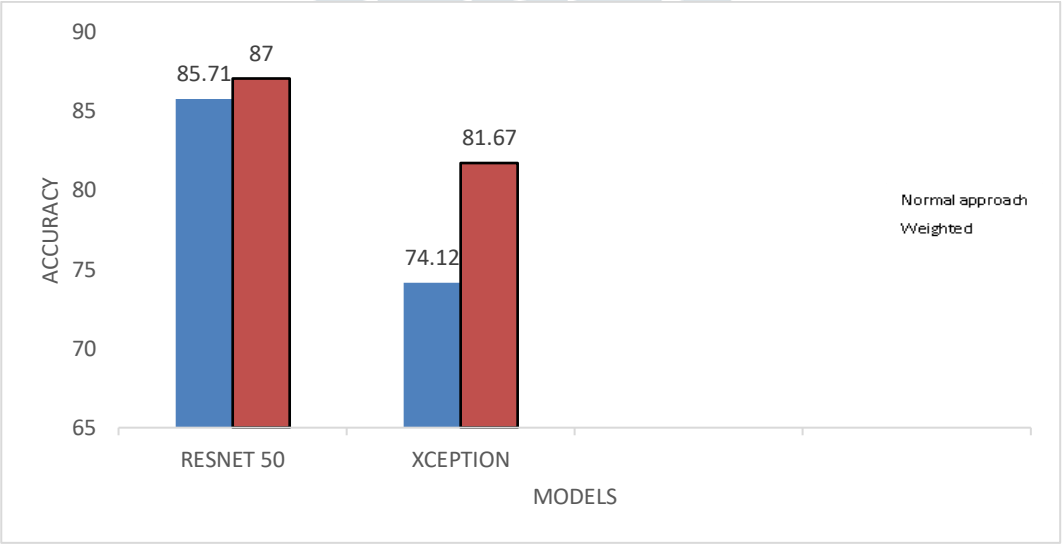


Fig-17: RESNET50 and XCEPTION Models with and without class weighted approach

MODEL || APPROACH	CLASS IMABALENCE (RAW DATA)	CLASS WEIGHTED
RESNET50	85.71	87.06
XCEPTION	74.12	81.67

Tab-1: RESNET50 and XCEPTION Models with and without class weighted approach

The raw dataset contains 1252 COVID files and 602 NON-COVID files. Clearly there is a class imbalance and COVID class is the Majority class while NON-COVID class is the minority class. The imbalanced dataset is trained with and without class weighted approach .The accuracy for RESNET50 and XCEPTION models on raw dataset with class imbalance are 85.71 and 74.12 respectively. These are further increased to 87.06 and 81.67 respectively. It is clearly evident that class weighted approach improved the accuracies. The results are tabulated as shown in Tab-1 and visualized as shown in the bar plot given by the figure 15.

iv. CONCLUSION AND FUTURE SCOPE

Numerous people remain undiagnosed due to a lack of efficient diagnosis equipment and personnel in developing and rural areas. Due to this, there is a significant variation between the number of actual and confirmed cases. Such emerging challenges are addressed. CT scans can detect COVID19 in the lungs that can replace the time-consuming viral and antibody test. In order to overcome the problems with covid-19 detection that include dataset overfitting and noise of a particular deep learning model for enhanced performance on COVID-19, This project employs three distinct CNN models for detecting COVID-19 from CT Scan image files. The models presented high levels of accuracy and optimized performance in terms of training time period.

This project can further be extended to an ensemble deep learning model with the three proposed models, which can also be federated across, and, in turn, data privacy can be achieved. Hence screening stage costs can be reduced greatly. A REST API can be made to this in order to make it more robust in nature. There are many chances of possibility of advancing this web application to a full standard application.

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