This lecture series would consist of a series of 20-22 lectures in which some basics and advanced topics of machine learning and deep learning. This series is based on the teachings of Andrew Ng, Stanford Online lecture series and Prof. Bin Yang.

To start of this series, it is very important to understand the basic difference between Signal Processing (SP) and Machine Learning (ML). They are related to one another, but they differ in a lot of ways. Both require a signal of some sort, an SP or ML rule to process that data and to provide a desired output. The input signal can be a 1D vector, 2D matrix like a BW image or a 3D tensor like a RGB image.

The main difference between SP and ML is that SP is a traditional model based rule which is a mathematical description of the input signal as a function of the desired or expected output signal or parameter or class; whereas ML is more learning-based or data-driven. In case of ML, the relationship between the input and output signals are very complex and cannot be defined using a mathematical signal model. They have to be learnt from signal.

When output signals are being talked about, there are various types of outputs based on applications. There are signal outputs like in digital filters or Fourier analysis, parameter outputs like radar detection, synchronisations. The last types of outputs are class like detection of targets in radar detection systems, or speech recognition systems.

Any machine learning consists of 5 major steps:

1. Dataset: - The data that is to be used for learning the machine learning tasks. The dataset is divided into 3 parts – training dataset used to learn the ML rule, validation dataset used for hyperparameter tuning, test dataset used for generalisation of the outputs.
2. Training: - In ML, the training involves using the data to learn the characteristics and identify patterns in the data. This is done such that the output that is obtained is compared with the ground truths available via a cost function or a loss function. The rule is then adjusted such that the loss function minimises and the output becomes as close to the ground truth as possible.
3. Validation: - Each machine learning model contains hyperparameters which need to be optimised such that there is no underfitting or overfitting of the data to the model. This is done using a validation dataset. The validation dataset, though a part of the training set, is used only for hyperparameter tuning and not for training purposes.
4. Testing: - The learned rules from the training along with the hyperparameters learnt from the validation dataset is then used on the testing dataset for the overall generalization of the errors and the testing error is reported. If the testing error is very high as compared to the training and validation error, then the phenomenon of overfitting occurs. In other words, overfitting means that instead of the pattern of the relationship of the input-output, the machine memorises the relation between the data that it has already seen. This is to be avoided as it leads to a very poor generalization.
5. Deployment: - Once the rule is learnt and all the parameters and hyperparameters are set, the rule is then deployed in production systems or in applications.

ML can be classified into 2 types on the basis of output – Classification (where the output is a discrete-valued output) and Regression (where the output is a continuous valued output).

Similarly, it can be divided into 5 types on the basis of learning of the rule: -

1. Supervised leaning: - The output signal or value is known for each corresponding input signal.