Artifical Intelligence and Data Science - 2

Q.1 a) Differentitate Between Machine learning and Deep learning with example.

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Machine learning	Deep learning
① Machine learning is a superset of Deep learning.	① Deep learning is a subset of Machine learning.
② The data represented in Machine learning is quite different as compared to Deep learning as it uses structured data.	② The data representation is used in Deep learning is quite different as it uses neural networks (ANN)
③ Machine learning is an evolution of AI.	③ Deep learning is an evolution of machine learning. Basically it is how deep is the ML.
④ The result of ML model is easy to explain.	④ The result of deep learning are difficult to explain.
⑤ Banks, doctor's office and mailboxes all employ machine learning already	⑤ Deep learning technology enables increasingly sophisticated and autonomous algorithms such as self-driving, automobiles or surgical robots.

Q.1 b) Draw the different layers in CNN Architecture for Image signal as input.

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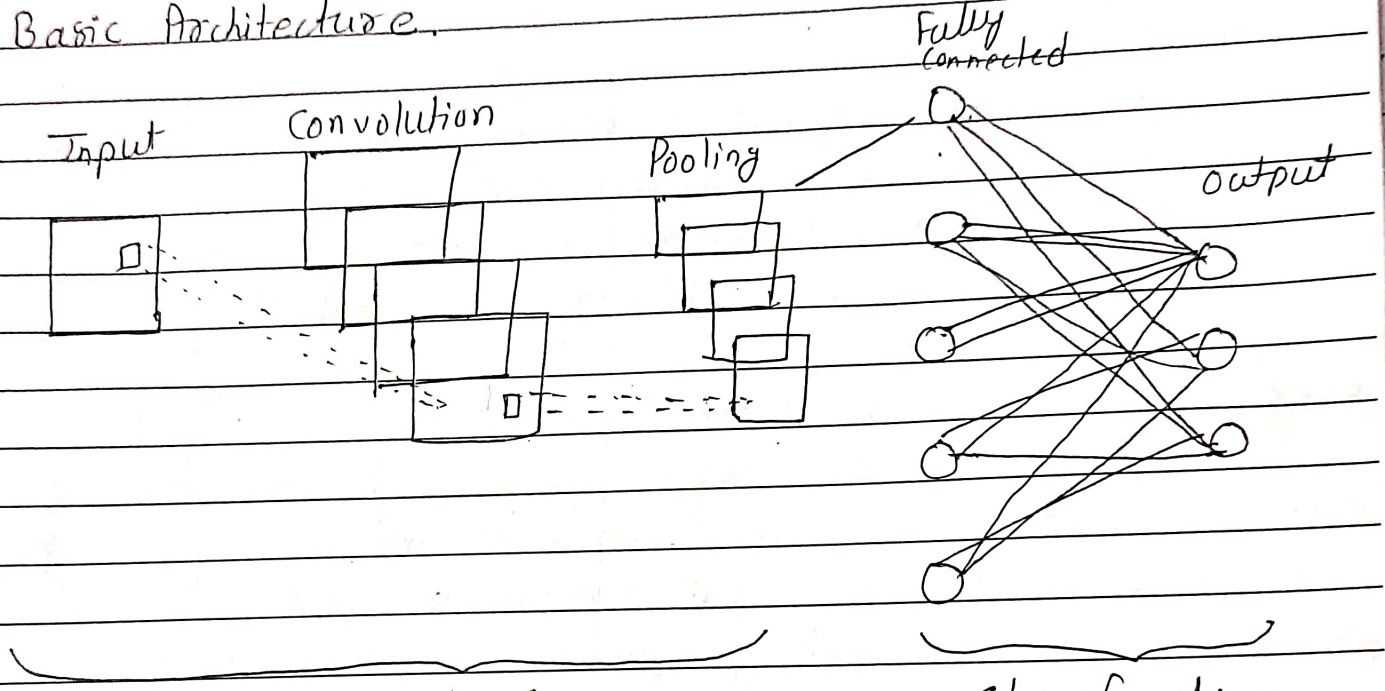
Basic Architecture.



There are two main part of a CNN architecture :

- A convolution tool that separates and identifies the various features of the image for analysis in a process called feature Extraction
- The network of feature extraction consists of many pairs of convolutional or pooling layers.
- A fully connected layer that utilizes the output from the convolution process and predicts the class of the image based on the features extracted in previous stages.
- This CNN model of feature extraction aims to reduce the number of features present in dataset.

Convolution layers
-There are three types that make up the CNN which are the convolutional layers, pooling and FC layers.

① Convolutional layers - This 1st layer that is used to extract the various features from the input images In this layer the mathematical operation of convolution is performed between the input image and a filter of a particular size MXM.

② Pooling Layer - In most cases, a Convolutional layer is followed by pooling Layer. The primary aim of this layer is to decrease the size of the converted feature map to reduce the computational costs. This performed by decreasing the connections between layers and independly operates on each feature map.

③ Fully connected layer - The fully Connected (FC) layer consists of the weights and biases along with the neurons and is used to connect the neurons between two different layers.

④ Dropout - Usually, when all features are connected to the FC layer, it can cause overfitting in the training dataset. ~~Over~~

⑤ Activation functions - In simple, words, it decides which information of the model should fire in forward direction and which ones should not at the end of the net

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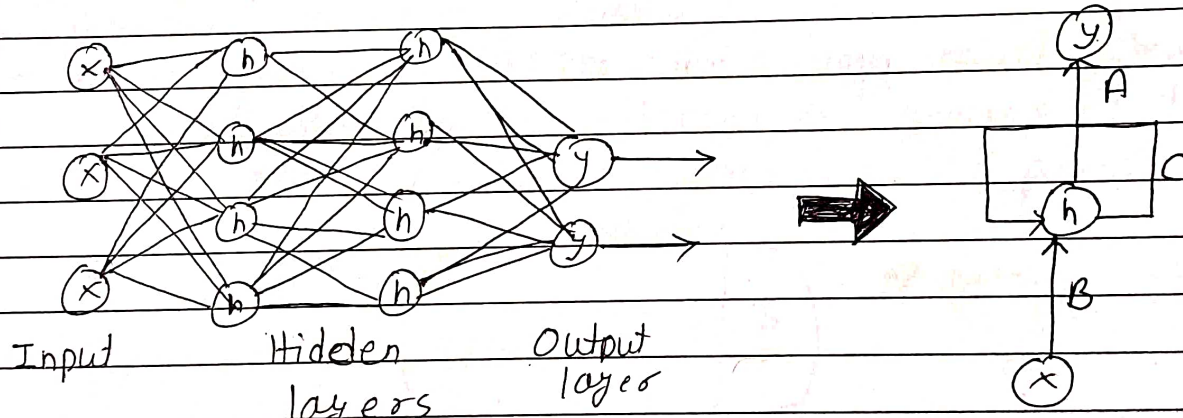
(Q.2 a) Demonstrate following Networks using suitable example.

a) RNN

→ - A neural n/w consists of different layers connected to each other, working on the structure and function of a human brain. It learns from huge volumes of data and uses complex algorithms to train a neural net.
- RNN is one of the type of neural network
- RNN works on the principle of saving the o/p of a particular layer and feeding this back to the input in order to predict the output of the layer.
- Below is how you can convert a Feed-Forward Neural n/w into a Recurrent Neural network.



Simple Recurrent Neural network

The nodes in different layers of the neural network are compressed to form a single layer of recurrent neural n/w. A, B, C are the parameter of the n/w
- Here, "x" is input layer, "h" is the hidden layer and "y" is the output layer. A, B, C, are the n/w parameters used to improve the output of the

model. At any given time t, the current th input is a combination of input at x(t) and x(t-1). The output at any given time is fetched back to the network to improve on the output.

$h(t) = f_c(h(t-1), x(t))$ ← Fully connected RNN

b) LSTM. (long short term Memory)

- Long short term Memory Network is an advanced RNN, a sequential network, that allows information to persist. It is capable of handling the vanishing gradient faced by RNN.
- At a high-level LSTM works very much like an RNN cell. Here is the internal functioning of the LSTM network. LSTM consists of 3 parts.

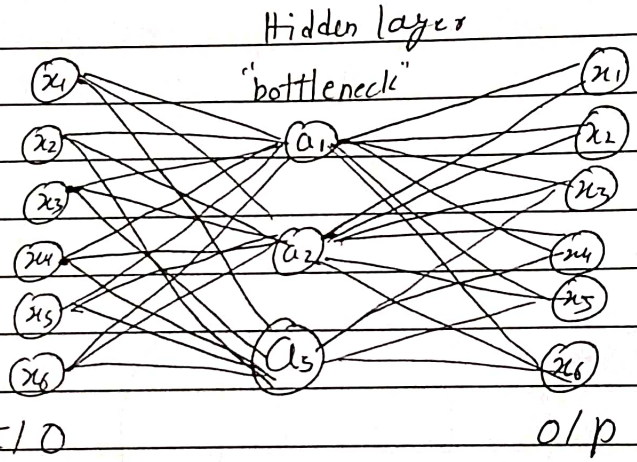
- First part choose whether the information coming from the previous timestamp is to be remembered or is irrelevant and can be forgetten
- The second part, the cell tries to learn new information from the input to this cell.
- At last, in the third part, the cell passes the updated information from the current timestamp to the next timestamp.

Q.2b) Explain Autoencoder in detail

→ -An autoencoder is a type of artificial neural n/w used to learn data encodings is an supervised manner.

- The aim of an autoencoder is to learn a lower-dimensional representation (encoding) for a higher-dimensional data, typically for dimensionality reduction, by training the n/w. to capture the most important parts of the input image.

Architecture of Autoencoders.



Autoencoders consists of 3 parts:

① encoder - A module that compresses the train-validate-test set input data into an encoded representation that is typically several orders of magnitude smaller than the I/O data.

② Bottleneck: A module that contains the compressed knowledge representations and is therefore the most important part of network.

③ Decoder - A module that helps the nw "decompress" the knowledge representation and reconstructs the data back from its encoded form. The o/p is the compared with a ground truth.

Q.3 a) Compare different ensemble methods in ensemble classifiers.

→ - An ensemble method is a technique which uses multiple independent similar or different models / weak learners to derive an output or make some predictions.

Types of ensemble methods.

① Bagging

② Boosting.

Similarities between bagging and boosting.

- Both the methods can be used for classification (discrete output) and regression (continuous output problems.
- Both methods are better in performance compared to single models as they aggregate the output of all the weak learners via voting leading to more accuracy in the predictions.

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Difference between the two methods.

Bagging	Boosting
① Individual trees/models are independent of each other	① Individual trees are not independent of each other.
② There is no concept of learning from each other in bagging	② In boosting, each of the trees will learn from the mistakes of the previous tree.
③ Helps to reduce variance.	③ Helps reduce both bias and variance.
④ Examples. Random forest extra tree algorithms	④ Example. Gradient Boosting, ADA Boost, XGBoost.

Q.3 b) Explain Random Forest algorithm with suitable example.

→ - Random Forest is a popular machine learning algo. that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in ML.

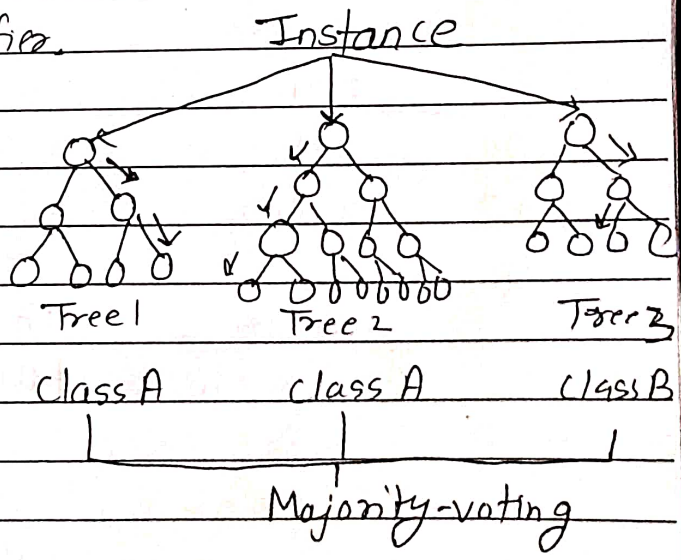
- It is based on the concept of ensemble learning, which is a process of combining multiple classifers to solve a complex problem and to improve the performance of the model.
- Random forest is a classifer that contains number of Decision trees on various subsets of given dataset and takes the average to improve

predictive accuracy of the dataset

Working of Random Forest.

① Select random K data points from the training set.
② Build the decision trees associated with the selected data points
③ Choose the number N for decision trees that you want to build.
④ Repeat step 1 & 2.
⑤ For new data points, find the predictions of each decision tree, and assign the new data points to the category that wins the majority votes.

example, Suppose there is dataset that contains multiple fruit images. So this dataset is given to the Random forest classifier. The dataset is divided into subsets and given to each decision tree. During the training phase each decision tree produces a prediction result, and when a new data points occurs then based on the majority of results the Random Forest classifier predicts the final decision. Consider the example 1.1



example 1.1

Q.4 a) Analyse given confusion matrix and calculate.

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		Actual values.		
		Positive	Negative	
Predicted values	Positive	65 (TP)	36 (FP)	101
	Negative	39 (FN)	43 (TN)	82
Total		104	79	

By comparing given matrix with confusion matrix we will get

TP = 65, FP = 36, FN = 39, TN = 43

① Accuracy $= \frac{TP + TN}{TT + TN + FP + FN} = \frac{65+43}{65+43+39+36}$

$= \frac{108}{183}$

$= 0.59 = 59\%$

② Precision $= \frac{TP}{TP + FP} = \frac{65}{101} = 0.6436$

③ Recall $= \frac{TP}{TP + FN} = \frac{65}{104} = 0.625$

④ F1 score $= \frac{2TP}{2TP + FN + FP} = \frac{2 \times 65}{2 \times 65 + 39 + 36} = \frac{130}{205} = 0.6341$

Q.4b) Explain cross validation and hold out in detail.

→ ① Cross validation

- Cross validation is a technique for validating the model efficiency by training it on the subset of input data and testing on previously unseen subset of input data. We can also says that it is a technique to check how a statistical model generalizes to an independent dataset.
- The basic steps of cross validation are:
  1. Reserve a subset of the dataset as a validation set.
  2. Provide the training to the model using the training dataset
  3. Now, evaluate model performance using the validation set. If the model performs well with the validation set, perform the further step else check for the issues.

② Hold out

- Hold out is the simplest set of method to evaluate a classifier. In this method, the dataset (a collection of data items or examples) is separated into two sets, called the training set and Test set
- example, emails in our being classifier into spam and non-spam.

Classifer should be evaluated to find out, it's accuracy, error rate, and error estimates. It can be done using various method, one of most primitive methods in evaluation of classifier is Hold out methods.

Q.5a) Design system for number Plate Recognition.

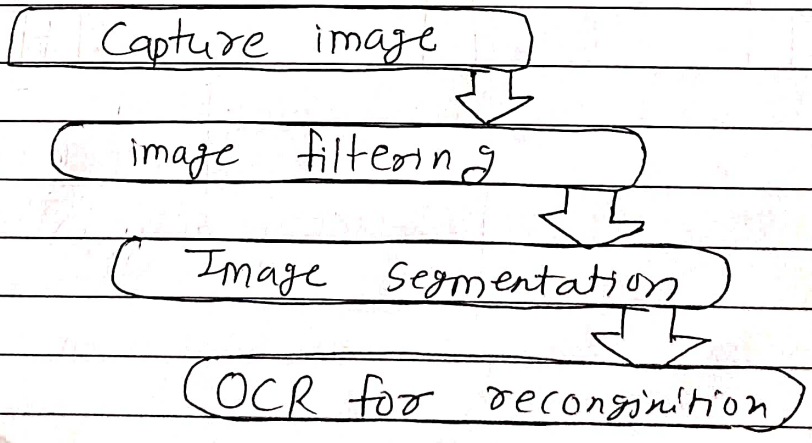
→ The overall ANPR system can be divided into the software design and hardware design.

A. Software design.

- The most important part of this system is the software design. The software design uses series of image processing techniques which are implemented in Android mobile platform which is supported min API 5.

The ANPR algorithm designed is divided into.

- Capture number plate image.
- Image filtering.
- Segmentation of the number plate image.
- Recongize the numbers plate image using OCR algorithm.



The first step is the capturing of an image using the camera provided by the mobile phone.

The next step is to filtering the number plate image. filtering can be divided into into two parts. The first technique involves removing of all white patchs that are connected to any order. The second filtering technique use pixel method to remove the small regions in an image other than plate region.

- The next step of ANPR algorithm is the segmentation of number plate in an image. The algorithm of segmentation basically finds the maximum peak in the graph of vertical projection iteravely.
- The final step is reconizing the character using OCR algorithm by compared the image charact that we have in second step against the alphanumerical database.

Hardware Design.

The hardware design is all consisting in mobile phone device including camera to capture image, central processing unit which will process our algorithms.

The entire system will work like as the camera capture the number plate, the ANPR algorithm on the mobile phone receives the image and performs the processing, which yields the vechiles number. This number is then showing in the mobile phone's screen as string foomat.

(Q.5 b) → Design System for Audio classification.

The system flow chart of audio classification system designed in this paper is shown below. The first step is pre processing. After doing so, we can get audio signal frame data. Several frame-level features such as short-time Average zero-crossing Rate, short time energy, Centroid of audio frequency Spectrum and sub-Band energy and MFCC. We also calculate some statistical characteristics, such as mean, variance, High zero crossing Rate Ratio and Low-short time energy. After that we can get complete set of features vectors.

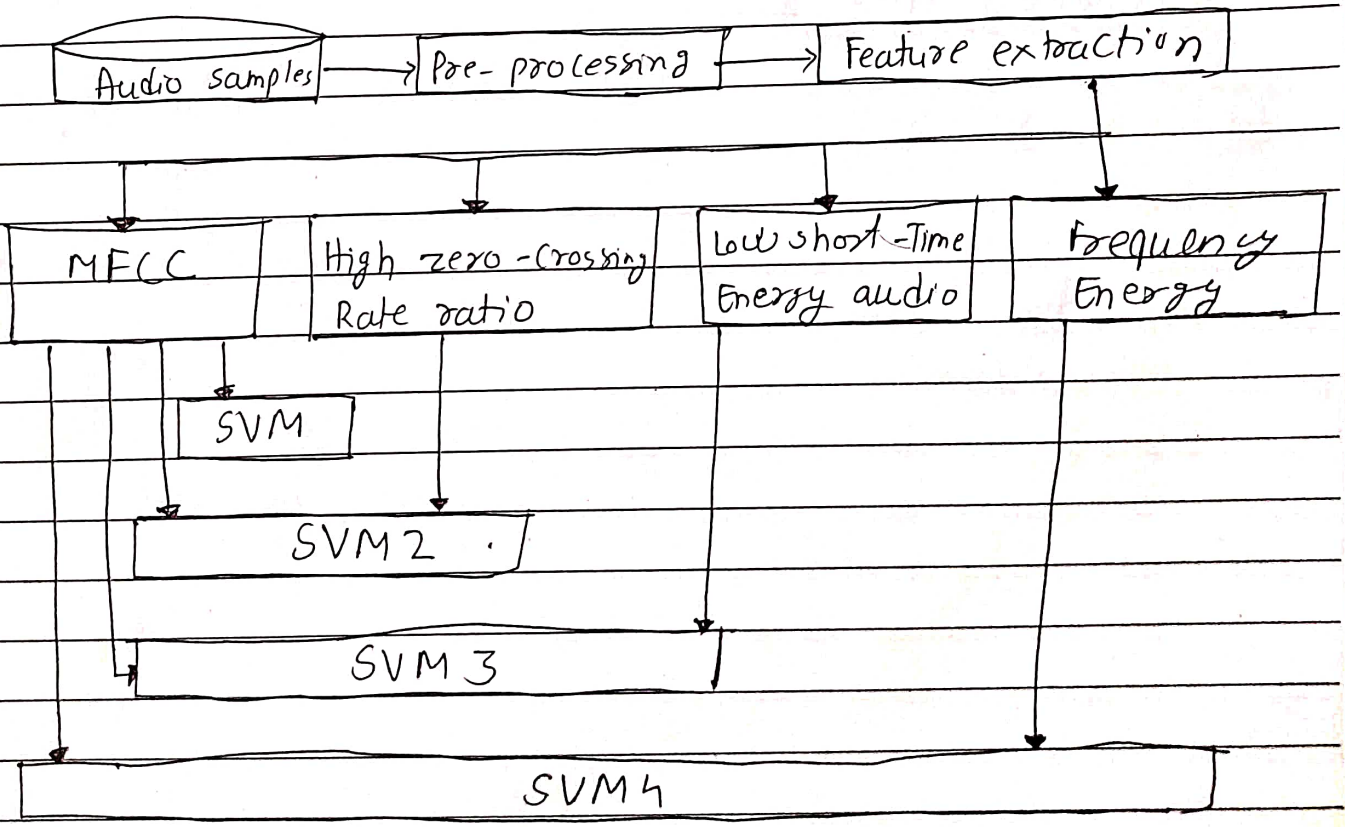


Fig 1 Flow chart of audio classification system.

The training samples and set test samples are sent to SVM to begin training and testing. The Block diagrams of classifers training and classification subsystem are designed fig 2 and Fig 3.

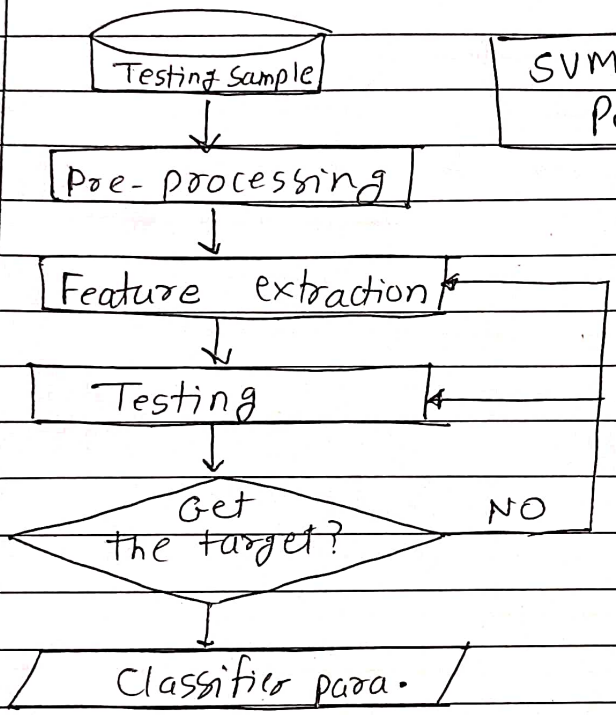


Fig 2
Block diagram of SVM training

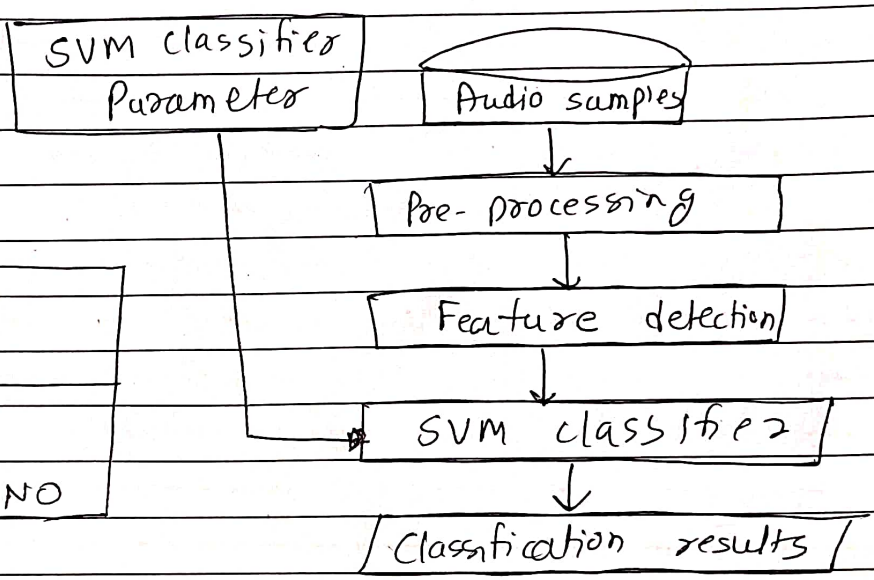


Fig 3
Block of SVM classification.