EXPLORATORY PROJECT

APPLICATION OF MACHINE LEARNING IN STRUCTURAL HEALTH MONITORING

NAME:GUNJAN KSHIRSAGAR

ROLL NO:21065058

WHY STRUCTURAL HEALTH MONITORING IS NEEDED?

Structural health monitoring is need to **visualize hidden damage inside infrastructure.**

Structural health monitoring **aims to identify , detect and characterize the degradation and damage** of all types of Engineering Structure like highways , railways , bridges , buildings etc .

Objective :- Accurately identify the current state of health and behaviour of the structure by using monitored data.

BENEFITS OF SHM :

MAINTENANCE /OPERABILITY

- Enhance reliability, safety , availability.
- Minimize downtime.
- Reduce overall maintenance costs.
- Provide improvement in designs and construction.

DESIGNS

- Optimize structural efficiency.
- Develop new design philosophies.
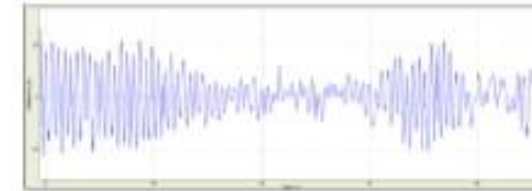- Save weight.

APPROACH OF SHM
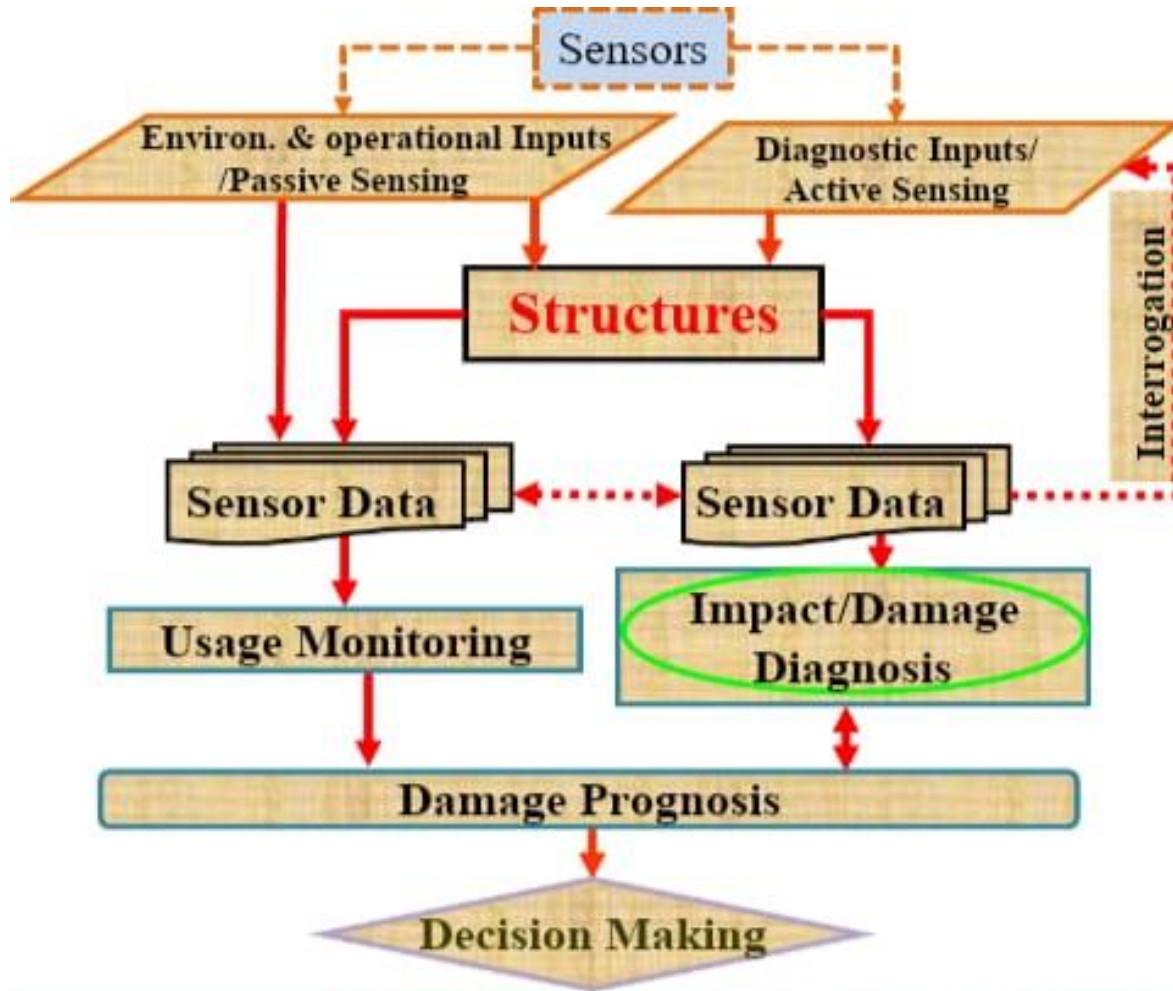
1) PHYSICS-BASED

1. Vibration- based SHM (MATLAB FE-MODEL)

2. Bridge Weigh-in-Motion

2) DATA-DRIVEN (ANNs and ML)

Artificial Neural Network (ANNs) Model
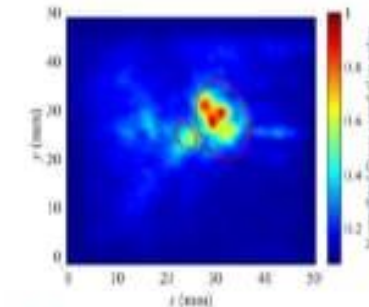
1. 1: Dynamic of beams (forward problem)

2. 2: Dynamic of beams using sensor array for full-field prediction

SHM SYSTEM FRAMEWORK
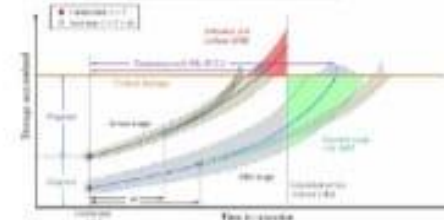
CHALLENGES:-

- Limited number of sensor available

- Big data (including historical data and sensor modalities)

- Small or insufficient sample for damage scenarios

- Sensitivity of modal parameters

- Measurement noise and modelling error

PROCESSING OF DATA

The process of SHM , overall software system like:-

1) Microcontroller units

2) Intelligent Sensor

Get data → Retrieve data → Condense data → Sorting data → Analysis data → Update Report to Computer → Human Interference Checking data
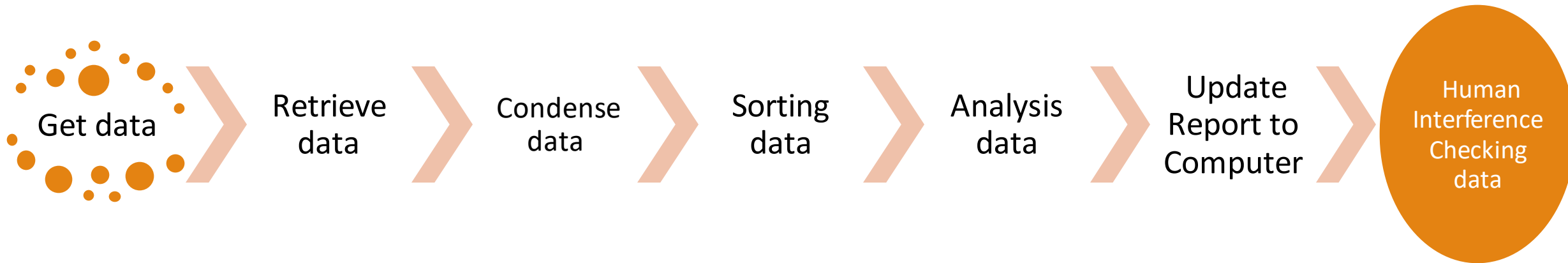
INTRODUCTION TO MACHINE LEARNING

Machine learning is an application of artificial intelligence that involves algorithms and data that automatically analyse and make decision by itself without human intervention. It describes how computer perform tasks on their own by previous experiences.

The difference between normal computer software and machine learning is that a human developer has not given codes that instructs the system how to react to situation ,instead it is being trained by a large number of data.

TYPES OF MACHINE LEARNING

There are three types of machine learning

- Supervised Learning

- Unsupervised Learning

- Reinforcement Learning

INTRODUCTION OF ALL TYPES OF ML

1 SUPERVISED LEARNING : learning is a technique where the program is given <u>labelled</u> input data and the expected output data , ex self driving car.

2 UNSUPERVISED LEARNING : This type of algorithm consist of input data <u>without labelled</u> response. There will not be any pre existing labels and human intervention is also less.

Unsupervised learning is mostly used in exploratory analysis as it can automatically Identify the structure in data.

3 REINFORCEMENT LEARNING : This model is used in making sequence of decision. It is learning by interaction with the <u>Environment</u> . It can be said that it is an trail and error method in finding the best outcome based on experience .

APPLICATION OF MACHINE LEARNING

➢Self Driving Car

➢Email Spam Filtering

➢Traffic Predication (GPS navigation service out location)

➢Online Transportation (Estimate cost and distance of the travel)

➢Social Media Services (app like Facebook personalizing our news feed)

➢ Product Recommendation (in online shopping while search for a product all its relavant product are display in our screen)

ADVANTAGES OF MACHINE LEARNING

- Wide range of real life application

- Fast , Accurate , Efficient

- Handing Multi-dimensional data

- No human intervention is needed

- Enhanced cyber security and spam detection

- Automation of most application

DISADVANTAGES OF MACHINE LEARNING

❖ It is very difficult to identify and rectify the error

❖ Data Acquisition

❖ Interpretation of results requires more time and space

SUPERVISED LEARNING
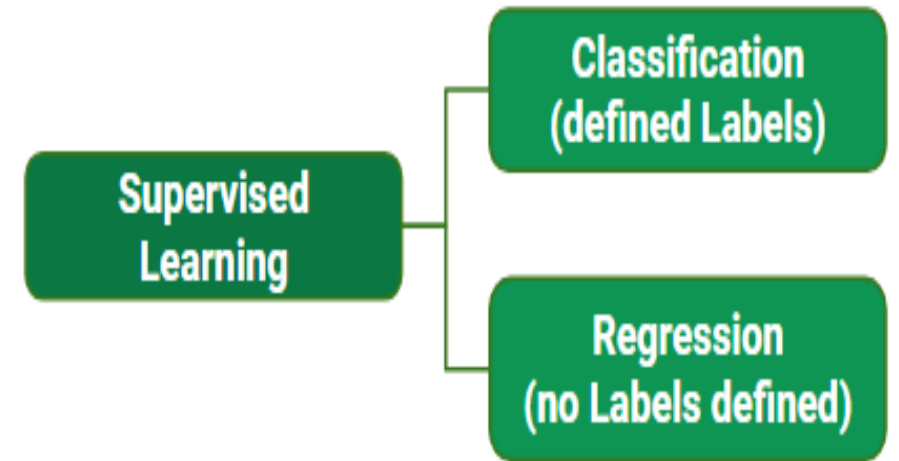
- **A) Classification** –

- It is task where output is having defined labels (Discrete value)

  There are two type of output class

  1)Binary classification (Either 0 or 1 and Yes or No)

  2)Multi-class classification (Gmail classifies like social , promotions , update)

  B) Regression

- It is a supervised task where output is having <u>continuous value</u> .

- The goal here is to predict a value as much closer to the actual output value as our model can and then <u>evaluation is done by calculation the error value</u> . Smaller the error the greater the accuracy of our regression model.

Supervised Learning

Classification (defined Labels)

Regression (no Labels defined)

Example of classification and regression

User ID	Gender	Age	Salary	Purchased
15624510	Male	19	19000	0
15810944	Male	35	20000	1
15668575	Female	26	43000	0
15603246	Female	27	57000	0
15804002	Male	19	76000	1
15728773	Male	27	58000	1
15598044	Female	27	84000	0
15694829	Female	32	150000	1
15600575	Male	25	33000	1
15727311	Female	35	65000	0
15570769	Female	26	80000	1
15606274	Female	26	52000	0
15746139	Male	20	86000	1
15704987	Male	32	18000	0
15628972	Male	18	82000	0
15697686	Male	29	80000	0
15733883	Male	47	25000	1

Figure A: CLASSIFICATION

Temperature	Pressure	Relative Humidity	Wind Direction	Wind Speed
10.69261758	986.882019	54.19337313	195.7150879	3.278597116
13.59184184	987.8729248	48.0648859	189.2951202	2.909167767
17.70494885	988.1119385	39.11965597	192.9273834	2.973036289
20.95430404	987.8500366	30.66273218	202.0752869	2.965289593
22.9278274	987.2833862	26.06723423	210.6589203	2.798230886
24.04233986	986.2907104	23.46918024	221.1188507	2.627005816
24.41475295	985.2338867	22.25082295	233.7911987	2.448749781
23.93361956	984.8914795	22.35178837	244.3504333	2.454271793
22.68800023	984.8461304	23.7538641	253.0864716	2.418341875
20.56425726	984.8380737	27.07867944	264.5071106	2.318677425
17.76400389	985.4262085	33.54900114	280.7827454	2.343950987
11.25680746	988.9386597	53.74139903	68.15406036	1.650191426
14.37810685	989.6819458	40.70884681	72.62069702	1.553469896
18.45114201	990.2960205	30.85038484	71.70604706	1.005017161
22.54895853	989.9562988	22.81738811	44.66042709	0.264133632
24.23155922	988.796875	19.74790765	318.3214111	0.329656571

Figure B: REGRESSION

# IMPORTANT OF SUPERVISED LEARNING AND TYPE OF REGRESSION MODEL

Supervised learning which means that the output variable is already known . The goal of supervised learning is to <u>learn a function</u> that can accurately predict the output variable based on the input variable.

Supervised learning algorithms are widely used in various field , such as natural language processing , computer vision , medical diagnosis , speech recognition , linear regression ,logistic regression ,support vector machine (SVM),Neural network.

Type of regression models:

EX: Predict the price of the house (Housing data set)

red line predicting price
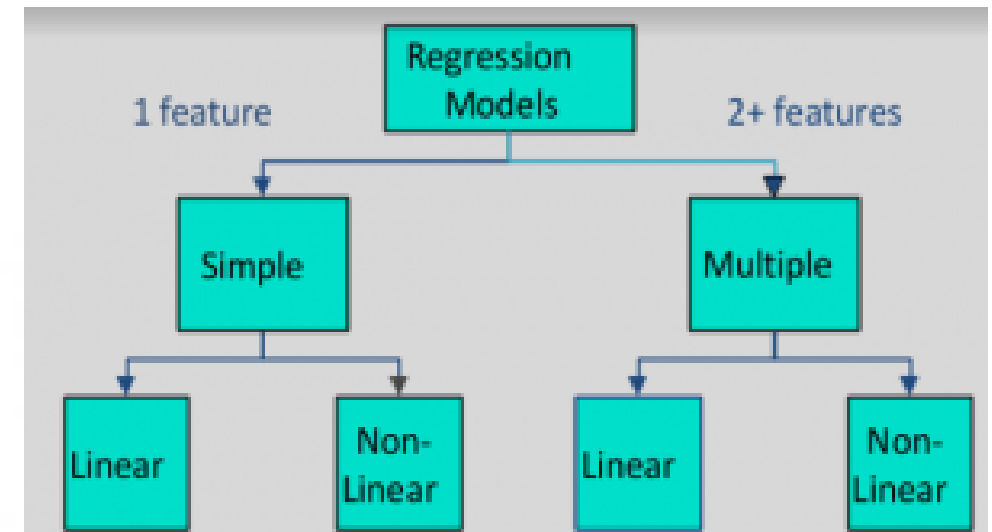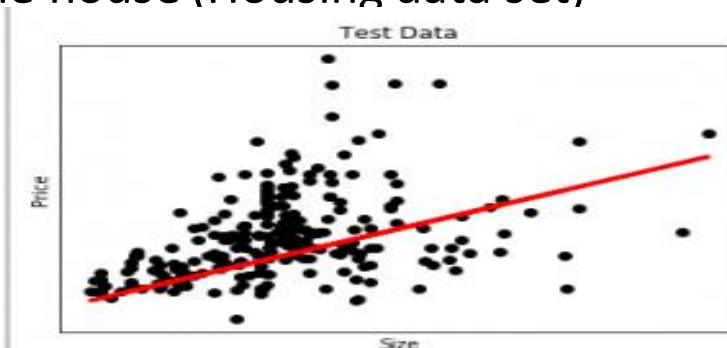
UNSUPERVISED LEARNING

Unsupervised learning is the training of a machine using **information that is neither classified nor labelled** and allowing the algorithm to act on the information without guidance.

Here the task of the machine is to group unsorted information according to similarities , patterns , and differences without any prior training of data.

Supervised learning : model where input variable (say , x) and output variable (say , y) and an algorithm to map the input to the output that is , Y=f(x).

Unsupervised learning : is where only input data (say , x) is present and no corresponding output variable is there.

The main aim of unsupervised learning is to model the **distribution in the data in order to learn more about the data.** Algorithms are left to their own devises to discover and present the interesting structure in the data.

Example of Unsupervised learning

Suppose there is a basket and it is filled with some fresh fruits. The task is to arrange the same type of fruits at one place.

This time there is <u>no information</u> about those fruits beforehand, its the first time that the fruits are being seen or discovered So how to group similar fruits without any prior knowledge about those. First, any physical characteristic of a particular fruit is selected. Suppose color. Then the fruits are arranged on the basis of the color.

The groups will be something as shown below: fruit are classified on basis of color and size

RED COLOR GROUP: apples & cherry fruits. **GREEN COLOR GROUP**: bananas & grapes.

RED COLOR AND BIG SIZE: apple. **RED COLOR AND SMALL SIZE**: cherry fruits.

GREEN COLOR AND BIG SIZE: bananas. **GREEN COLOR AND SMALL SIZE**: grapes

Difference Between supervised and unsupervised data

Supervise learning

❖ classifying big data can be challenging.

❖ allows collecting data and produces data output from <u>previous experience</u>.

❖ It allows estimating or mapping the result to a new sample.

❖ Cannot handle all complex tasks in machine learning.

Unsupervised learning

❖ It does not require a training data to be labelled.

❖ Capable of finding previously unknow patterns in data.

❖ the result often less accuracy .