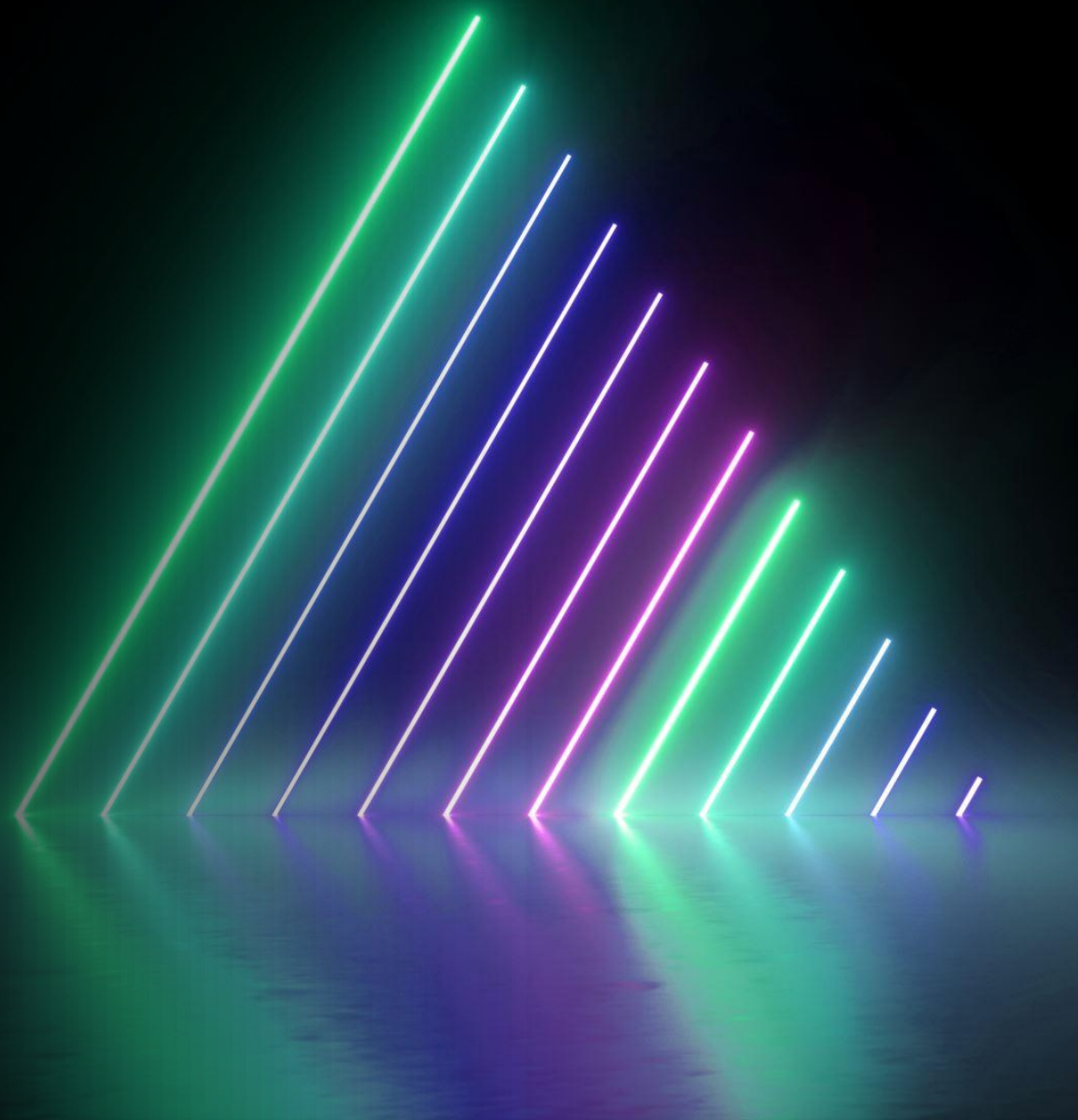
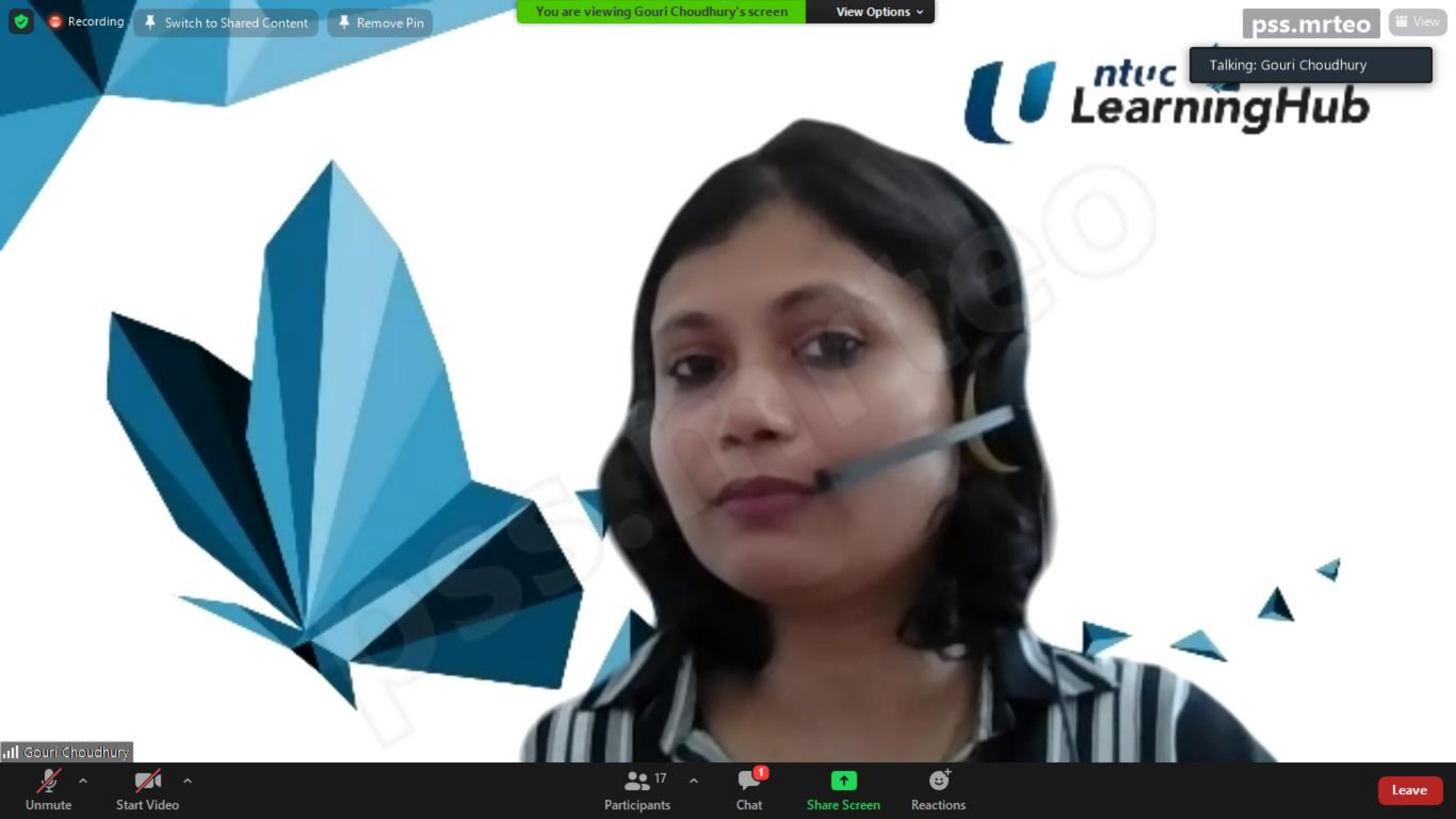
Machine Learning and Advanced Analytics Using Python

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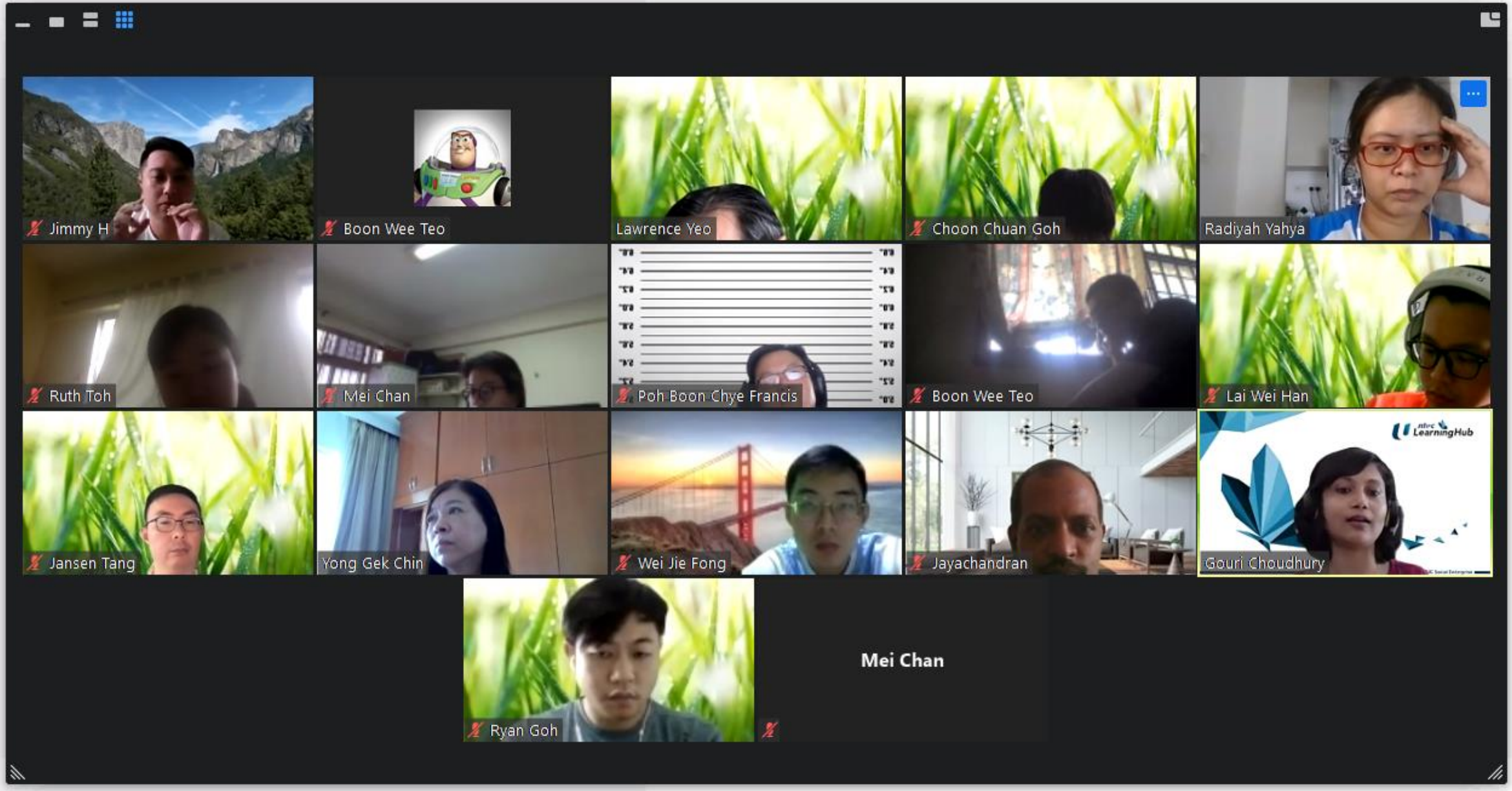
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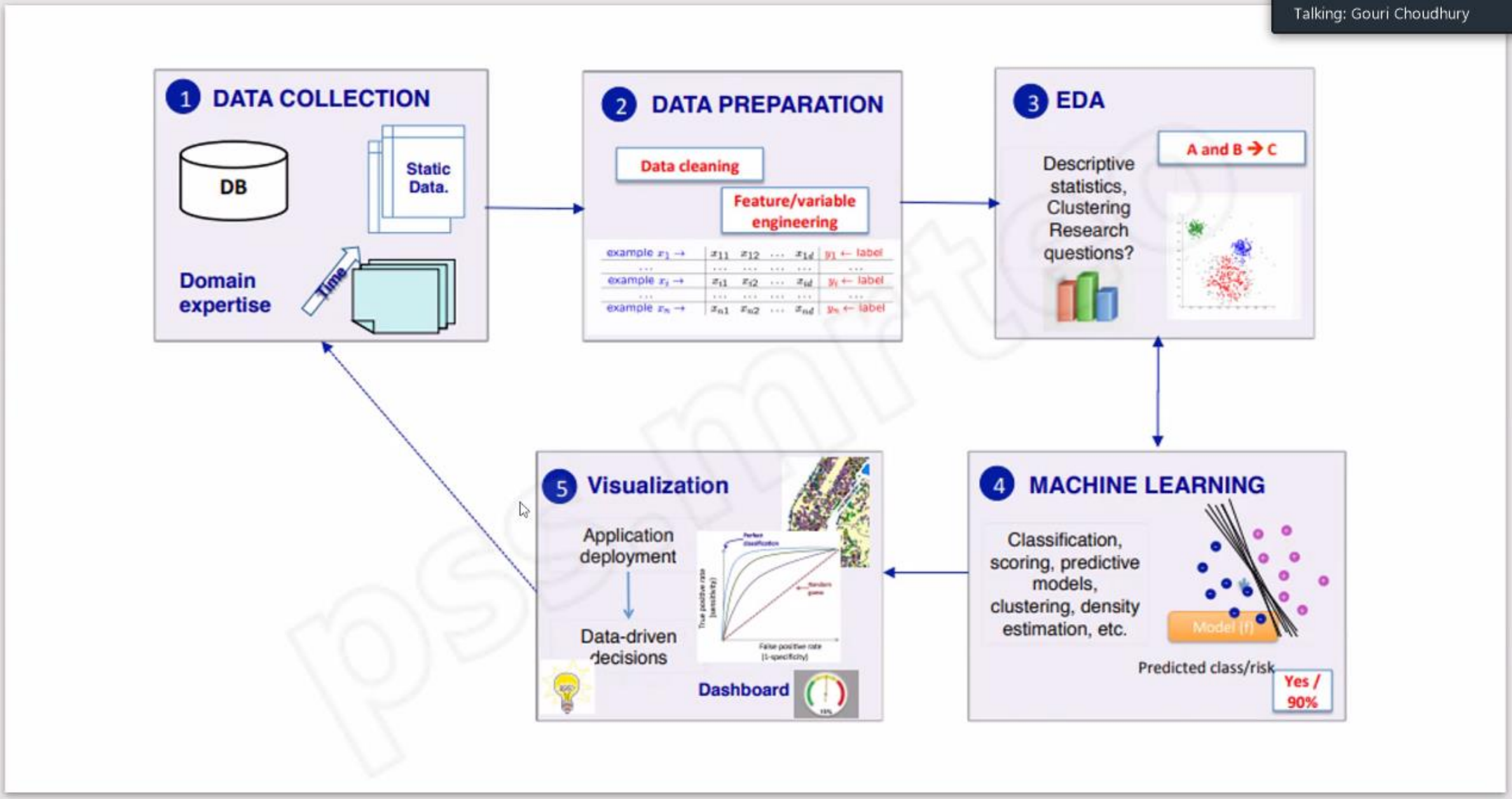

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What is Learning?

1

"Learning denotes changes in a system that ... enable a system to do the same task ... more efficiently the next time." - Herbert Simon

2

"Learning is constructing or modifying representations of what is being experienced." - Ryszard Michalski

3

"Machine learning refers to a system capable of the autonomous acquisition and integration of knowledge."

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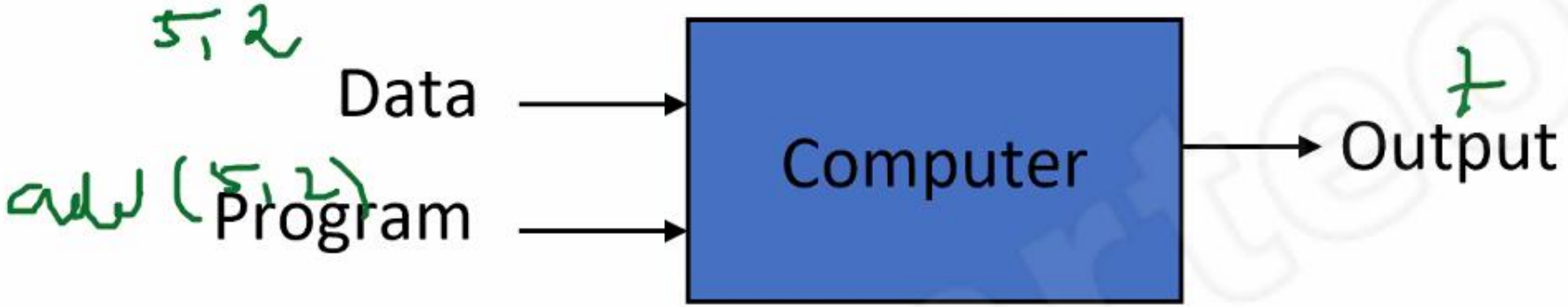
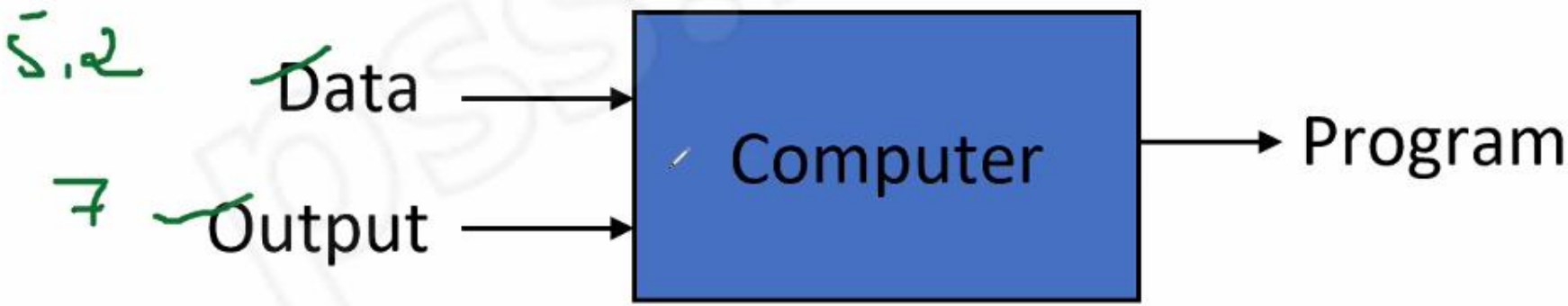
Traditional Programming



Machine Learning



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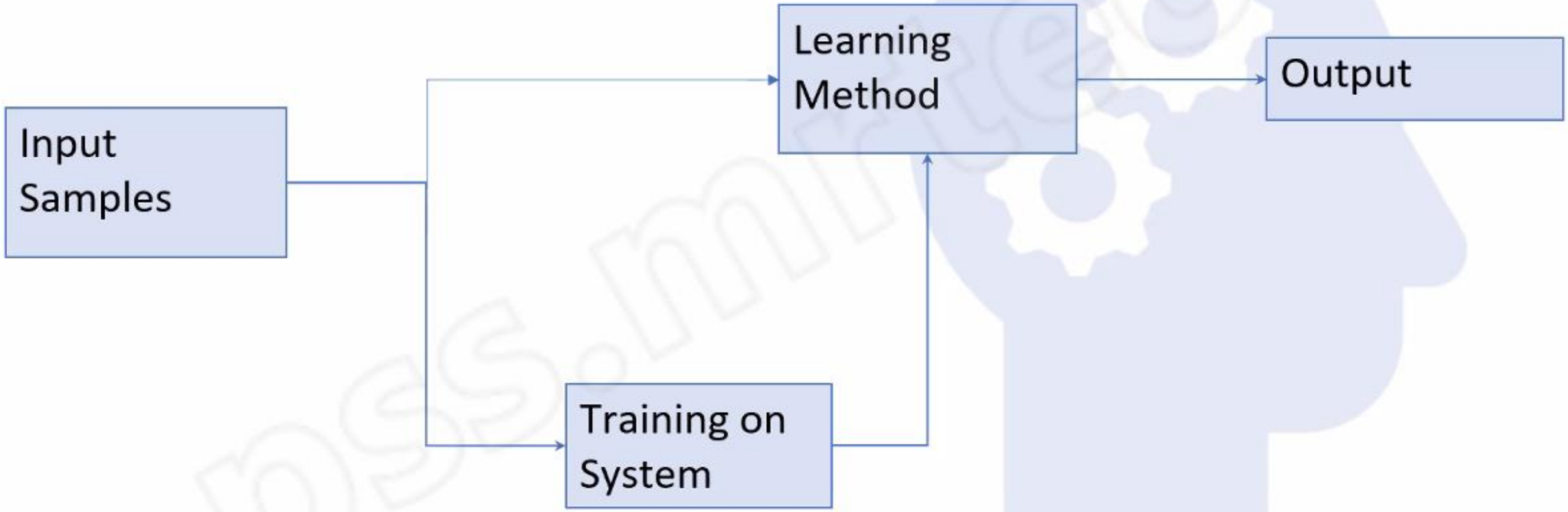
Learning System Model



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Why is machine learning required?

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Some examples that machine learning solves

Recognizing patterns:

- Facial identities or facial expressions
- Handwritten or spoken words
- Medical images

Generating patterns:

- Generating images or motion sequences

Recognizing anomalies:

- Unusual credit card transactions
- Unusual patterns of sensor readings in a nuclear power plant

Prediction:

- Future stock prices or currency exchange rates

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3 vital things to define

Task: Recognizing hand-written words

Performance Metric: Percentage of words correctly classified

Experience: Database of human-labeled images of handwritten words

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Types of Learning

Supervised (inductive) learning –

- Given: training data + desired outputs (labels)

Unsupervised learning –

- Given: training data (without desired outputs)

Semi-supervised learning –

- Given: training data + a few desired outputs

Reinforcement learning –

- Rewards from sequence of actions

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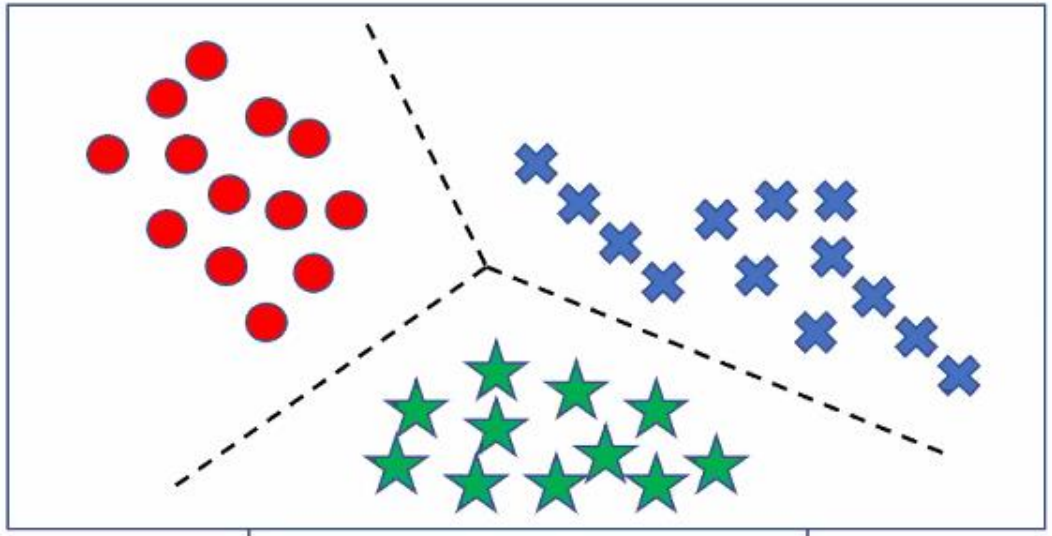
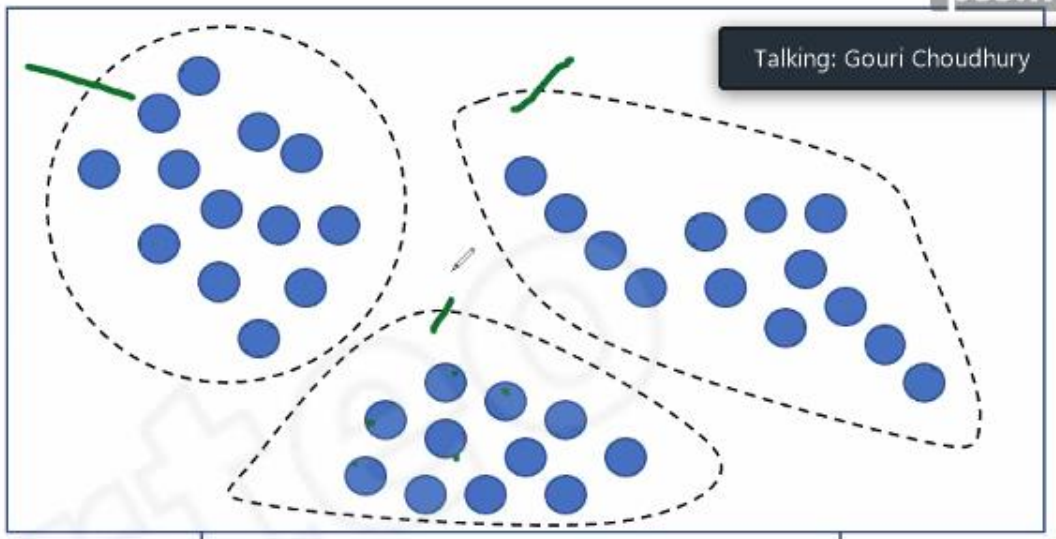
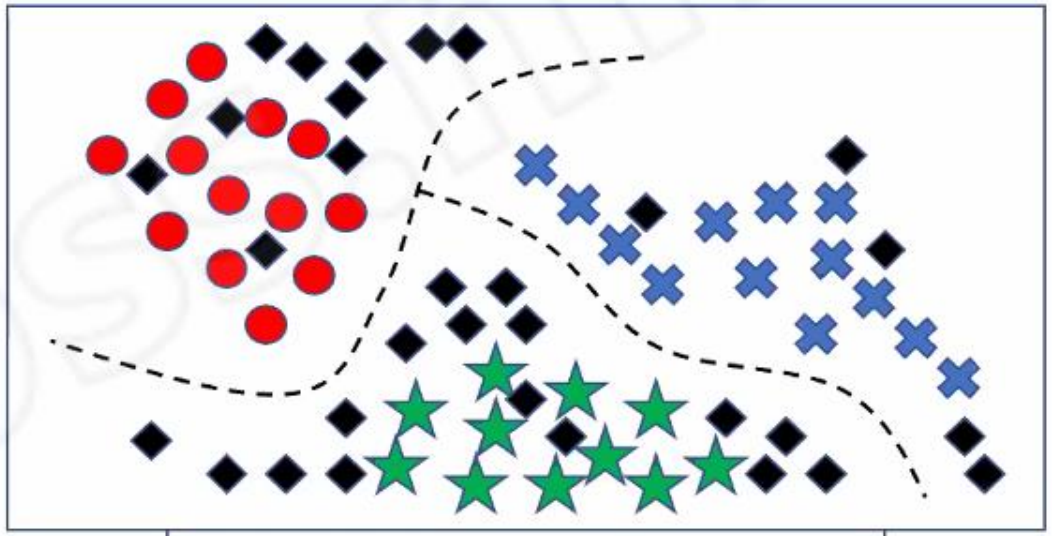


Supervised learning



Unsupervised learning



Semi-supervised learning

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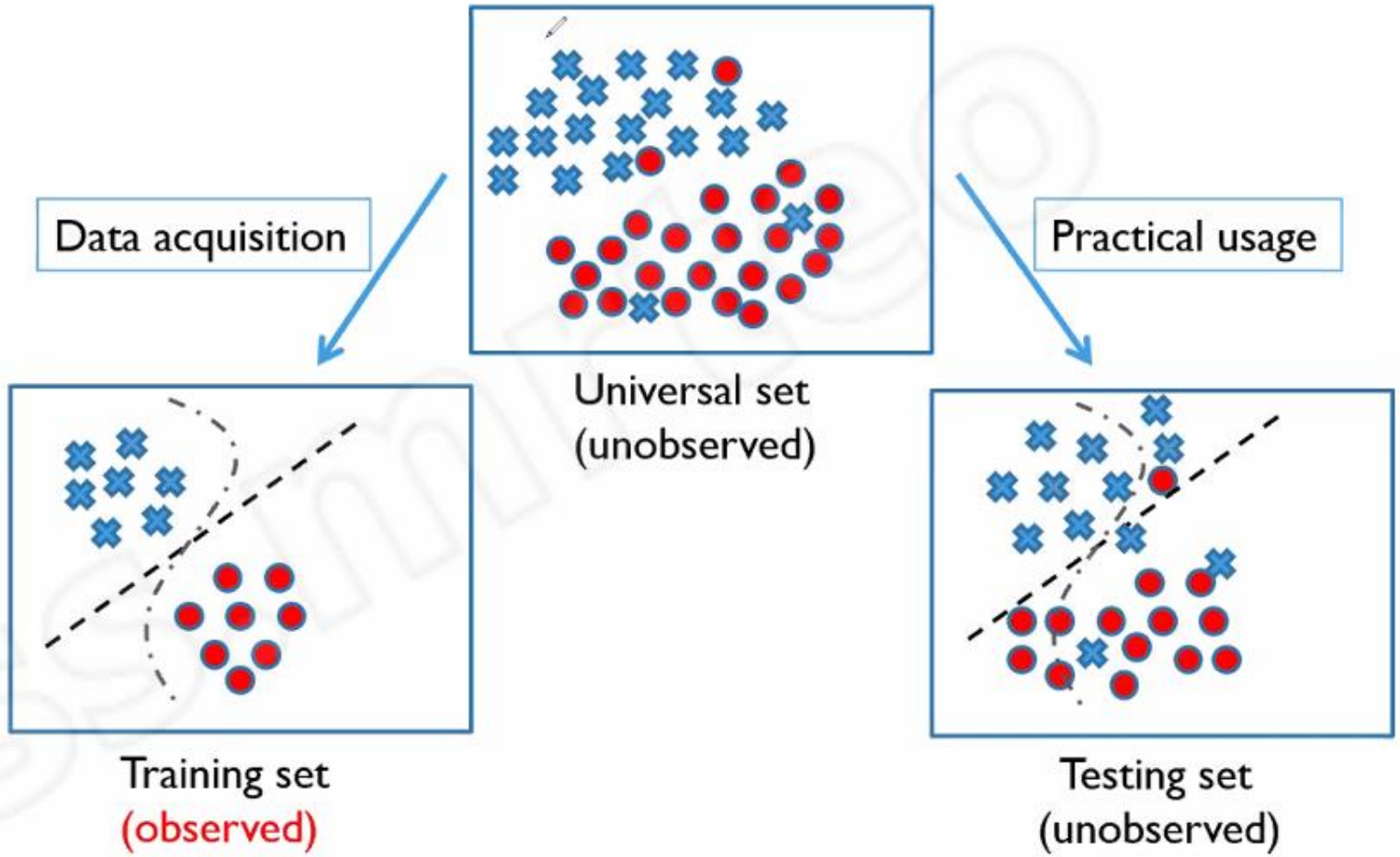
Training and Test Sets



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Unsupervised Learning

The data has no target attribute.

We want to explore the data to find some intrinsic structures in them.

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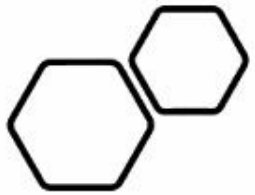

What is Clustering?

Clustering

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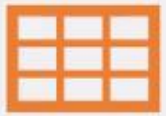
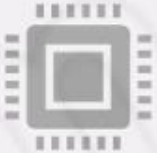
What's a cluster?



Intuitive definition:

Grouping of data points that are close to each other



To make this computer friendly, need a mathematical definition of "close."

Closeness (most common definitions):

based on distance or density

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Clustering as unsupervised learning

Unlabeled data —algorithm→ Structured data

New data (unlabeled) —assignment→ New data included in structure

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K-means is a partitional clustering algorithm

The *k*-means algorithm partitions the given data into *k* clusters.

Each cluster has a cluster **center**, called **centroid**.

k is specified by the user

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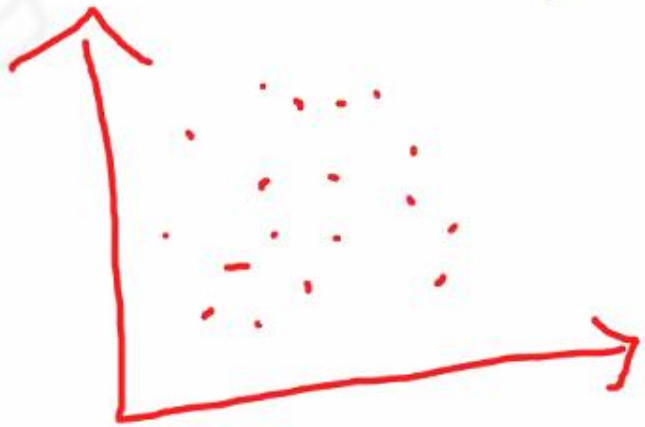
k-means clustering: the **algorithm**

- Choose *k* centroids
- Assign points to cluster based on nearest centroid
- Recompute centroids
- Repeat steps (2) and (3) until there is no more change to the centroids



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k-means performance

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k-means: adding new data

Add — Add new data to nearest cluster

Treat — Treat clusters as labeled data

Use — Use this data to train a classifier

Apply — Apply classifier to new data

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k-means: strengths and weaknesses

Strengths:

- Simple—one parameter (*k* clusters)
- Typically fast
- Easy to implement

Weaknesses:

- Optimal *k* is often not obvious
- Sensitive to outliers
- Scaling affects results

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Clustering - Real life Examples

Example 1: groups people of similar sizes together to make “small”, “medium” and “large” T-Shirts.

Tailor-made for each person: too expensive	One-size-fits-all: does not fit all.

Example 2: In marketing, segment customers according to their similarities

To do targeted marketing.

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Other clustering algorithms

Self Organizing Maps (SOM)

Agglomerative Hierarchical Clustering

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Supervised Learning

Data includes both the input and the desired results.

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Think of the following examples.

- An emergency room in a hospital measures 17 variables (e.g., blood pressure, age, etc) of newly admitted patients.
- **A decision is needed: whether to put a new patient in an intensive-care unit.**
- Due to the high cost of ICU, those patients who may survive less than a month are given higher priority.
- **Problem**: to predict high-risk patients and discriminate them from low-risk patients.

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Another example..

- A credit card company receives lots of applications for new cards. Each application contains information about the applicant for the card,
  - age
  - Marital status
  - annual salary
  - location
  - outstanding debts
  - credit rating
  - Family information etc
- **Problem**: to decide whether an application should be approved or not approved.

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Types of Data vs Algorithm

Supervised Learning

Continuous

- Regression

Categorical

- Classification

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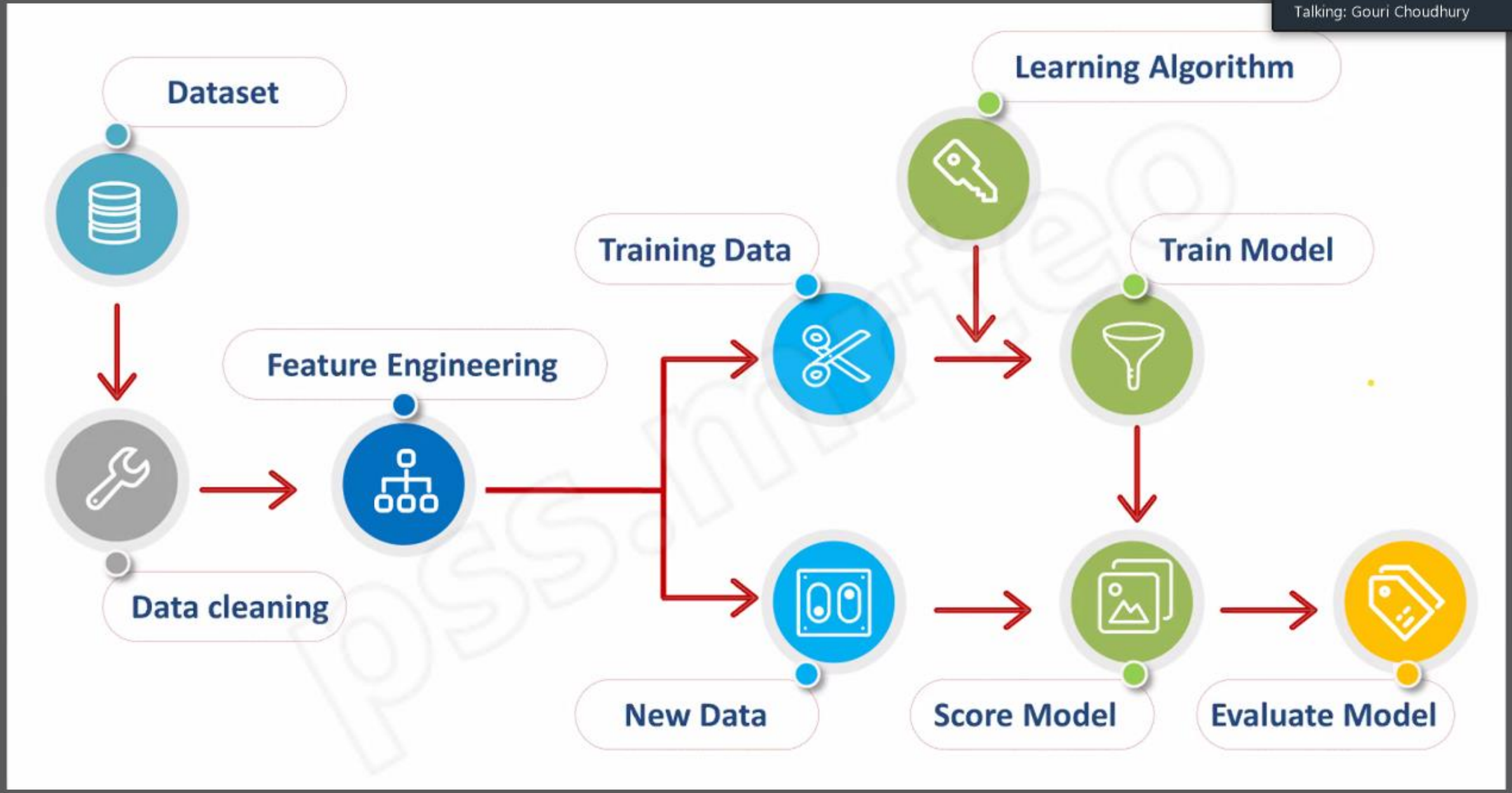

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Jargons to be aware of!

Model Inputs: Features, Attributes, Predictors, Inputs, Independent Variables, Dimensions, probably more.

Model Outputs (what we're trying to predict): Target, Response, Output, Dependent Variable, Labels

Row of Data (Inputs + Outputs): Observation, Datapoint, Record, Row

Labels: The values on the target variables in Supervised Learning

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Linear Regression

Getting our line straight!

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Introduction to Regression Analysis

- Regression analysis is used to:
  - Predict the value of a dependent variable based on the value of at least one independent variable
  - Explain the impact of changes in an independent variable on the dependent variable

- Dependent variable:

The variable we wish to predict or explain

- Independent variable:

The variable used to explain the dependent variable

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Simple Linear Regression Model

Only **one** independent variable, X

Relationship between X and Y is described by a linear function.

Changes in Y are assumed to be caused by changes in X

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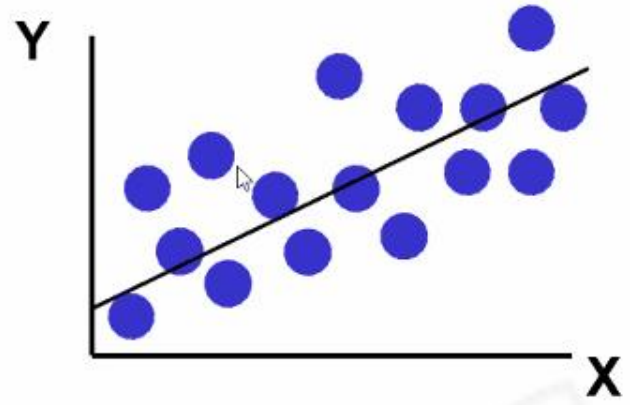
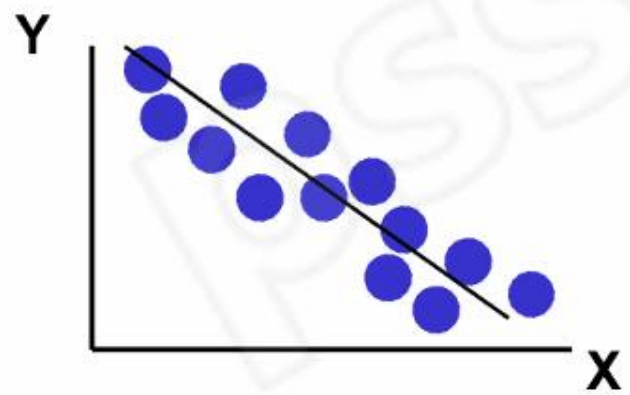
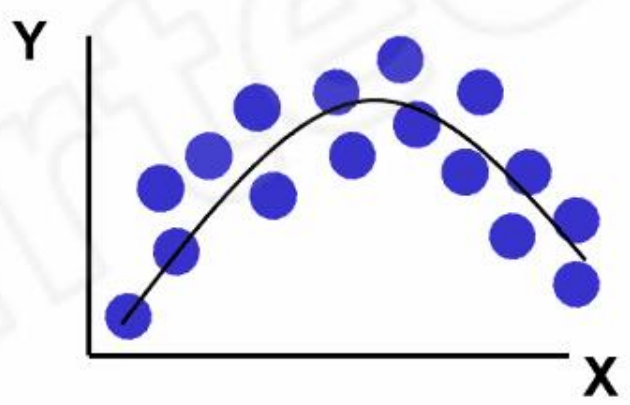
Types of Relationships

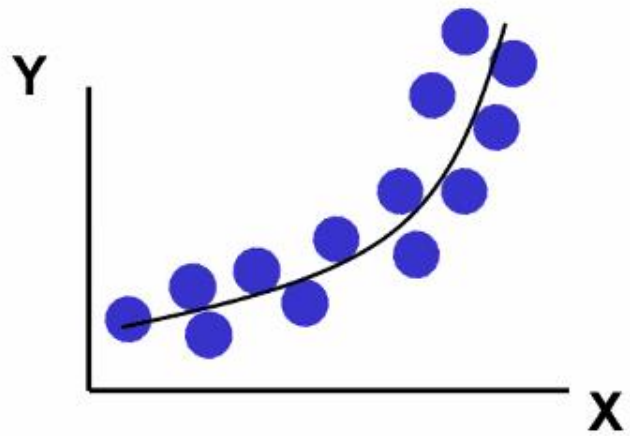
Linear relationships





Curvilinear relationships





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Feature Engineering

What is it all about?

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Feature engineering

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- The first thing we need to do when creating a machine learning model is to decide what to use as features.
- **Features** are key to a model, like a person's name or favorite color. pieces of information that we take from the text and give to the algorithm so it can work its magic.
- E.g, if we do classification on health, some features could be a person's height, weight, gender, and so on.
  - We would exclude things that maybe are known but aren't useful

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Benefits of Feature Engineering

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- **Reduces Overfitting** : Less redundant data means less opportunity to make decisions based on noise.
- **Improves Accuracy :** Less misleading data means modeling accuracy improves.
- **Reduces Training Time :** Fewer data points reduce algorithm complexity and algorithms train faster.

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What is logistic regression?

- **Logistic regression** is the appropriate regression analysis to conduct when the dependent variable is **binary**.
- Like all regression analyses, the logistic regression is a predictive analysis.
- Logistic regression is used to describe data and to explain the relationship between one dependent **binary variable** and **one or more nominal, ordinal, interval or ratio-level independent variables.**

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Good to know!

Nominal

- Nominal scales are used for labeling variables, without any quantitative value. “Nominal” scales could simply be called “labels.”
  - E.g Male/Female, Red/Green/Yellow

Ordinal

- With ordinal scales, the order of the values is what’s important and significant, but the differences between each one is not really known.
  - E.g Good, Very good, Excellent, Fantastic – 1#, 2#, 3#, 4#

Interval

- Interval scales are numeric scales in which we know both the order and the exact differences between the values.
  - E.g Temp Celsius - because the difference between each value is the same.

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Model Evaluation

Model Evaluation is an integral part of the model development process.

It helps to find the best model that represents our data and how well the chosen model will work in the future.

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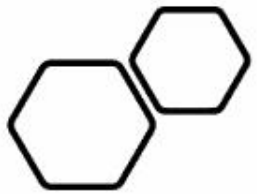

Performance Metrics (Classification)

Confusion Matrix

Accuracy

Precision and Recall

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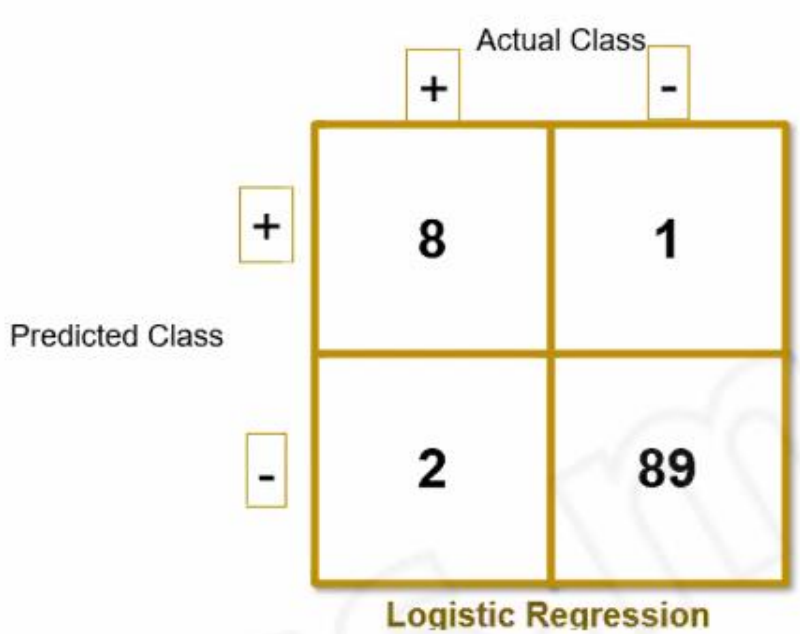
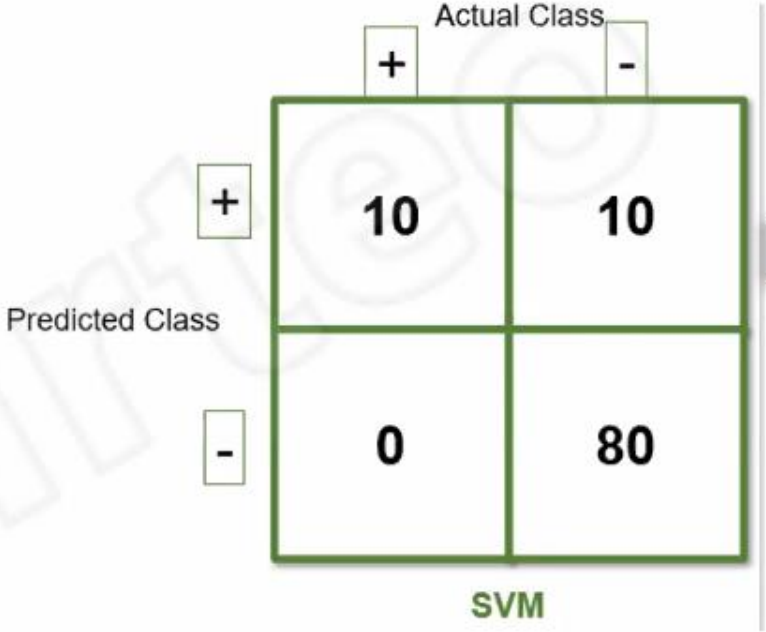
We can compare them!





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Accuracy: (TP+TN)/(TP+TN+FP+FN)	97%	90%
Precision: TP/(TP+FP)	89%	50%
Recall:	80%	100%

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	Predicted class POSITIVE (spam ✉)	Predicted class NEGATIVE (normal 📧)
Actual class POSITIVE (spam ✉)	TRUE POSITIVE (TP) ✉ ✉ **320**	FALSE NEGATIVE (FN) ✉ 📧 **43**
Actual class NEGATIVE (normal ✉)	FALSE POSITIVE (FP) ✉ ✉ **20**	TRUE NEGATIVE (TN) ✉ 📧 **538**

Recall

$$= \frac{TP}{TP + FN}$$

$$= \frac{320}{320 + 43} = 0.882$$

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Precision

$$= \frac{TP}{TP + FP}$$

$$= \frac{320}{320 + 20} = 0.941$$

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Precision and Recall

Precision attempts to answer the following question:

What proportion of positive identifications was corre

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Recall attempts to answer the following question:

What proportion of actual positives was identified correctly?

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Support Vector Machines

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What are SVMs?

- SVMs are linear or non-linear classifiers that find a hyperplane to separate two class of data, positive and negative.
- SVM not only has a rigorous theoretical foundation, but also performs classification more accurately than most other methods in applications, especially for high dimensional data

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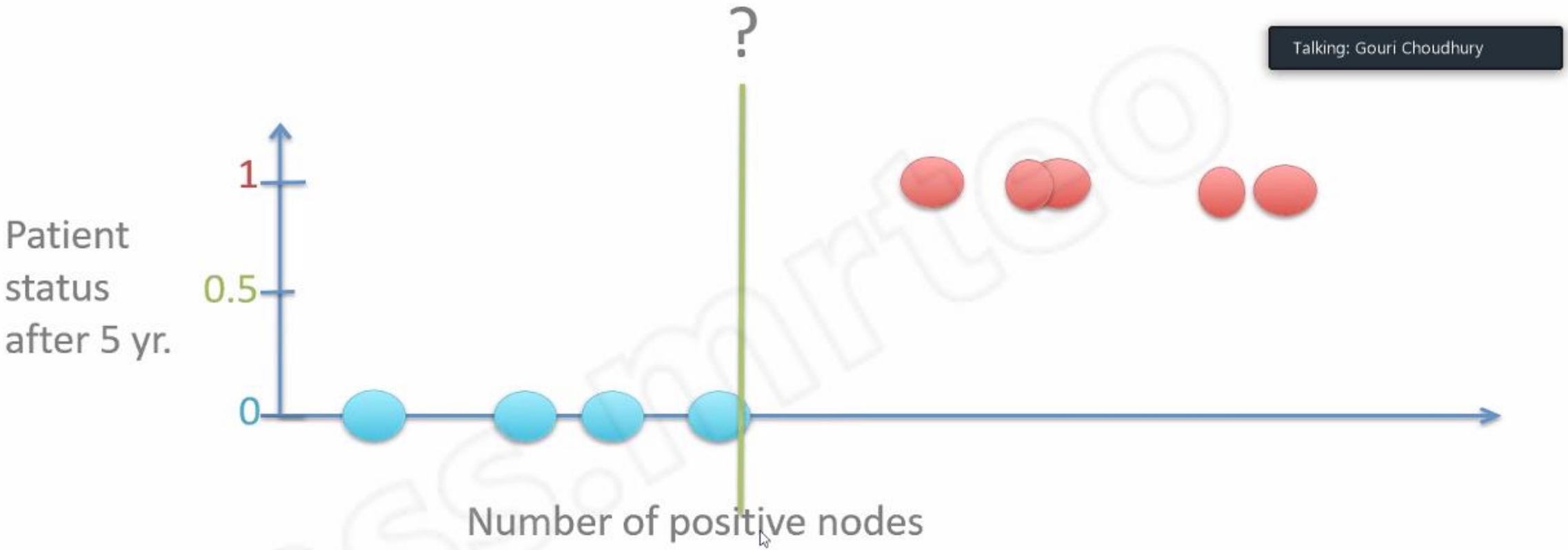
Support Vector Machine (SVM)



Accuracy: 100%

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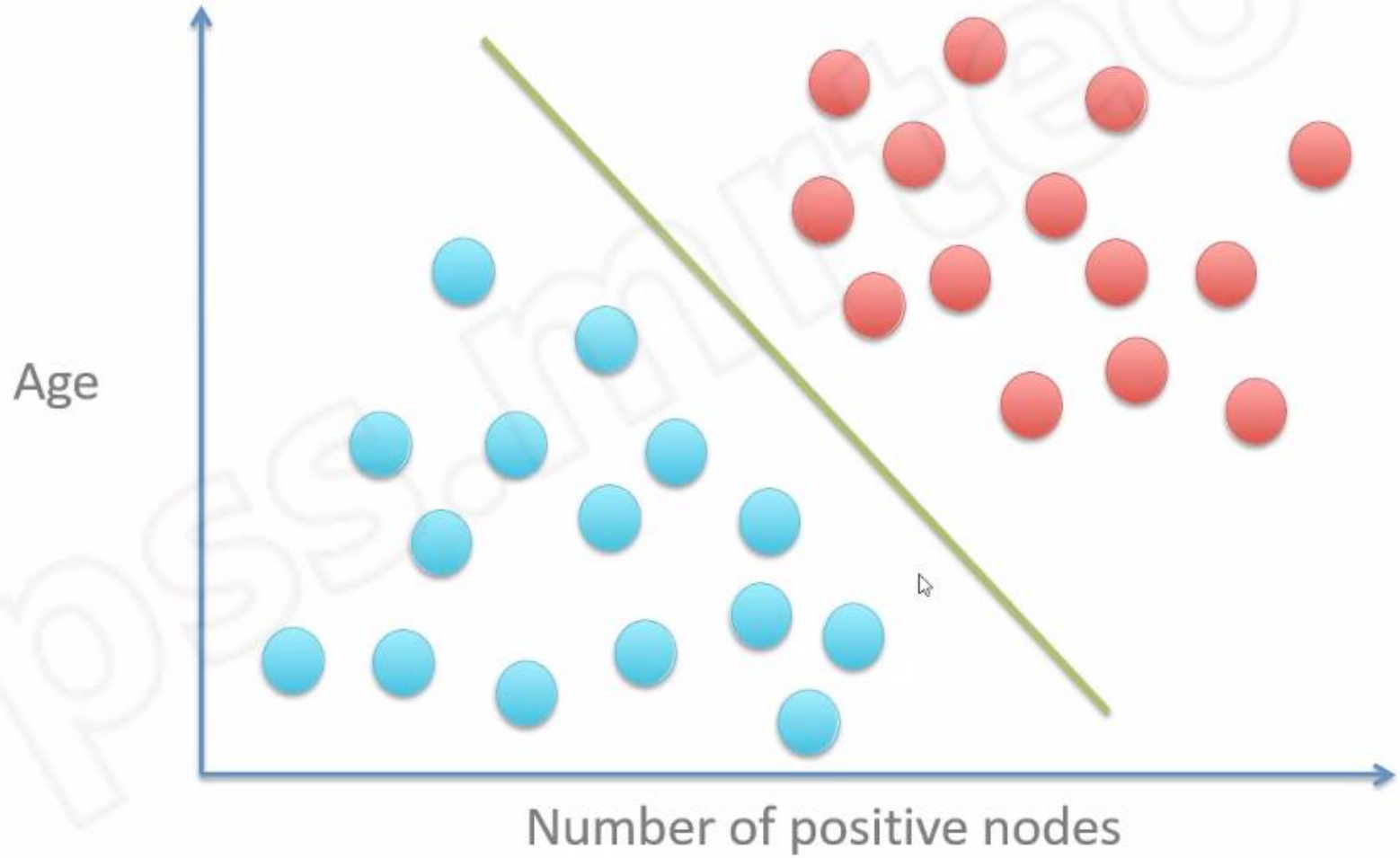

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Best boundary

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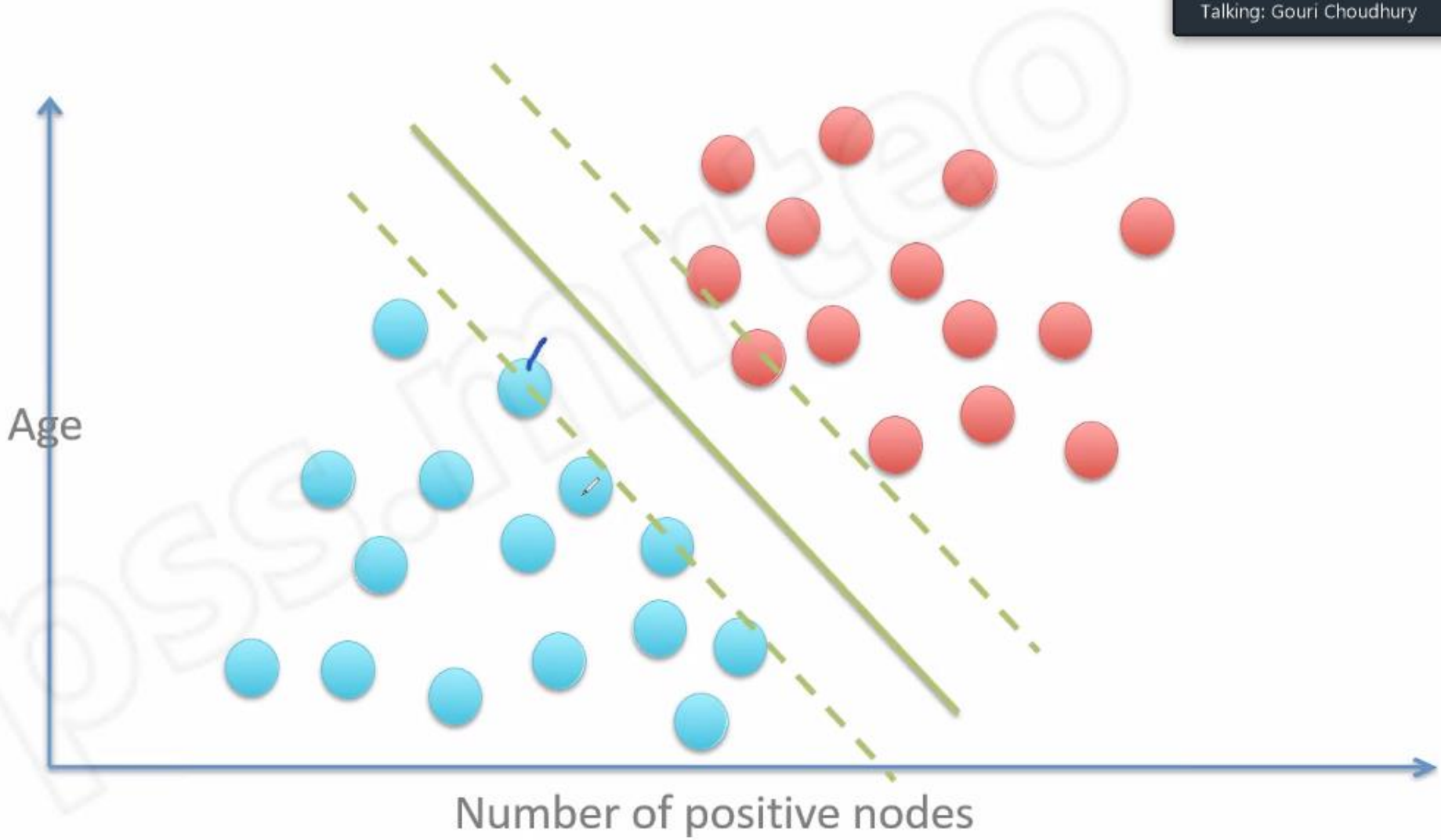

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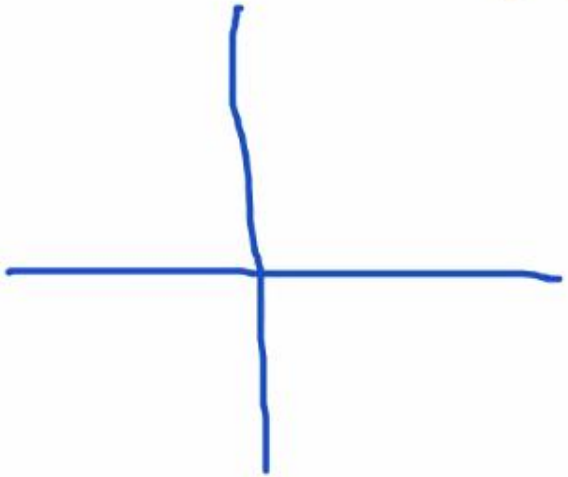
3 features: Find the best boundary plane

(More features: hyperplane)



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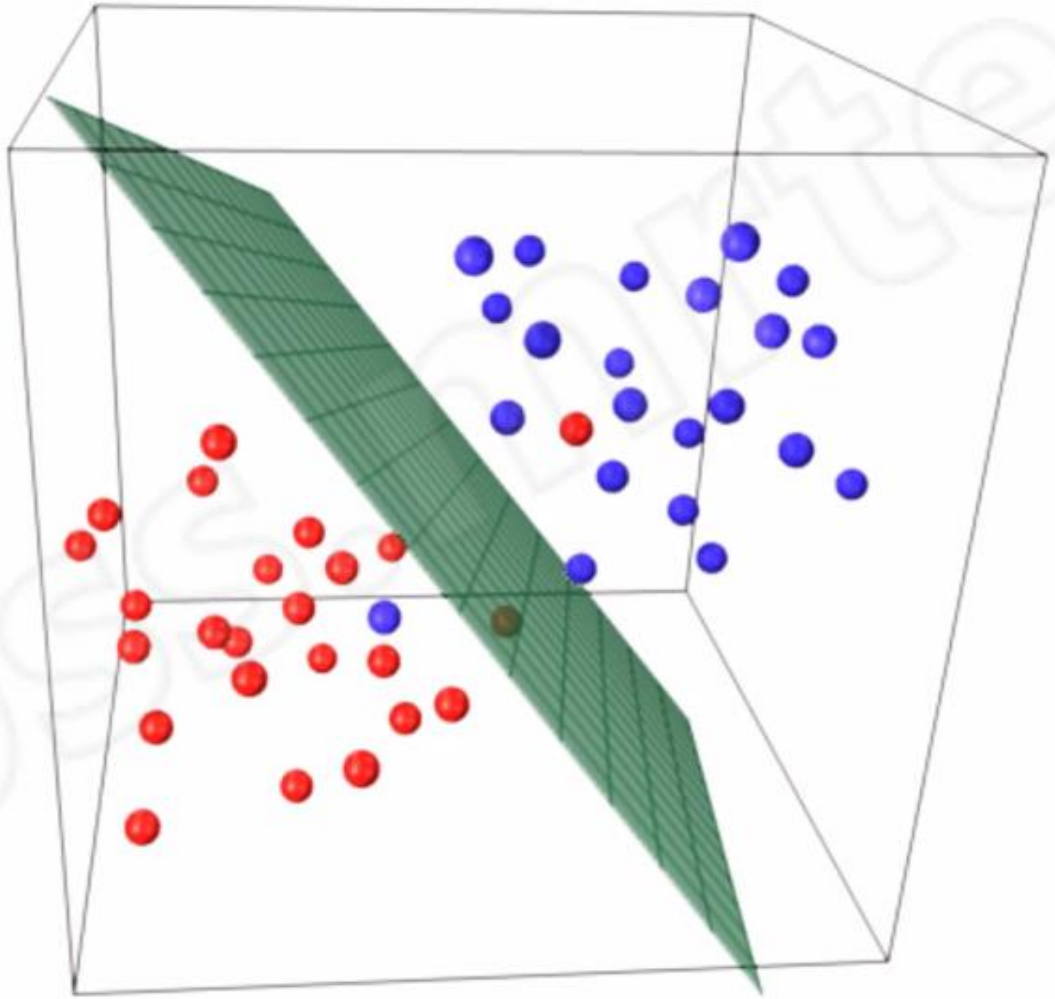

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What is a hyperplane?

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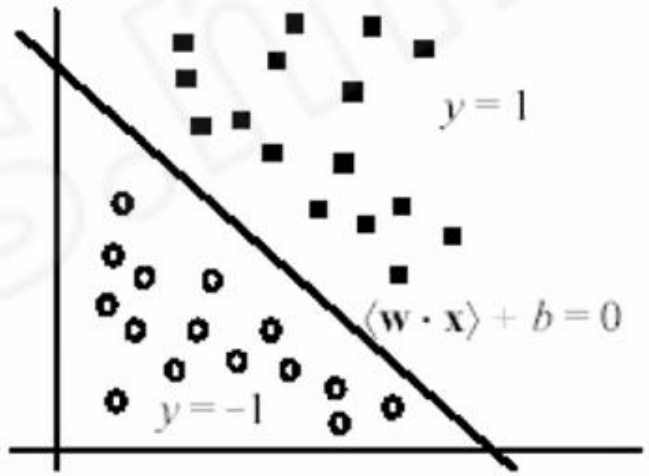
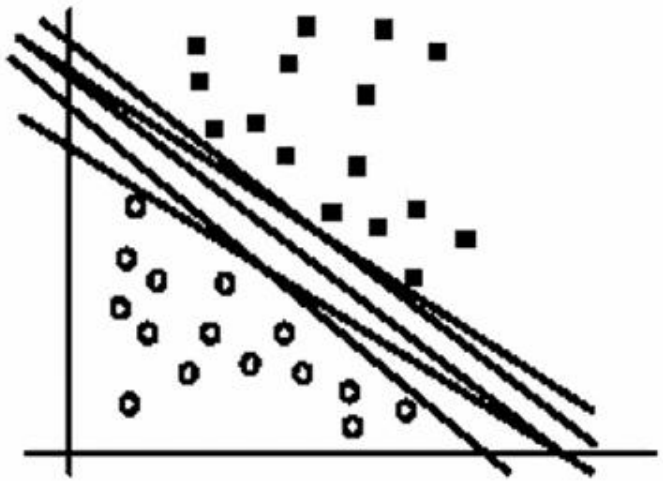
- The hyperplane that separates positive and negative training data is

$$\langle \mathbf{w} \cdot \mathbf{x} \rangle + b = 0$$

- It is also called the decision boundary (surface).





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Pros

- Accuracy
- Works well on smaller cleaner datasets
- It can be more efficient because it uses a subset of training points

Cons

- Isn't suited to larger datasets as the training time with SVMs can be high
- Less effective on noisier datasets with overlapping classes

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Each inner node is a decision based on a feature
Each leaf node is a **class label**

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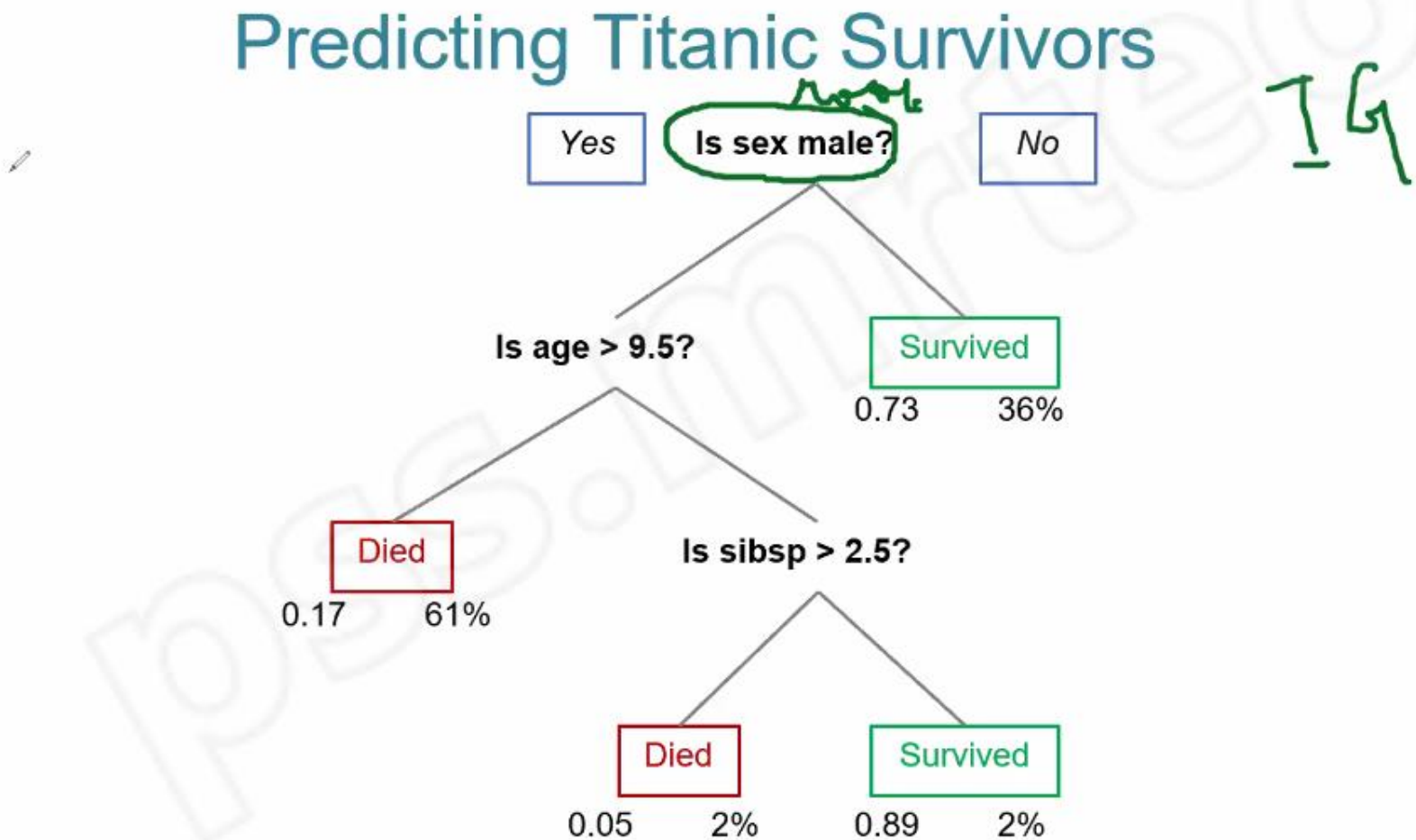

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Build tree split by split,
Find the best split you can at each step

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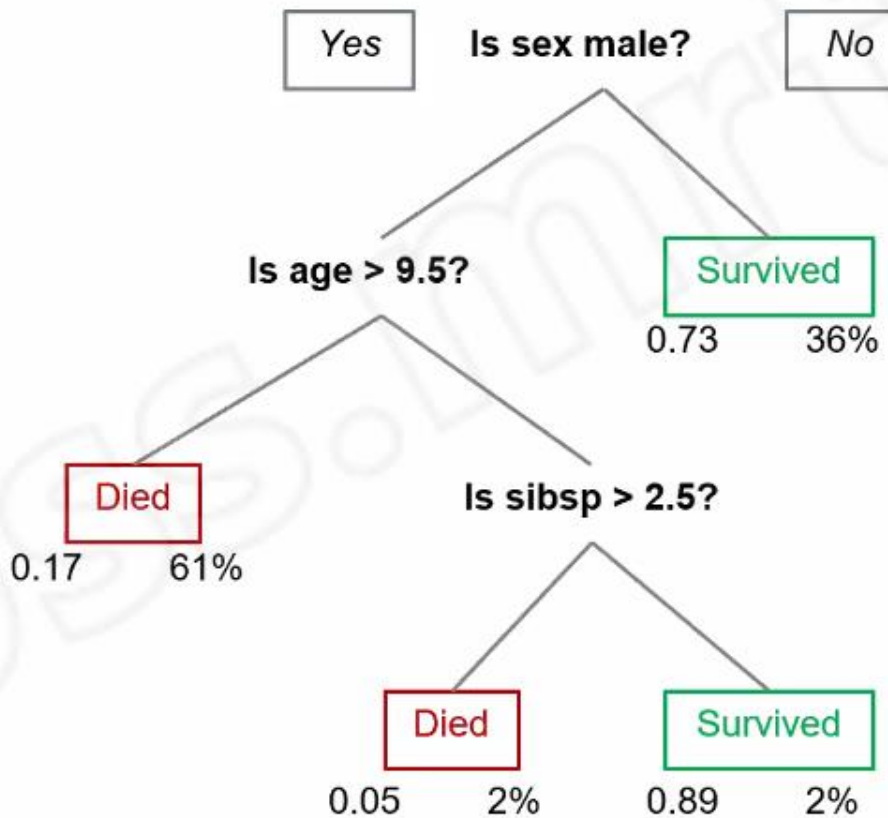

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Strengths of decision tree methods

- Generates understandable rules.
- Perform classification without requiring much computation.
- able to handle both continuous and categorical variables.
- Provides a clear indication of which fields are most important for prediction or classification.
- Natural multiclass classifier.

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Weaknesses of decision tree

- It is less appropriate for estimation tasks where the goal is to predict the value of a continuous attribute.
- Prone to errors in classification problems with many class and relatively small number of training examples.
- Computationally expensive to train.
  - Growing a decision tree is computationally expensive.
  - At each node, each candidate splitting field must be sorted before its best split can be found.
- Small changes in input data can result in totally different trees.
- Can make mistakes with unbalanced classes.

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Financial Services

- Customer targeting/engagement
- Improved risk management
- Fraud detection in real-time

Retail & CPG

- Multi-channel sales analysis & optimization
- Customer behaviour modeling
- Real-time recommendation engines

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Transportation

- Consumers choose time of home deliveries
- Fleet vehicle maintenance optimization
- Making logistics and fuel consumption less dependent on weather and traffic

E-commerce

- Analyze internet behavior and buying patterns
- Digital asset piracy

Telecommunications

- Customer churn & experience analysis
- Network service quality/predictive maintenance via sensor data

Utilities

- Service Quality Optimization
- Weather impact analysis on power generation
- Smart meter data analysis

Call Centers

- On-the-fly offer prompting
- Improved consumer experience
- Compliance verification

IT

- Network analysis & optimization
- Application log analysis (performance, threats, optimization

Healthcare

- E-Prescriptions
- Remote Patient Monitoring

Source: bigdata4analytics

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Talking:

A Self Organizing Map (SOM) is an example of which type of learning algorithm?

- Unsupervised Learning
- Supervised Learning

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Imagine, you are solving a classification problems with highly imbalanced class.

The majority class is observed 99% of times in the training data. Which of the following is a suitable metric to look at?

- Accuracy
- Precision
- Mean Absolute Error
- None of the above

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A feature F can take certain value: A, B, C, D, E, & F and represents grade of students from a college.

Which of the following statement is true?

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- Feature F is an example of nominal variable
- Feature F is an example of ordinal variable
- Both the above
- None of the ab

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At least eighty percent of the time spent on a Web-based data mining project is devoted to this

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- interpretation of results
- data mining
- goal identification
- data preparation

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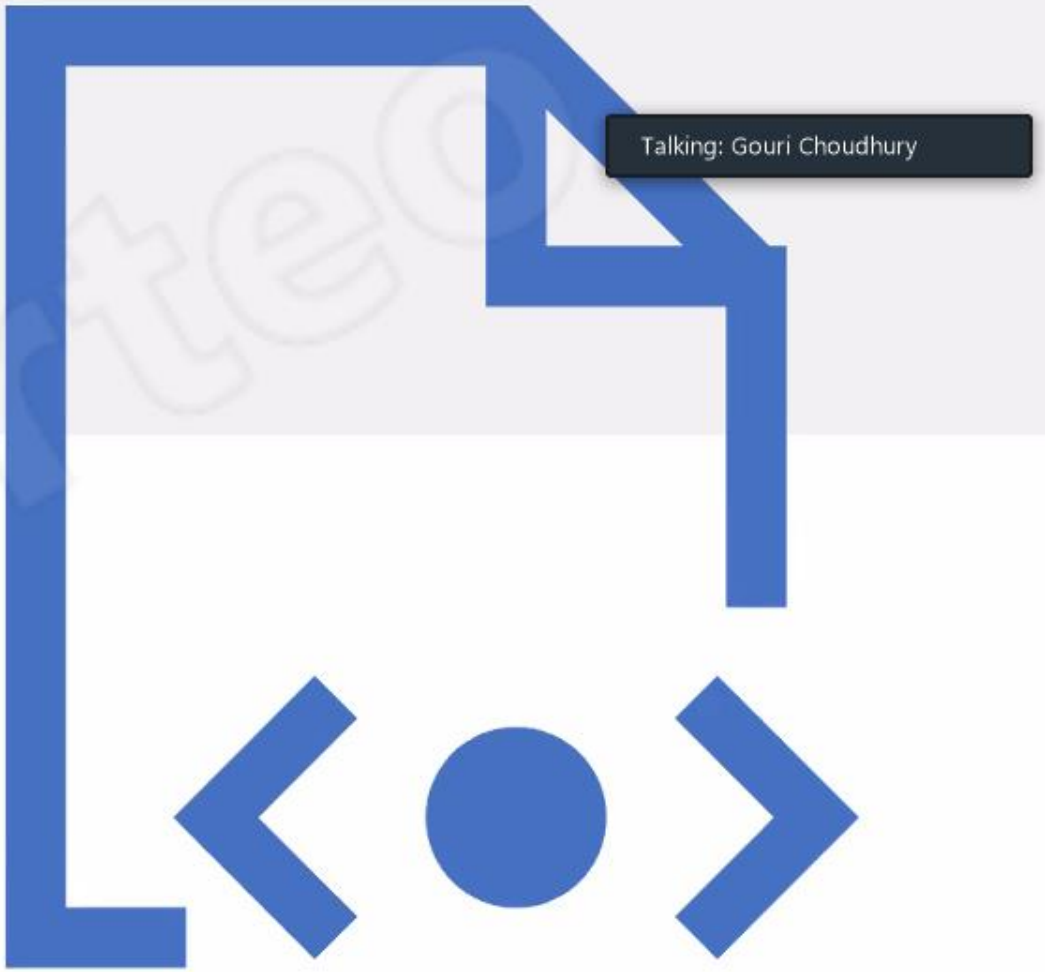
Which statement is true about the K-Means algorithm?



- All attribute values must be categorical
- The output attribute must be cateogrical
- Attribute values may be either categorical or numeric
- All attributes must be numeric

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The correlation between the number of years an employee has worked for a company and the salary of the employee is 0.75.

What can be said about employee salary and years worked?

- Individuals that have worked for the company the longest have higher salaries
- There is no relationship between salary and years worked
- Individuals that have worked for the company the longest have lower salaries.
- The majority of employees have been with the company a long time.

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Simple regression assumes a

_____

relationship between the input attribute and output attribute

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- quadratic
- reciprocal
- inverse
- linear

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A correlation coefficient enables you to:

- establish whether the data is telling you what you think it should tell you.
- quantify the strength of the linear relationship between two ranked or quantifiable variables.
- assess whether two variables measure the same phenomenon.
- measure the difference between two variables.

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Exploratory Data Analysis (EDA) is:

- A set of statistical methods specially designed for exploring a small, unruly data set and identifying any abnormalities in distribution or highly unusual scores
- The stage at which the data are described by the traditional measures of central tendency, spread and distribution shape
- Especially appropriate for nominal data
- Of limited value because no formal statistical tests are made

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The average squared difference between classifier predicted output and actual output

- mean squared error
- root mean squared error
- mean absolute error
- mean relative error

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