

LECTURER: MAX MUSTERMANN

# DATA UTILIZATION

## TOPIC OUTLINE

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**Introduction to Data Utilization**

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1

**Pattern Recognition**

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**Natural Language Processing (NLP)**

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3

**Image Recognition**

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4

**Detection and Sensing**

5

## TOPIC OUTLINE

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**Problem-Solving**

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6

**Decision Support**

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7

**Data Security and Data Protection**

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8

**UNIT 2**

# **PATTERN RECOGNITION**



On completion of this unit, you will have learned ...

- ... definitions of pattern recognition and its real-world applications.
- ... definitions of user attitude, behavior, dissonance, and consonance.
- ... the concept of big data and its main characteristics.
- ... how to conduct research using online data such as Google Trends analytics.
- ... the predictive analytics process.
- ... well-known predictive algorithms such as regression, decision tree, and neural network.



1. What is pattern recognition and why is it needed in data analytics?
2. What are the different statistical and machine learning techniques available for predictive analytics? Are all of them reliable and accurate?
3. How can we design a neural network models' structure and evaluate the process?

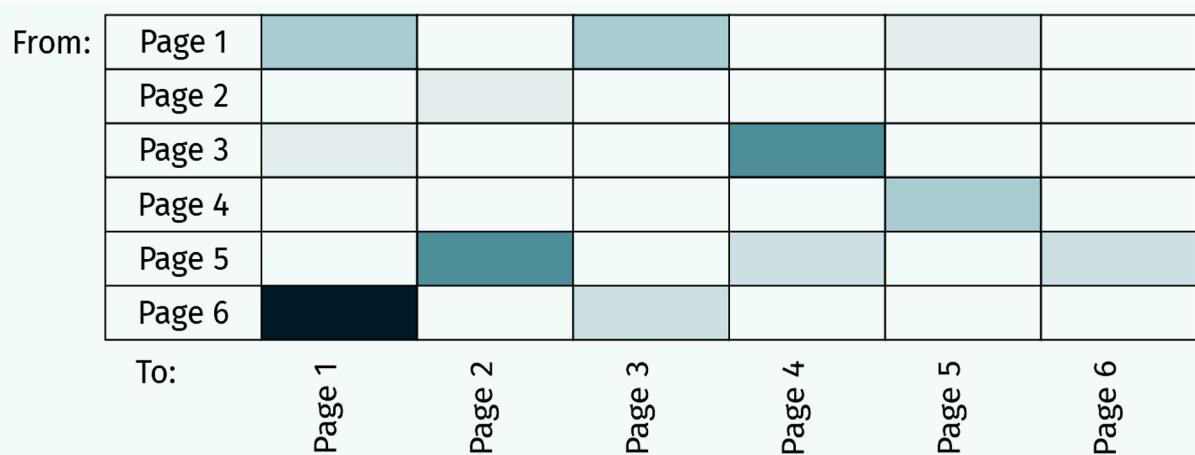
- Automated recognition of patterns and regulations in data using **AI** and **machine learning** techniques.
- Used in **predictive and prescriptive analytics**.
- Predictive analytics with the aim of finding future trends, improves different sectors.
  - **Predicts future sales and customers' demands**
  - **Personalizes drug combinations to cure leukemia**
  - **Personalizes products and services for customers**

- **Attitude:** feelings, tendencies, and beliefs determining how a person behaves
- **Behavior:** including actions taken in accordance to a person's attitude
- **Cognitive dissonance:** tension caused by inconsistency between one's attitudes and behavior
- **Cognitive consonance:** relief offered by consistency between one's attitudes and behavior

## CLICKSTREAM ANALYTICS

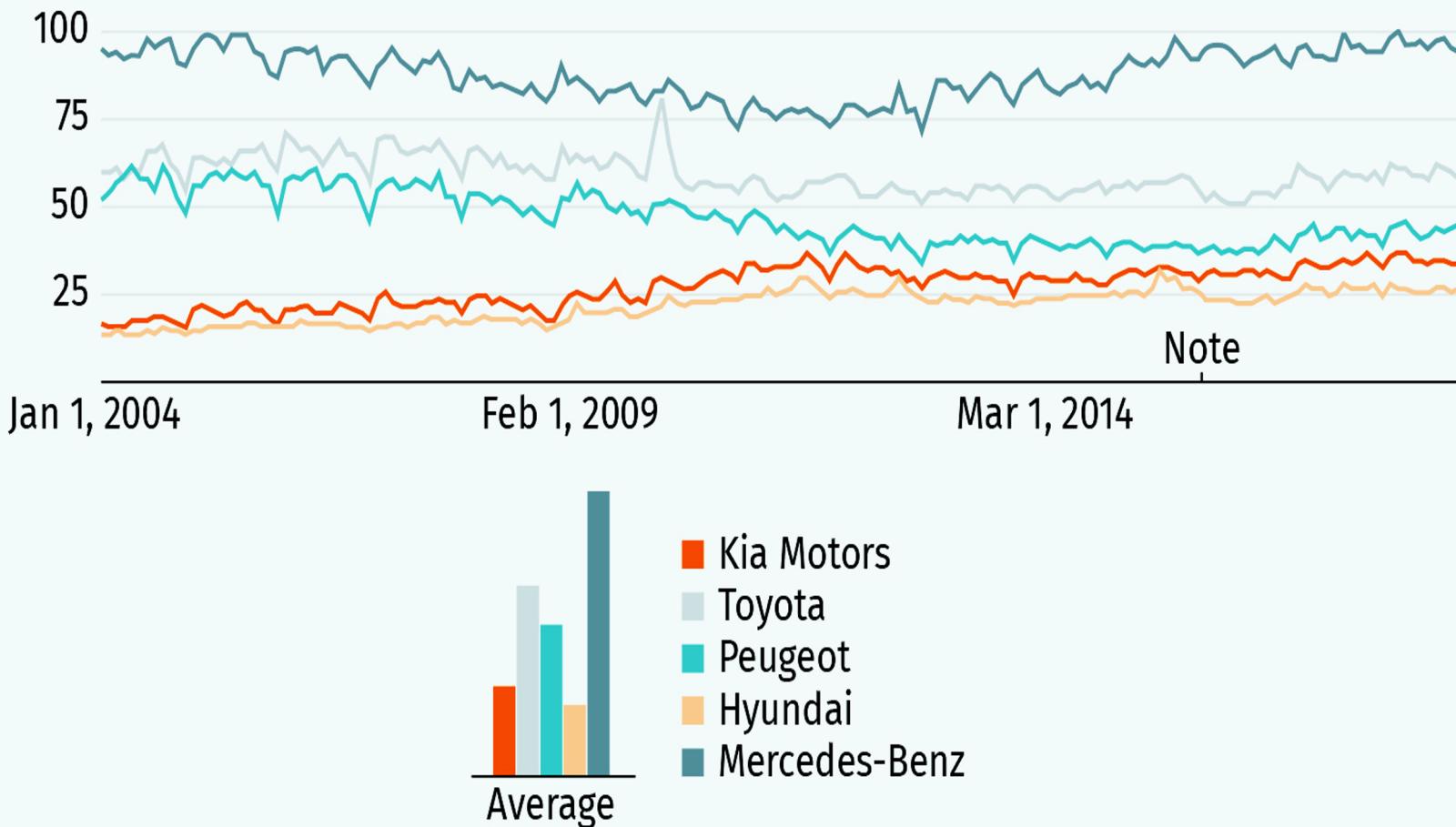
- Process of collecting, analyzing, and reporting aggregated data about user's **website activity** and the sequence of web pages they have visited
- **Aim:** providing 360-degree view of the customer by identifying their interests
- **How:** clickstream analytics log and analyze all events occurring within the *time interval between user login and logout* (e.g., user session)

- Markov chain:
  - A **stochastic** model used to describe the sequence of events where the **probability** *is a function of the current state.*
  - *predicts user's next click.*
- Clustering:
  - **Finds users with similar patterns of visiting webpages**
- Big data analytics:
  - **Apache Spark, SAP HANA**



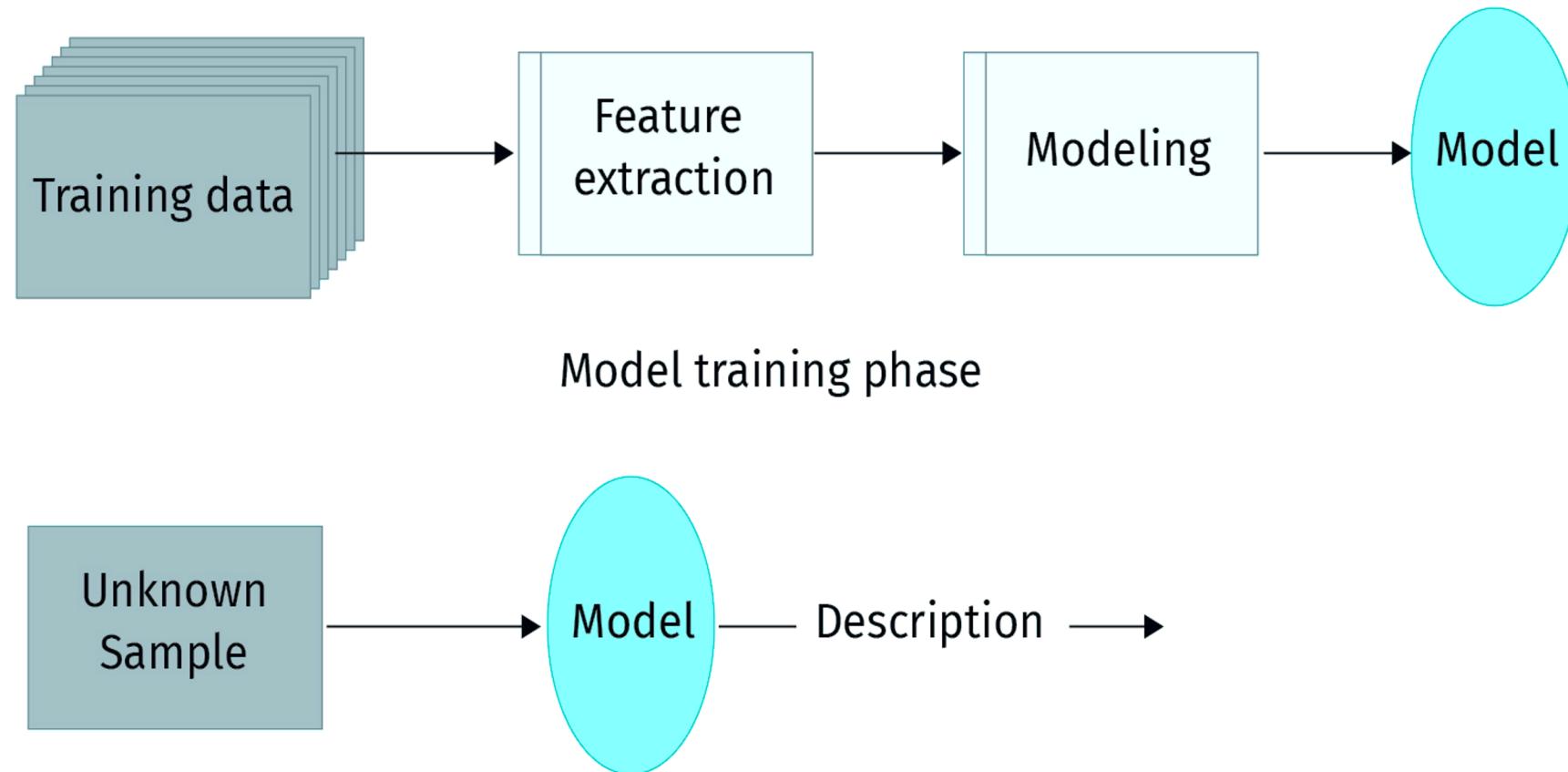
- Clickstream analytics is a practical tool for understanding **customer's online activities.**
- **Google Trends** has made it possible to analyze the relative popularity of search enquiries in Google searches over time.
- Google Trends data for searches related to automobile sales were used to investigate the correlation between forward planning and GDP.

## CLICKSTREAM ANALYTICS APPLICATION AND TOOLS



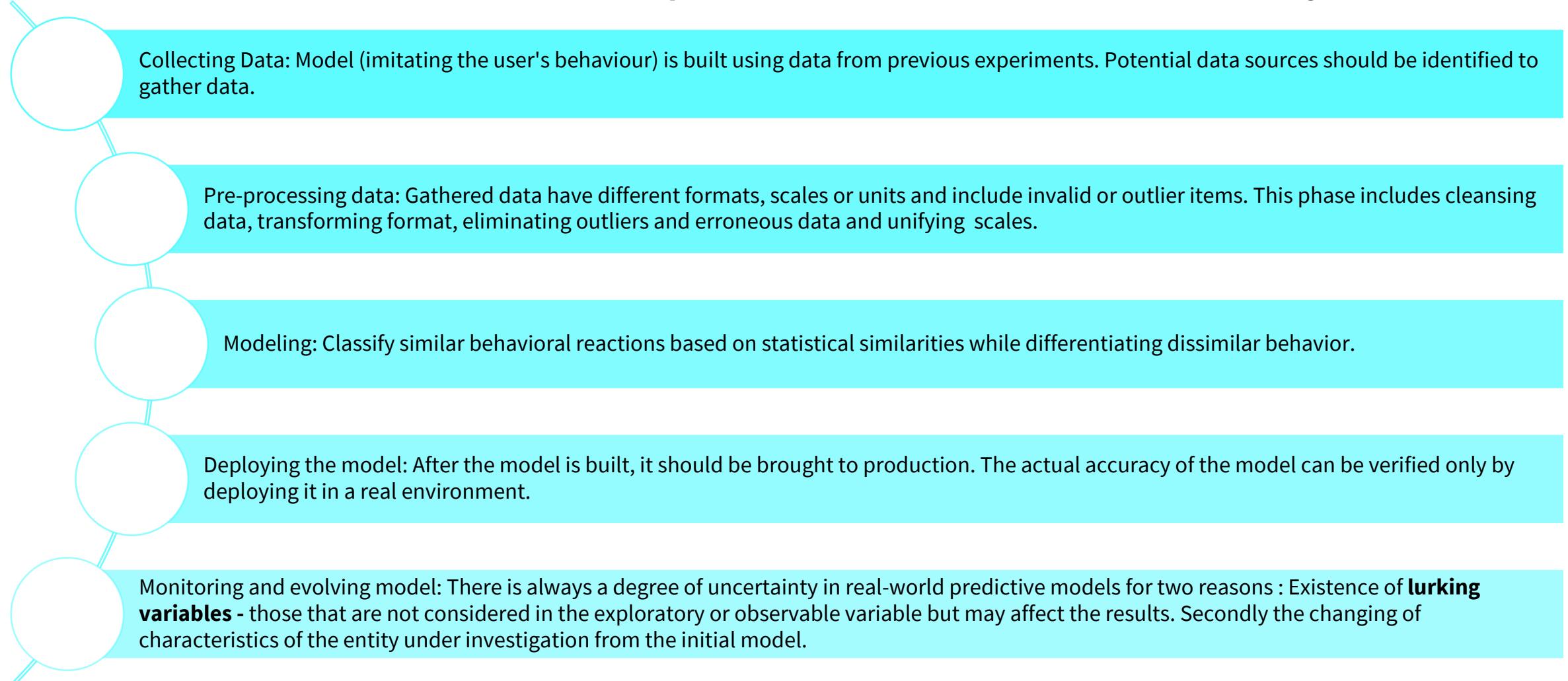
- **Prediction:** an estimation or forecast of future outcomes based on knowledge of the past.
- Requires identification of factors that have occurred in the past and appear to have influenced the outcome we are trying to predict.
- While developing a predictive model, one should consider the **impact** of each characteristic in the data and the **correlation** between them, all while **minimizing** the rate of misclassification.

## BUILDING AND USING A DESCRIPTIVE MODEL



## PROJECT AIM AND SCOPE DEFINITION

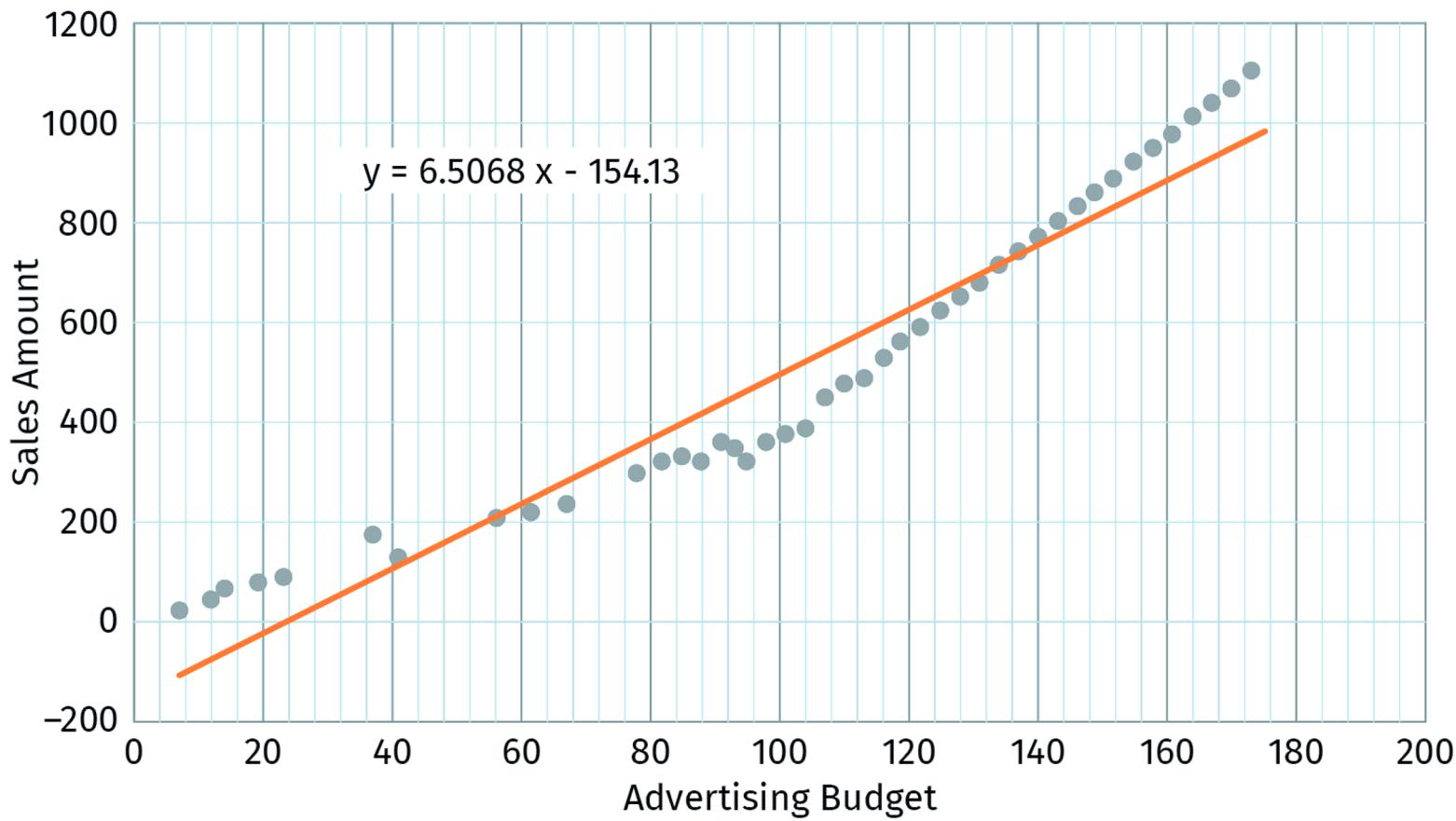
### – Predictive analysis aim: predict behavior of an entity



- A statistical model relying on the probability distribution of input values and conditional probabilities.
- The knowledge or information available prior to the experiment incorporating our backgrounds, or domain and knowledge, are considered as **a-priori information**; this information is the core part of the **Naïve Bayes** analysis.
- The data used for developing a model is a subset of a total set of observable data.

- Determines the existing relationship between a dependant variable (target/responsive variable) and one or more independent variables/predictors.
- Predictor variables could be demographic, geographical, or domain-specific variables.
- Regression reveals how the value of a response variable changes when one of its predictors is varied while the other predictors remain fixed.

## REGRESSION

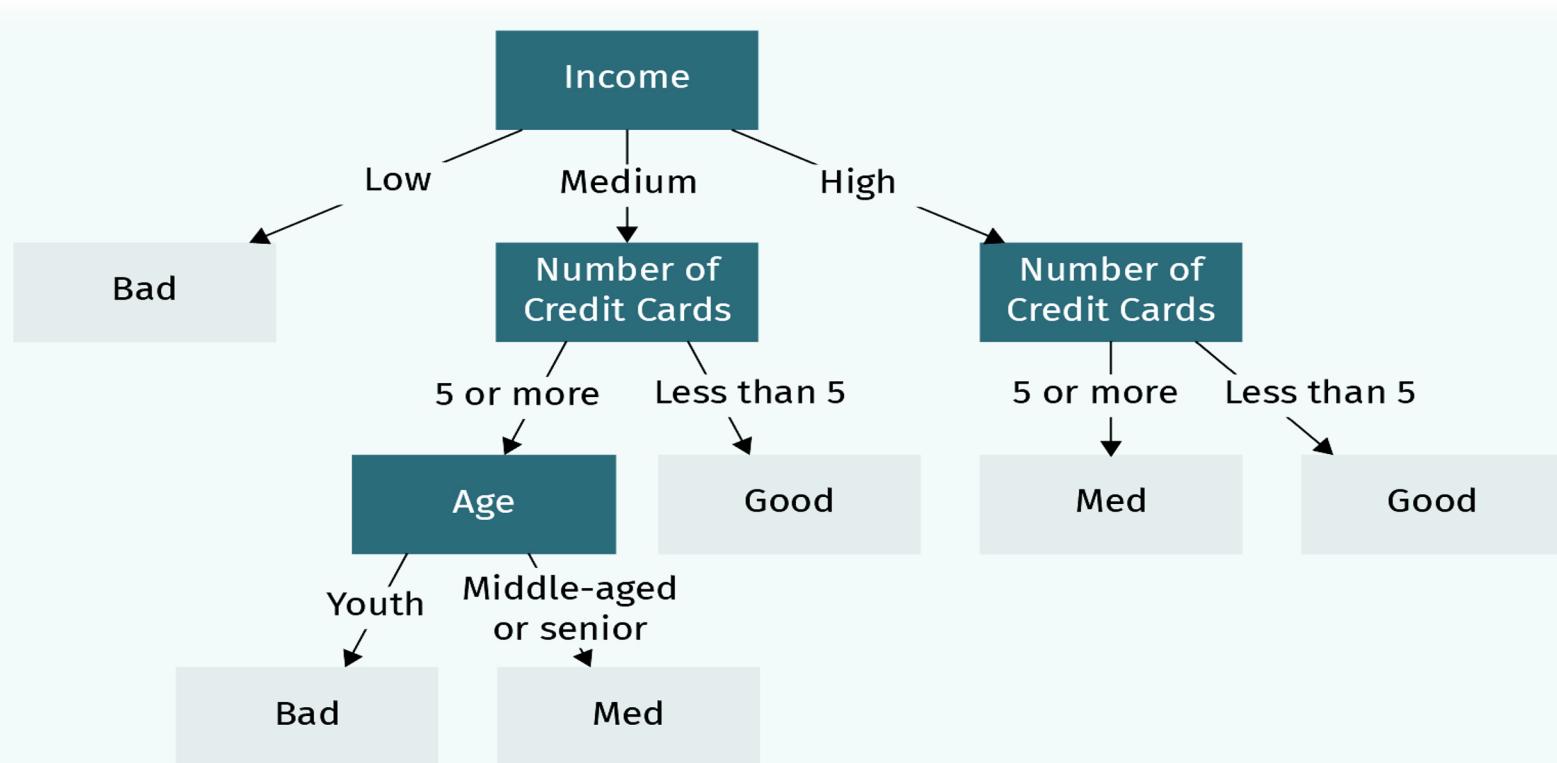


## DECISION TREE

- Using a branching model to show each possible outcome of a decision.
- A classification method made up of decision nodes and branches.
- Beginning with the root node, an attribute or combination of attributes are evaluated at each following decision node.
- Sequence of one or more decision nodes leads to a terminating leaf node.

## DECISION TREE

**Advantage:** A tree provides an easy way to interpret the results by creating a rule-based prediction system.



## C4.5 Algorithm

- extension of ID3 algorithm
- Tests every variable at each level of the tree and selects the best splitter.
- using information gain or entropy

## Classification and regression trees (CART)

- Construct binary decision tree (there are exactly two branches/ outcomes) at each decision node
- The best attribute at each level is selected based on the **Gini index**.

- Inspired by biological neural systems in animal brains.
- Dense network of neurons with large numbers of interconnections that can solve complex learning problems.
- Features in a neural network are obtained throughout the learning process and are not provided manually.
- A typical neural net consists of several input neurons (nodes) arranged in the input layer, then connected to hidden units in the hidden layer.

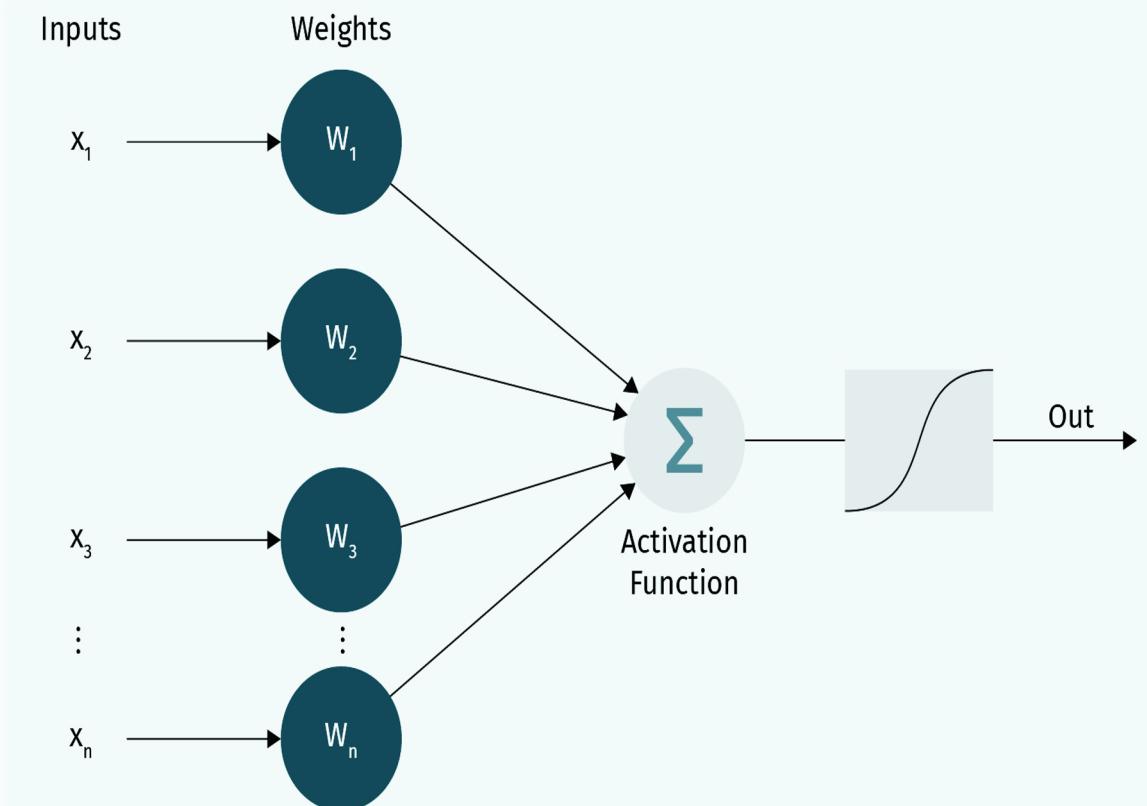
## AN ARTIFICIAL NEURON

- Each link between a neuron and its input has a weight.

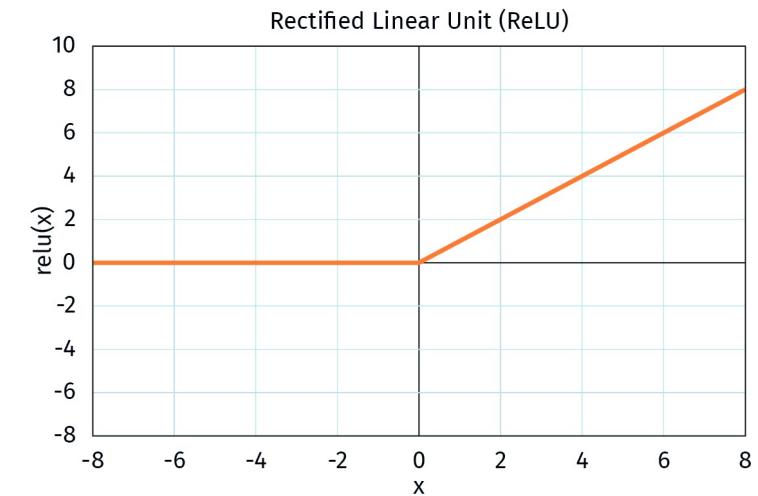
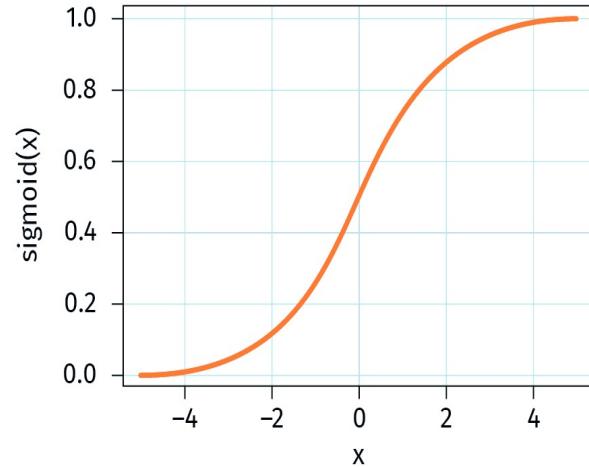
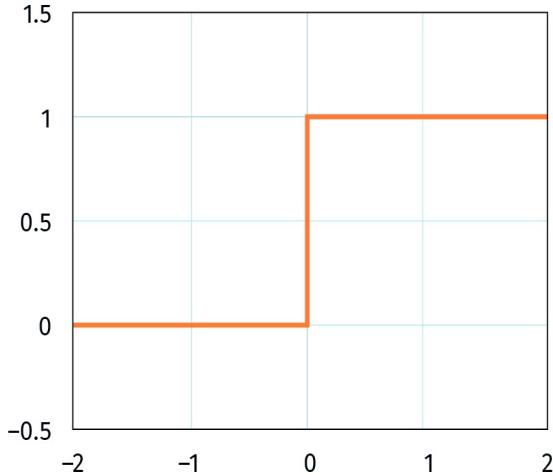
$$\text{net} = \sum w_i x_i = w_1 x_1 + \dots + w_n x_n$$

- An activation function is applied to determine the output.

$$y = f(\text{net})$$



## ACTIVATION FUNCTIONS



### Step Function

- Simulates the behavior of biological neurons.
- Defines a threshold for neural activation.

### Logistic Sigmoid

- Nonlinear function (continuous version of step)

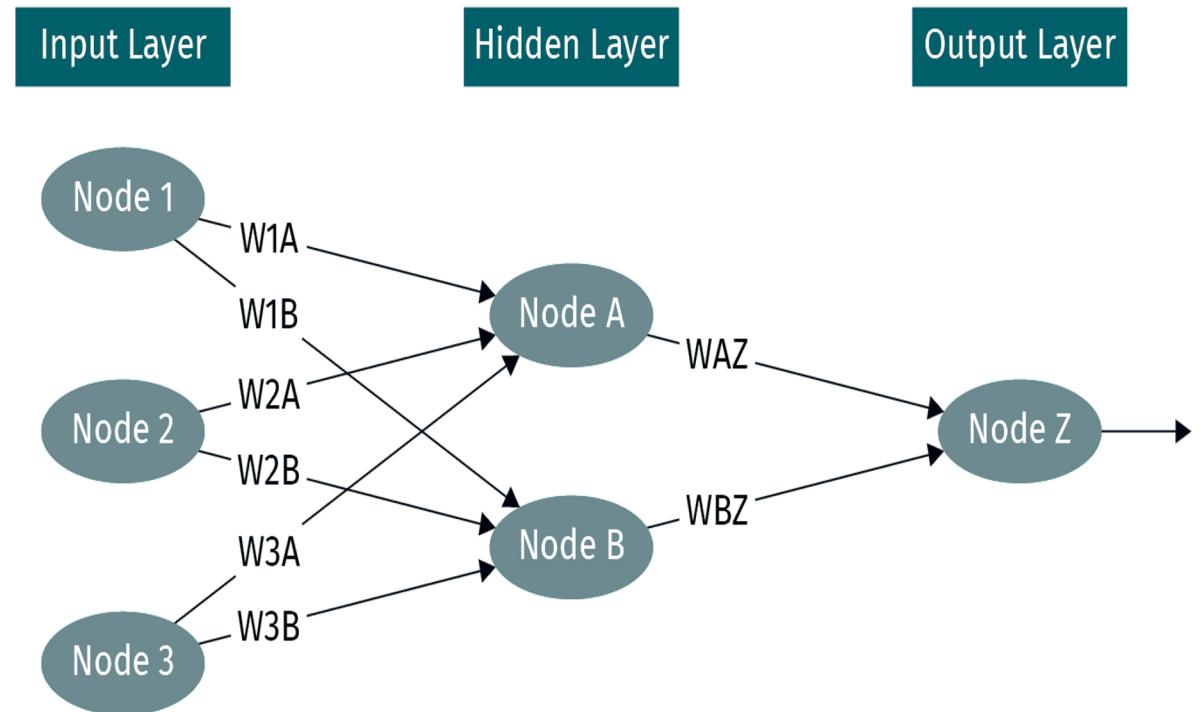
$$f(x) = \frac{1}{1 + e^{-x}}$$

### Rectified Linear Unit (ReLU)

$$\text{ReLU}(x) = \max(x, 0) = \begin{cases} x & x > 0 \\ 0 & x \leq 0 \end{cases}$$

## NETWORK ARCHITECTURE

- Fully-connected network  
(each neuron in a layer is connected to all neurons in the next layer)
- Feedforward network  
(signal flows in a forward direction, no closed loop)

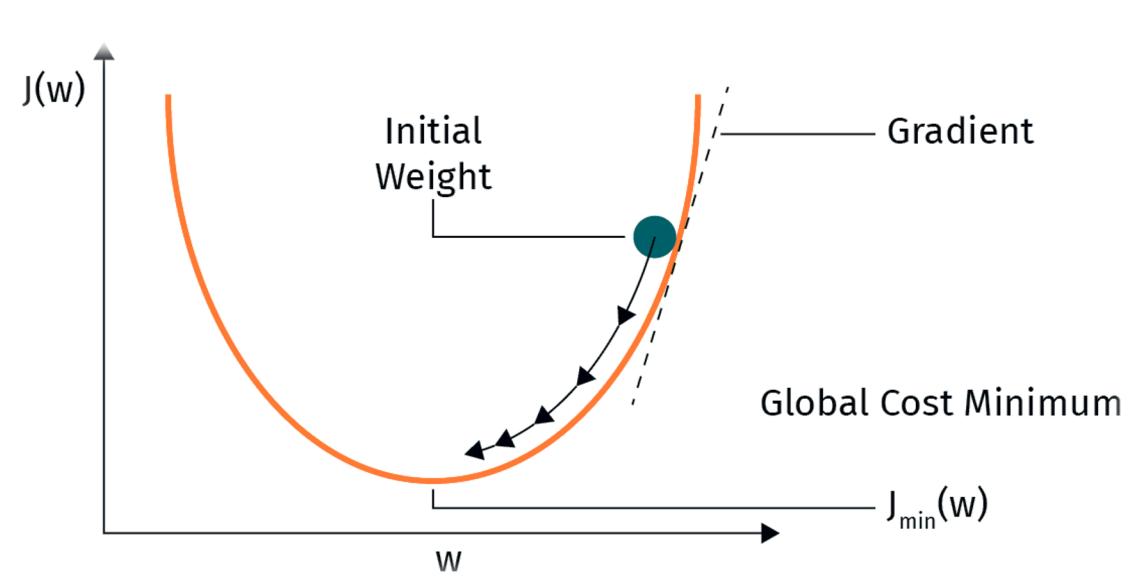


- Learning = learning weights
- Weights are initialized with random values or with a special procedure like Glorot initialization.
- Error for training sample: the discrepancy between calculated output and the predetermined target value
- Methods of measuring discrepancy:
  - **sum of squares error (SSE)**
  - **cross entropy error function**

**SSE**

$$\text{SSE} = \sum_{\text{instances}} \sum_{\text{output nodes}} (\text{actual value} - \text{predicted value})^2$$

- Find a set of weights to minimize SSE
- Gradient descent method as the optimization method to specify the direction in which the weight should be adjusted



$$\nabla \text{SSE}(W) = \left[ \frac{\partial \text{SSE}}{\partial w_0}, \frac{\partial \text{SSE}}{\partial w_1}, \dots, \frac{\partial \text{SSE}}{\partial w_m} \right]$$

$$W^{(\tau+1)} = W^{(\tau)} - \alpha \nabla \text{SSE}(W)$$

## LIMITATIONS OF PREDICTION

- Limitations of using data mining or machine learning techniques in predicting future events:
  - **dependence on historical data**
  - **dependence on the quality of data**
  - **bias**
  - **overfitting**
  - **selectivity**



On completion of this unit, you will have learned ...

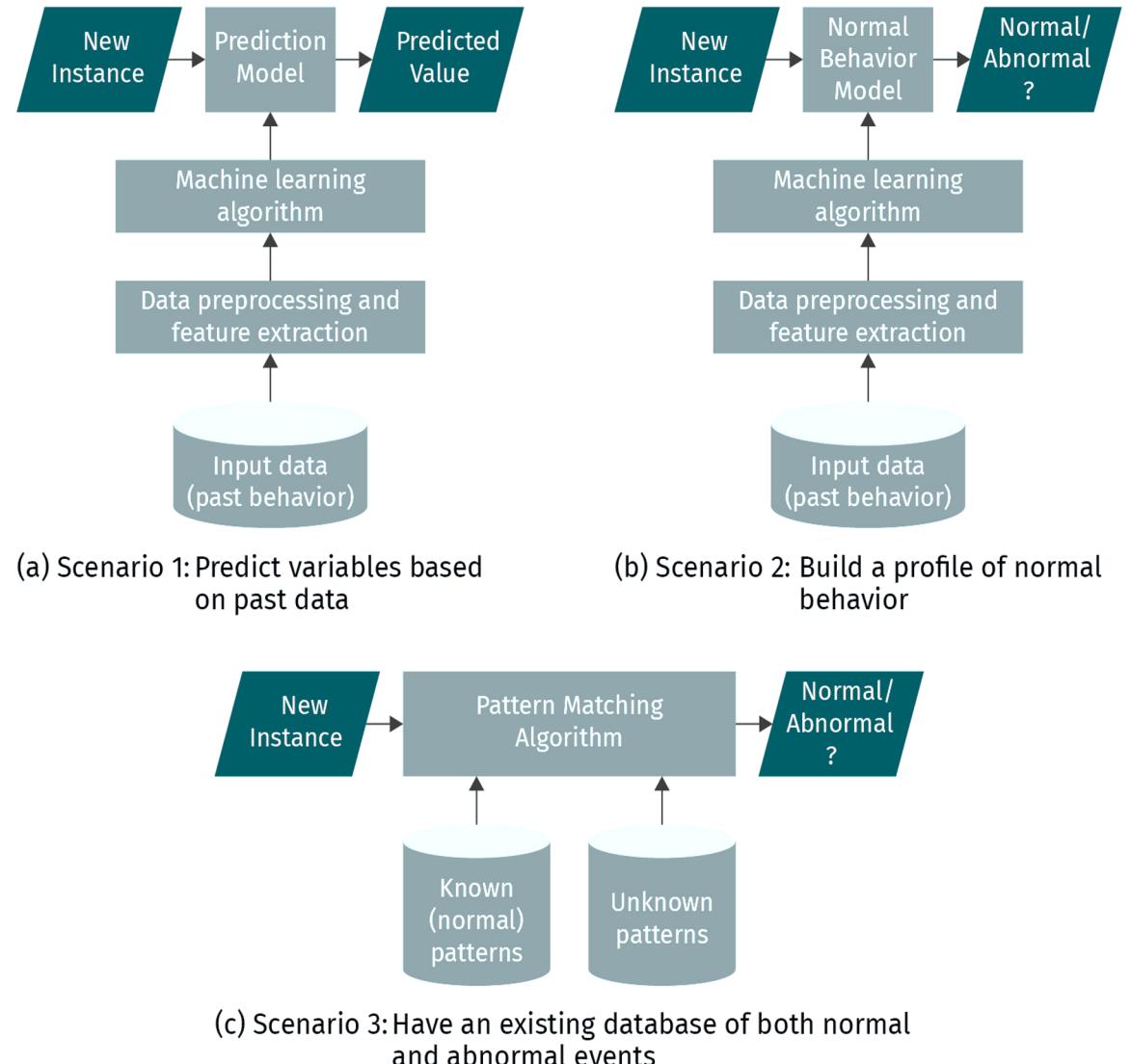
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**SESSION 2**

# **TRANSFER TASK**

## TRANSFER TASKS

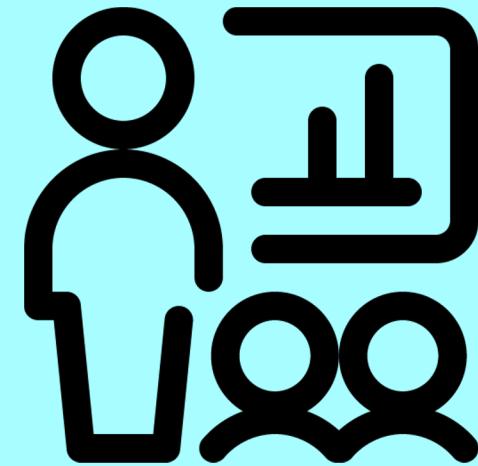
Based on the three following proposed models of distinguishing normal events from abnormal events in an existing database, **try to explain** the how cyber security systems protect the systems from cybercrimes and reduce the associated costs.



**TRANSFER TASK**  
**PRESENTATION OF THE RESULTS**

Please present your  
results.

The results will be  
discussed in plenary.





1. Which statement about decision trees is incorrect?

- a) All decision tree algorithms use information entropy to construct the tree.
- b) A decision tree is a classification technique.
- c) A single decision tree is easy to interpret.
- d) A set of decision trees (forest) produces more.



2. Which technique is used to minimize the error of a neural network?

- a) sigmoid function
- b) sum of squares error
- c) gradient descent
- d) randomized weights



3. Which of the following is a stochastic model used to describe a sequence of events where the probability of the next event is a function of the current state only.
- a) regression model
  - b) Markov model
  - c) neural network model
  - d) entropy

## LIST OF SOURCES

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