

EBU4203 Introduction to AI – Week 1 Tutorial 2023

Q1: STATE and EXPLAIN the THREE ways that an experiment can fail when uncertainties are not considered appropriately.

LAZINESS: too much work to list the complete set of antecedents or consequents needed to ensure an exceptionless rule and too hard to use such rules.

THEORETICAL ignorance: Medical science has no complete theory for the domain.

PRACTICAL ignorance: Even if we know all the rules, we might be uncertain about a particular patient because not all the necessary tests have been or can be run.

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Q2: STATE and EXPLAIN the THREE main types of learning in AI.

The type of learning depends on the feedback to learn from, there are 3 main types of learning, namely unsupervised learning, supervised learning and reinforcement learning.

1. Unsupervised learning: the agent learns patterns in the input even though no explicit feedback is supplied. (Example: detecting potentially useful clusters of input examples.)

Unsupervised machine learning is the training of models on raw and unlabelled training data. It is often used to identify patterns and trends in raw datasets, or to cluster similar data into a specific number of groups. It's also often an approach used in the early exploratory phase to better understand the datasets.

The vast majority of available data is unlabelled, raw data. By grouping data along similar features or analysing datasets for underlying patterns, unsupervised learning is a powerful tool used to gain insight from this data. In contrast, supervised machine learning can be resource intensive because of the need for labelled data.

Unsupervised machine learning is mainly used to:

- Cluster datasets on similarities between features or segment data
- Understand relationship between different data point such as automated music recommendations
- Perform initial data analysis

2. Supervised learning: the agent observes some example input–output pairs and learns a function that maps from input to output. (Example: the inputs are percepts and the outputs are provided by a teacher who says “Brake. or “Turn left.”).

Supervised machine learning requires labelled input and output data during the training phase of the machine learning model lifecycle. This training data is often labelled by a data scientist in the preparation phase, before being used to train and test the model. Once the model has learned the relationship between the input and output data, it can be used to classify new and unseen datasets and predict outcomes.

The reason it is called supervised machine learning is because at least part of this approach requires human oversight. The vast majority of available data is unlabelled, raw data. Human interaction is

generally required to accurately label data ready for supervised learning. Naturally, this can be a resource intensive process, as large arrays of accurately labelled training data is needed.

Supervised machine learning is often used for:

- Classifying different file types such as images, documents, or written words.
- Forecasting future trends and outcomes through learning patterns in training data.

3.Reinforcement learning: the agent learns from a series of reinforcements—rewards or punishments. (Example, the lack of a tip (reward) at the end of the journey gives the taxi agent an indication that it did something wrong.)

In reinforcement learning, developers devise a method of rewarding desired behaviors and punishing negative behaviors. This method assigns positive values to the desired actions to encourage the agent to use them, while negative values are assigned to undesired behaviors to discourage them. This programs the agent to seek long-term and maximum overall rewards to achieve an optimal solution.

Current uses include but are not limited to the following:

- Gaming.
- Resource management.
- Personalized recommendations.
- Robotics.

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Q3: Discuss the challenges and limitations of current AI technologies.

Data limitations: AI heavily relies on large amounts of high-quality data for training and learning. Limited or biased data can lead to inaccurate or biased AI systems.

Lack of interpretability: Many AI algorithms, such as deep neural networks, are considered black boxes, making it challenging to understand and interpret their decision-making processes.

Computing power and resource requirements: AI algorithms, particularly deep learning, often require significant computing power and resources, which can be a limitation for certain applications or organizations.

Q4: In class, 30% of students study History, 45% study Maths, and 15% study both History and Maths. If a student is randomly selected, what is the probability that he/she study History or maths?

Given that 45% study Math, i.e., $P(H) = 45/100 = 9/20$

30% study History, i.e., $P(M) = 30/100 = 6/20$

15% study both History and Maths, i.e., $P(H \cap M) = 15/100 = 3/20$

So, $P(H \cup M) = P(H) + P(M) - P(H \cap M)$

$= 9/20 + 6/20 - 3/20$

$= 12/20$

$$= 3/5$$

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$$\text{eq: } P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

Q5: Suppose that 10% of the registered patients of a chest clinic have been diagnosed with cancer. Also based on the clinic's data, 50% of its registered patients are smokers, and 80% of patients diagnosed with cancer are smokers. Suppose that patient X comes into the clinic for the first time. What is the probability that X will be diagnosed with cancer if we know that he is a smoker?

Solution:

We are given: $P(\text{cancer})=0.1$, $P(\text{smoker})=0.5$ and $P(\text{smoker}|\text{cancer})=0.8$

From simple Bayes, it follows that $P(\text{cancer}|\text{smoker}) = P(\text{smoker}|\text{cancer}) * P(\text{cancer}) / P(\text{smoker}) = (0.8 \times 0.1) / 0.5 = 0.16$

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$$\text{Eq: } P(A | B) P(B) = P(B | A) P(A)$$

Q6: The dataset in the table below has 10 observations belonging to two classes 'Yes' and 'No'. In the outcome, 6 observations belong to the class 'Yes', and 4 observations belong to class 'No'. Answer the following questions accordingly:

Grade	Colour	Outcome
Low	Red	Yes
Low	Red	No
Low	Yellow	Yes
Low	Yellow	Yes
Low	Red	Yes
High	Yellow	Yes
High	Red	No
High	Red	No
High	Red	Yes
High	Yellow	No

i) Compute the entropy of the outcome $H(\text{outcome})$.

Solution to i):

$$E(S) = - (6/10 * \log_2 6/10 + 4/10 * \log_2 4/10) \approx 0.971$$

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Using the equation for calculating the entropy

$$H(X) = - \sum_{i=1}^n P(X = i) \log_2 P(X = i)$$

- ii) Explain what will happen to the Entropy for $H(outcome)$ if all 10 observations belong to 1 class only, e.g., all outcomes are 'Yes'.

Solution to ii)

$$E(S) = -(1 \log_2 1) = 0$$

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Still using the equation for calculating the entropy

$$H(X) = - \sum_{i=1}^n P(X = i) \log_2 P(X = i)$$

- iii) Compute the entropy for $H(outcome|colour)$ and $H(outcome|grade)$.

$$H(outcome|colour) = -\frac{6}{10} \left(\frac{1}{2} \log_2 \frac{1}{2} + \frac{1}{2} \log_2 \frac{1}{2} \right) - \frac{4}{10} \left(\frac{3}{4} \log_2 \frac{3}{4} + \frac{1}{4} \log_2 \frac{1}{4} \right) = 0.92$$

$$H(outcome|grade) = -\frac{1}{2} \left(\frac{4}{5} \log_2 \frac{4}{5} + \frac{1}{5} \log_2 \frac{1}{5} \right) - \frac{1}{2} \left(\frac{2}{5} \log_2 \frac{2}{5} + \frac{3}{5} \log_2 \frac{3}{5} \right) = 0.84$$

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Using the equation for calculating the conditional entropy

$$H(Y|X) = - \sum_{x \in X} \sum_{y \in Y} p(x, y) \log_2 p(y|x)$$

- iv) Based on your answers in iii), Compute the Information Gain for both conditions.

$$IG(outcome, colour) = H(outcome) - H(outcome|colour) = 0.971 - 0.92 = 0.051$$

$$IG(outcome, grade) = H(outcome) - H(outcome|grade) = 0.971 - 0.84 = 0.131$$

Eq for calculating the information gain: $I(X_n, Y) = H(Y) - H(Y|X_n)$

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- v) Based on your answers in iv), state which attribute should be used as the root of a decision tree?

Grade

Choose the decision tree based on how much information we would gain from the decision. Since $IG(outcome, grade) > IG(outcome, colour)$, we choose Grade.