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Course: Artificial Intelligence
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Assignment 2
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Problem 1

Solution: Supervised learning, unsupervised learning, and reinforcement learning are three different approaches to machine learning. Each approach has its unique characteristics, advantages, and limitations.

- Supervised Learning: Supervised learning is a type of machine learning in which the model learns to make predictions based on labeled data. In supervised learning, the training data consists of input-output pairs, where the inputs are the features of the data and the outputs are the labels or categories.

  Example: One example of supervised learning is image classification. The goal is to classify images into different categories. The model is trained on a set of labeled images and learns to recognize patterns in the images that correspond to different categories.

- Unsupervised Learning: Unsupervised learning is a type of machine learning in which the model learns patterns and relationships in the data without explicit labels. The goal is to discover the underlying structure of the data.

  Example: One example of unsupervised learning is clustering. In clustering, the goal is to group similar data points together. For instance, a company might use clustering to group customers based on their purchasing behavior.

- Reinforcement Learning: Reinforcement learning is a type of machine learning in which an agent learns to make decisions by interacting with an environment. The agent receives feedback in the form of rewards or penalties based on the actions it takes in the environment. The goal of the agent is to learn a policy that maximizes the expected cumulative reward over time.

  Example: A common example is training a computer program to play a game. The program interacts with the game environment and learns which actions result in higher scores and which actions result in lower scores. Over time, the program learns a policy that maximizes the score.

Criteria	**Supervised ML**	**Unsupervised ML**	**Reinforcement ML**
Definition	Learns by using labelled data	Trained using unlabelled data	Works on interacting with the environment
Type of data	Labelled data	Unlabelled data	No – predefined data
Type of problems	Regression and classification	Association and Clustering	Exploitation or Exploration
Supervision	Extra supervision	No supervision	No supervision
Algorithms	Linear Regression, SVM, KNN etc.	K – Means, C – Means, Apriori	Q – Learning, SARSA
Aim	Calculate outcomes	Discover patterns	Learn a series of action
Application	Risk Evaluation, Forecast Sales	Recommendation Sys, Anomaly Detection	Self Driving Cars, Gaming, Healthcare

In summary, reinforcement learning is useful for decision-making problems where there is an interactive environment, unsupervised learning is useful for discovering patterns and relationships in data without explicit labels, and supervised learning is useful for making predictions based on labeled data.

Problem 2

Solution: Sepehr's model exhibits high bias and low variance, indicating that it is underfitting the data. This means that the model is not complex enough to capture the underlying patterns in the data, leading to significant errors in both the training and testing data.
To address this issue, Sepehr can consider the following strategies:

1. Increase the model's complexity by adding more features or increasing the number of hidden layers in the neural network. This can enable the model to better capture the patterns in the data and reduce the bias.

2. Increase the amount of training data to provide more examples for the model to learn from and improve its ability to generalize to new data.

On the other hand, Ali's model has low bias and high variance, indicating that it is overfitting the data. This means that the model is too complex and is memorizing the training data instead of generalizing to new data.
To address this issue, Ali can consider the following strategies:

1. Use regularization techniques such as L1, L2, or dropout regularization to prevent overfitting. These techniques can help reduce the variance by limiting the model's capacity to memorize the training data.

2. Simplify the model by reducing the number of features or hidden layers in the neural network. This can help reduce the model's complexity and improve its ability to generalize to new data.

Problem 3

Solution:

we know that;

$$\text{Entropy}: I(P(C_1), \ldots, P(C_k)) = -\sum_{i=1}^{k} P(C_i) \log_2 (P(C_i))$$

and; $H = I(P, 1-P)$

which; $H_{before} = I\left(\frac{P}{P+N}, \frac{N}{P+N}\right)$

and; $H_{after} = \sum_{i=1}^{k} \frac{P_i+N_i}{P+N} \cdot I\left(\frac{P_i}{P_i+N_i}, \frac{N_i}{P_i+N_i}\right)$

Now we have to find; $\text{Max}(H_{before} - H_{after})$

OR

$\text{Min}(H_{after})$

At first, we do calculations by sorting based on "Age".

the resulted table is something like below;

Take loan	Score credit	Income(1k)	Age
Yes			21
NO			25
NO			28
NO			37
NO			38
Yes			43
Yes			45
⋮	⋮	⋮	⋮

As it's obvious the two selected areas are the points where the answer changes; so, we use these points for our calculation and using multi branch Entropy we have;

$$H_{before} = I\left(\frac{4}{10}, \frac{6}{10}\right) = -\left(\frac{4}{10}\log_2\left(\frac{4}{10}\right)\right) - \left(\frac{6}{10}\log_2\frac{6}{10}\right) = 0.97$$

which is a good amount!

So we devide the table, considering this factor.

As a result we have 3 different scenarios;

1. Age < 23
2. Age > 23 & Age < 37.5 (23 < Age < 37.5)
3. Age > 37.5

Now we find the amount of entropy for these scenarios;

$$H_{after} = \frac{1}{10} \cdot I(1,0) + \frac{4}{10} \cdot I(1,0) + \frac{5}{10} \cdot I(1,0) = 0$$

$$\Rightarrow H_{before} - H_{after} = 0.97 - 0 = 0.97$$

According to the resulted amount, we can conclude that by deviding the data just for a time, we can reach the desired value. The result also can be conducted by using 'some credit' Colum.

So, the decision tree is something like this;