

## TOPIC NAME:

### What is Decision Theory?

Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment.

#### Key Takeaways

- Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment.
- Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision-making process.
- Descriptive, prescriptive, and normative are three main areas of decision theory and each studies a different type of decision making.

### Understanding Decision Theory

Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision-making process. Decision theory is closely related to [game theory](#) and is studied within the context of understanding the activities and decisions underpinning activities such as [auctions](#), evolution, and marketing.

There are three main areas of decision theory. Each studies a different type of decision making.

1. Descriptive decision theory: examines how irrational beings make decisions.
2. Prescriptive decision theory: tries to provide guidelines for agents to make the best possible decisions given an uncertain decision-making framework.
3. Normative decision theory: provides guidance for making decisions given a set of values.

Decision theory framework generally identifies three types of decision classes:

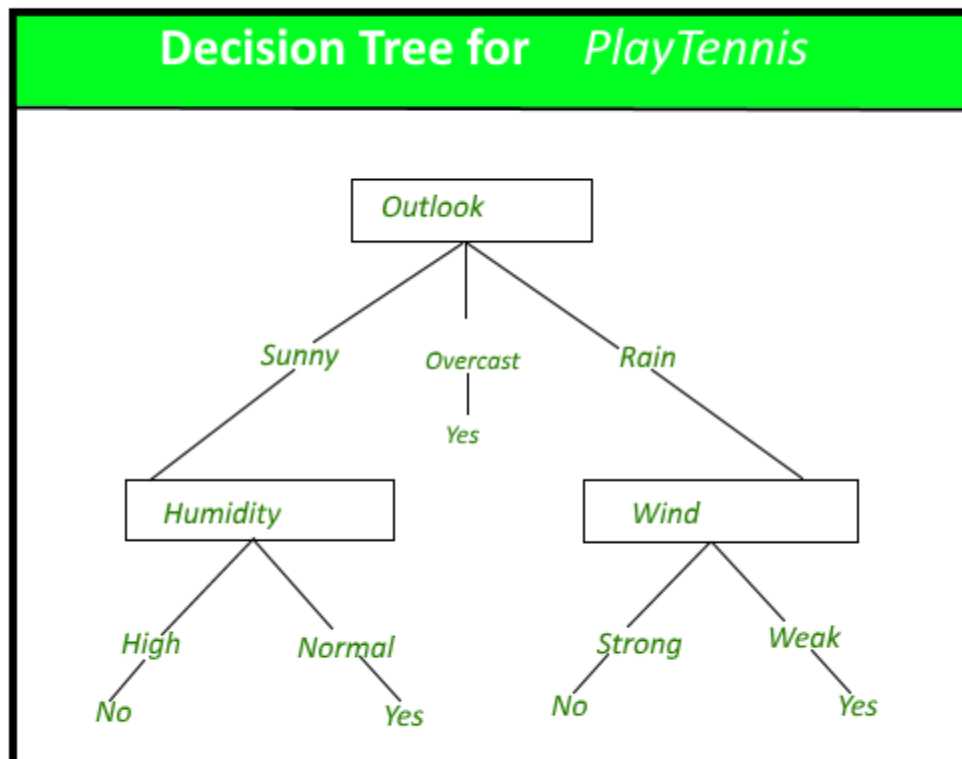
1. Decisions under certainty: an abundance of information leads to an obvious decision
2. Decisions under uncertainty: analysis of known and unknown variables lead to the best probabilistic decision.
3. Decisions under conflict: a reactive approach that involves anticipating potential consequences to the decision, prior to making a decision.

## Decision Under Uncertainty: Prisoner's Dilemma

A common example of decision theory stems from the [prisoner's dilemma](#) in which two individuals are faced with an uncertain decision where the outcome is not only based on their personal decision, but also on that of the other individual. Since both parties do not know what actions the other person will take, this results in an uncertain decision framework. While mathematics and statistical models determine what the optimal decision should be, psychology and philosophy introduce factors of human behaviors to suggest the most likely outcome.

### Decision Tree

Decision Tree : Decision tree is the most powerful and popular tool for classification and prediction. A Decision tree is a flowchart like tree structure, where each internal node denotes a test on an attribute, each branch represents an outcome of the test, and each leaf node (terminal node) holds a class label.



*A decision tree for the concept PlayTennis.*

Construction of Decision Tree :

A tree can be “*learned*” by splitting the source set into subsets based on an attribute value test. This process is repeated on each derived subset in a recursive manner called *recursive partitioning*. The recursion is completed when the subset at a node all has the same value of the target variable, or when splitting no longer adds value to the predictions. The construction of decision tree classifier does not require any domain knowledge or parameter setting, and therefore is appropriate for exploratory knowledge discovery. Decision trees can handle high dimensional data. In general decision tree classifier has good accuracy. Decision tree induction is a typical inductive approach to learn knowledge on classification.

Decision Tree Representation :

Decision trees classify instances by sorting them down the tree from the root to some leaf node, which provides the classification of the instance. An instance is classified by starting at the root node of the tree, testing the attribute specified by this node, then moving down the tree branch corresponding to the value of the attribute as shown in the above figure. This process is then repeated for the subtree rooted at the new node.

The decision tree in above figure classifies a particular morning according to whether it is suitable for playing tennis and returning the classification associated with the particular leaf. (in this case Yes or No).

For example, the instance

(Outlook = Rain, Temperature = Hot, Humidity = High, Wind = Strong )

would be sorted down the leftmost branch of this decision tree and would therefore be classified as a negative instance.

In other words we can say that decision tree represent a disjunction of conjunctions of constraints on the attribute values of instances.

(Outlook = Sunny ^ Humidity = Normal) v (Outlook = Overcast) v (Outlook = Rain ^ Wind = Weak)

Strengths and Weakness of Decision Tree approach

The strengths of decision tree methods are:

- **Decision trees are able to generate understandable rules.**
- **Decision trees perform classification without requiring much computation.**
- **Decision trees are able to handle both continuous and categorical variables.**

- **Decision trees provide a clear indication of which fields are most important for prediction or classification.**

The weaknesses of decision tree methods :

- **Decision trees are less appropriate for estimation tasks where the goal is to predict the value of a continuous attribute.**
- **Decision trees are prone to errors in classification problems with many class and relatively small number of training examples.**
- **Decision tree can be computationally expensive to train. The process of growing a decision tree is computationally expensive. At each node, each candidate splitting field must be sorted before its best split can be found. In some algorithms, combinations of fields are used and a search must be made for optimal combining weights. Pruning algorithms can also be expensive since many candidate sub-trees must be formed and compared.**