National University of Singapore
School of Computing

Semester 2, AY2023-24

CS4246/CS5446 AI Planning and Decision Making

Tutorial Week 6: DT, DA and MDP

Guidelines

- You can discuss the content of the questions with your classmates.
- However, everyone should work on and be ready to present ALL the solutions.
- Your attendance is marked in the tutorial and participation noted to award class participation marks.

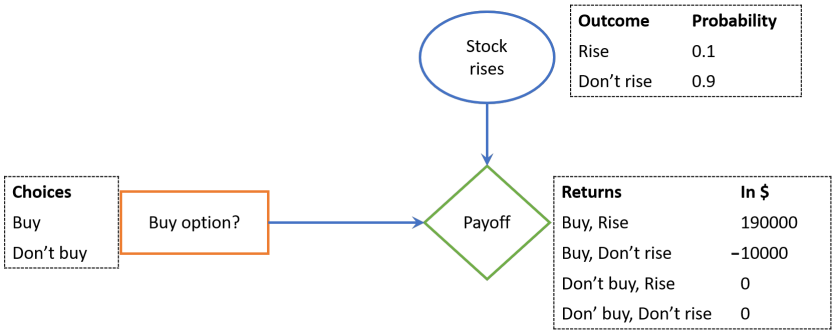
Problem 1: Basic Risky Decision

Note: This question is brought forward from the last week's tutorial to give you the context for the next problem

Richie Bean is trying to strike it big in the stock market during the economic downturn. He is considering buying some options to a very risky stock on a diamond mine in Africa. There is only a 10% chance that the stock price will rise if he exercises his options, but the payoff is $200,000. It costs $10,000 to buy and exercise the options. The alternative is not to buy at all, in which case Mr. Bean's profit is zero.

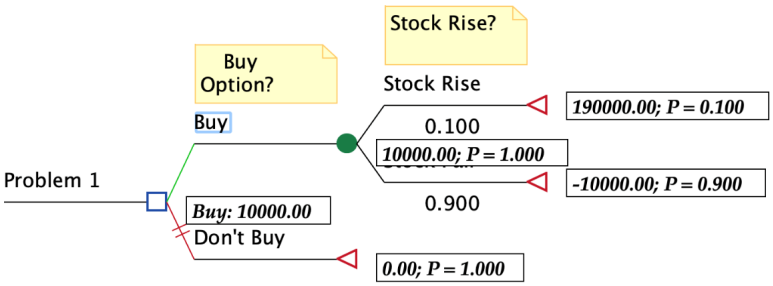
a. Draw an influence diagram to represent Mr. Bean's problem. Clearly indicate all the options/outcomes and numbers. Should he buy the options? Use the solution approaches mentioned in the lecture to substantiate your answer.

Solution:



b. Draw an decision tree to represent Mr. Bean's problem. Clearly indicate all the options/outcomes and numbers. Should he buy the options? Show all the details in your decision tree.

Solution:



EMV for buy \$10000, don't buy \$0.

Problem 2: Value of Perfect Information

a. Represent the hypothetical situation where Mr. Bean will get perfect information before he makes the decision. How to represent this situation in an influence diagram? Clearly indicate all the options/outcomes and numbers.

b. How to represent this situation in the decision tree? What is the expected value of the decision with perfect information?

Problem 3: Scrooge and his nephews

Uncle Scrooge is deciding which of his three grand-nephews, Huey, Duey, and Louie, is going to inherit his wealth and business empire. To help him in his assessment, Uncle Scrooge sets up the following lottery, where the choice is between:
Option (A): Receiving \$4900 (with probability 1), OR
Option (B): participate in a lottery which has a 60% probability of winning \$7000 and a 40% probability of winning \$20.

a) Huey's utility function for wealth (money) x is represented by an exponential utility function: $U(x) = log_{10}(x)$, for all $x > 0$. Assuming that Huey would choose the option with the higher utility, which option would he choose?

b) Duey's utility function for wealth x is represented by $U(x) = \sqrt{x}$, for all $x > 0$. Assuming that Duey would choose the option with the higher utility, which option would he choose?

c) Louie's utility function for wealth $x, \forall x > 0$ is represented by the following utility function

$$U(x) = \begin{cases} x, & 0 \leq x \leq 5000 \\ (10000 - x), & 5000 < x \leq 10000 \\ 10000, & x > 10000 \end{cases}$$

Assuming Louie would choose the option with the higher utility, which option would Louie choose?

d) Uncle Scrooge Scrooge needs to choose a successor who is rational and reasonably risk averse, so that he can preserve and yet grow the business. After fully understanding each of their utility functions, which of Huey, Duey, and Luey would Uncle Scrooge consider to be his successor? There could be more than one choice.

Problem 4: Formulating Markov Decision Processes

Specify the following problems as a Markov decision process, *i.e.* specify the state space, the actions, the transition functions, and the reward function. What is the (approximate) size of the state space and the action space?

- The traveling salesman problem. A salesman must visit every city in a graph and minimize travel time and is constrained not to visit any city twice.
- Inventory control. The company has space to store N items. At the end of each day, the company will make an order to increase the number of items up to $M \leq N$. Placing an order cost c for each time an order is made. If there is not enough items in the inventory to meet the orders for the day, a back order has to be made at the cost of b per unit back ordered (up to a known maximum of B units). There is a holding cost of 1 for each item in the inventory at the end of the day.