**CS1571 Intro to Artificial Intelligence  
Fall 2020 – Week 5  
9/16 Wednesday Worksheet**

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**I am ok with having my solutions discussed in class on Monday: Yes**/No

**Textbook Reading:** Russell & Norvig, Chapters 12, 16

**Videos:** Week 5, Videos 1-4

**This Week’s Learning Objectives:**

* Describe key elements of probability theory
* Make basic decisions using expected value
* Create a decision tree based on a scenario
* Explain how utility functions relate to decision making

**Worksheet Activities:**

* Go through quiz solutions
* Go through some basic probability exercises, which will lay the foundation for our future units on probabilities
* Practice construct decision trees for more complex scenarios
* Explain how you would use utility functions as part of your decision trees

1. **Solutions for Quiz Questions**

The solutions for the quiz questions are posted this week as part of your Canvas (if you go back to the quiz, you should be able to view them). Start by reviewing them. What did you get right? What did you get wrong? If you have any questions or find anything surprising, raise them with your groupmates.

1. **Probability Theory**

Answer the following questions given this joint distribution.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **WBCCount** | | |
|  |  | **high** | **medium** | **low** |
| **Pneumonia** | **True** | .08 | .04 | .01 |
| **False** | .22 | .56 | .09 |

1. What is P(*Pneumonia*=True, *WBCCount* = high)?

Pr = .08

1. What is P(*Pneumonia*=False)?

Pr = .22 + .56 + .09 = 0.87

1. What is P(*WBCCount =* Medium)?

Pr = 0.6

Answer the following questions given this joint distribution

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Paleness | | *~*Paleness | |
|  | *Fever* | *~Fever* | *Fever* | *~Fever* |
| *Pneumonia* | .15 | .04 | .10 | .01 |
| *~Pneumonia* | .10 | .20 | .15 | .25 |

1. What is *P(Pneumonia =* True*)*?

Pr = 0.3

1. What is P(*Fever* = True, *Pneumonia* = True)?

Pr = .25

1. What is P(*Pneumonia=*True | Fever=True)

Pr = .25/.5 = 0.5

1. What is P(*Pneumonia*=True | *Fever*=True, *Paleness*=True)

Pr = .15/(.15+.1) = .6

The following table represents a joint probability distribution for three variables *a*, *b,* and *c.* The different probabilities in the cells of the distribution are simply represented as *Pi.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *a* | | *~a* | |
|  | *b* | *~b* | *b* | *~b* |
| *c* | *P1* | *P2* | *P3* | *P4* |
| *~c* | *P5* | *P6* | *P7* | *P8* |

Answer the following questions.

1. (4 pts) What is P(~*c*)? Give your answer in terms of *P1 … Pn.*

P(~c) = P5 + P6 + P7 + P8

1. (4 pts) What is P(*b* | *a*)? Give your answer in terms of *P1 … Pn.*

P(b|a) = (P1+P5)/(P1+P2+P5+P6)

1. **Decision Trees**
2. Construct a decision tree for the following scenario, and explain the best action to take. You are deciding whether to invest $1000 in the stock market or put your money in the bank. **For the purposes of this exercise, assume only two periods of investment.**
   * Let Upk be a random variable representing whether the stock value goes up for an investment period k.
   * P(Up1=True) = .40
   * For k>1, P(Upk= True | P(Upk-1) = True) = 0.50   
     and P(Upk= True| P(Upk-1) = False) = 0.40
   * If Upk the return is 15%
   * if Downk, you lose 10% of your money
   * There is a fixed fee per investment period of $5
   * If you invest in the bank, the return is 3% each pay period, with no fee
3. You are making a decision of whether to drill for oil at a particular site. Construct a decision tree for the following scenario, and explain what the best course of action is.
   * P(Oil = True) = 0.4
   * Cost of drilling is $70K
   * If you hit Oil, you get 220K
   * There is a seismic resonance test that will give you an indication of whether there is oil at a location:

P(Test = T | Oil = T) =.8

P(Test = F | Oil = F) = .7

The test costs $10K

Note: this is a simplified version of this problem: <http://camvac.hugin.com/index.php/Oil_Wildcatter>

1. It may be more appropriate to use a utility function for money gained or lost, rather than absolute monetary value. The following is a potential utility function for the above scenario (taken from p. 535 of the textbook):

*U(n) =* -263.31+22.09log(*n*+150,000)

where *n* is a monetary value in the range [-$150,000 , $800,000]

Do you think it would be appropriate to use this utility function instead of the absolute monetary gains and losses of drilling and striking oil? How would you incorporate the utility function into your calculations?

It would be appropriate since the exact value of money doesn’t always represent what people want. A utility function does this better. I would incorporate the function by putting all the values in the end nodes in the function and use the results in the calculations for choosing the best course of action.

1. Draw a decision tree for a single round of rock paper scissors (<https://en.wikipedia.org/wiki/Rock_paper_scissors>) – in a round, both players make one shape with their hands. Explain the assumptions that went into your decision tree.
2. Say Player 1 has a strong preference for winning in a game of rock paper scissors over losing or drawing. Devise a utility function that fits Player 1’s preference. Given your decision tree, does this utility function change Player 1’s behavior?

U(Win) = 10

U(draw) = 2

U(loss) = 1

This does not change his behavior because his odds of winning, losing, or drawing aren’t affected by what decision he makes. They always have an equal chance of occuring. Player just needs to deal with losing more often.