TDT4171 Methods in Artificial Intelligence

Assignment 3

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March 3, 2021

1 Decision Network

1.1 Drawing of decision network

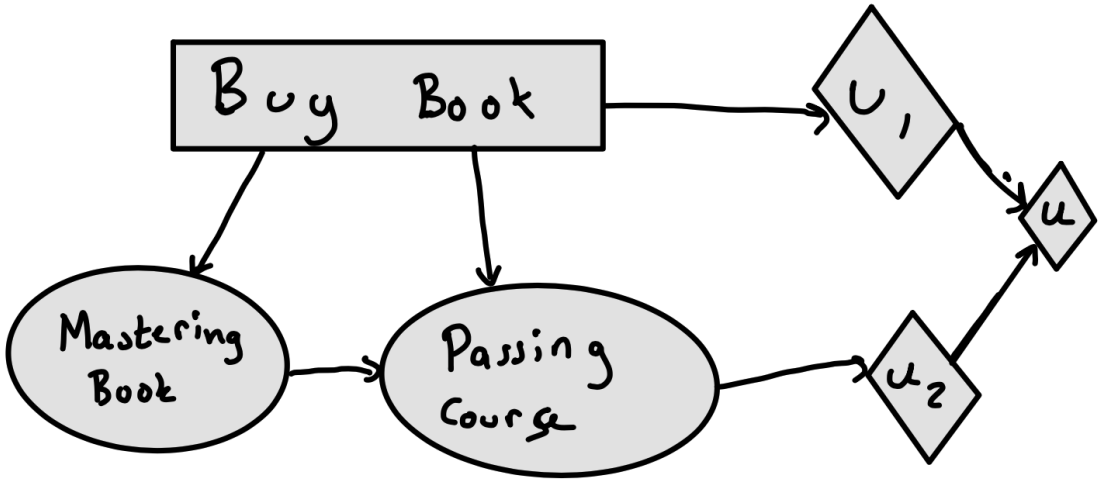


Figure 1: Drawing of decision network

1.2 Expected utility

$$P(P \mid B) = P(P \mid B \wedge M) \cdot P(M \mid B) + P(P \mid B \wedge \neg M) \cdot P(\neg M \mid B)$$
$$= 0.9 \cdot 0.9 + 0.4 \cdot 0.1$$
$$= 0.85$$

$$EU[B] = EU_1[B] + EU_2[P \mid B] =$$
$$-150 + 0.85 \cdot 2100 = 1635$$

Figure 2: Calculating Expected Utility of buying the book

$$P(P \mid \neg B) = P(P \mid \neg B \wedge M) \cdot P(M \mid \neg B) + P(P \mid \neg B \wedge \neg M) \cdot P(\neg M \mid \neg B)$$

$$= 0.7 \cdot 0.65 \; 0.2 \cdot 0.35$$

$$= 0.525$$

$$EU[\neg B] = EU_1[\neg B] + EU_2[P \mid \neg B]$$

$$= 0 + 0.525 \cdot 2100 = 1102.5$$

Since $EU[B] = 1635 > EU[\neg B] = 1102.5$,

Geir should buy the book!

Figure 3: Calculating Expected Utility of not buying book, and comparing to buying book

$$EU[Buyingbook = True] = 1635 \tag{1}$$
$$EU[Buyingbook = False] = 1102.5 \tag{2}$$

As can been seen from eq. (1) and eq. (2), taken from fig. 2 and fig. 3 the Expected Utility of buying the book is larger than not buying the book. As a consequence, **Geir should buy the book**.

2 Decision Support System

At the summers, I run a small construction company with a friend in my hometown. We have several job offers. Which of these jobs should I do? And should I bring my friend/colleague, or should I do it alone? My decision support system has the purpose to decide those two things. In this task I have assumed that we have two job offers to choose between. Namely building a terrace or renovating a bathroom.

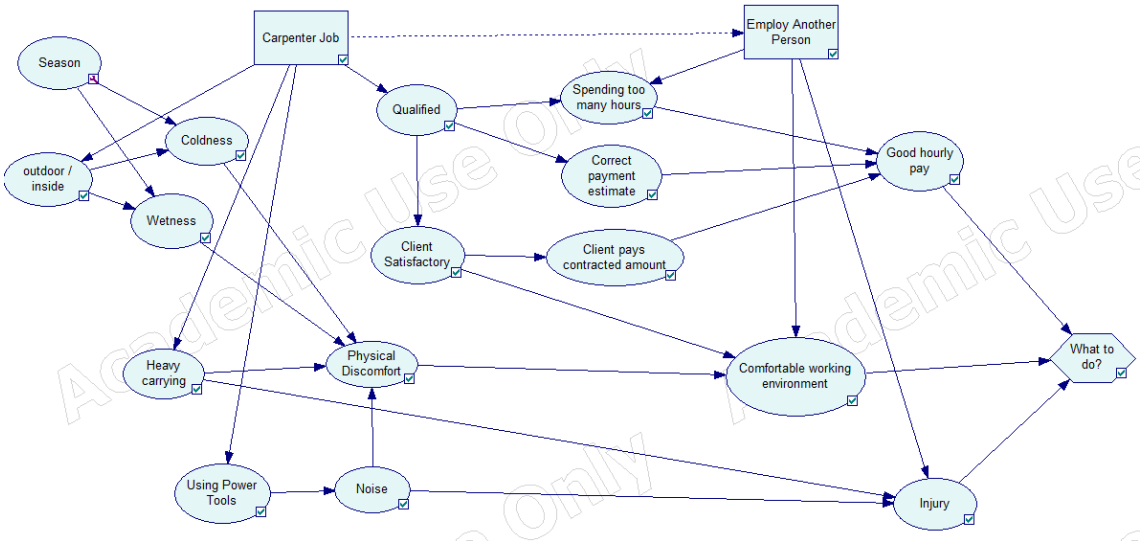


Figure 4: My final decision network

A screenshot of the network can be seen in fig. 4. I will try to describe my though process. I start from the utility function. My assumption is that the factors that give the utility of the project can be simplified into 3 factors: Good pay, no injuries, and a comfortable/fun working environment. Out of these factors, I prioritise not getting injured, comfortable working environment and then good pay, in that order. The utilization definition is shown in fig. 5. You can clearly see my rationale discussed above being reflected in the values for the different utilities.

Node properties: What to do?

General | Definition | Format | User properties | Value

Good hourly pay	Yes				No			
Injury	Yes		No		Yes		No	
Comfortable working environment	Yes	No	Yes	No	Yes	No	Yes	No
Value	600	400	1000	700	500	0	500	300

Figure 5: Utilization

Good pay is decided by our time usage, my ability to price the job correctly, and the client paying the contracted amount. A zoom-in of the factors contributing to the probability of good pay can be seen in fig. 6

Our time usage depends on how qualified we are for the job, as well as how many people we are. I have assumed, by experience, that on most jobs, employing another person to work with you, will increase the total time usage on the project.

I have assumed that my ability to correctly estimate the price is solely dependent on how qualified

I am for the job. In practise, other factors like how focused I am that day and how many jobs we currently have available, will contribute.

Good pay is also dependent on the client paying the contracted amount, and not declining to pay the full amount because of imperfections in the product. I have assumed that this willingness to pay is only dependant on client satisfactory, which is in turn only dependant on if I am qualified for the job. In reality, this is also dependant on other factors such as the personality of the client and daily variations in the quality of my work. But because of simplicity, these factors are not included in my model.

Personally, I have a lot more experience with building terraces than with renovating bathrooms. The likelihood that I am qualified by the job is only dependant on what type of job it is. The probabilities for this specific variable are given below. They are strongly influenced by my own experience described above.

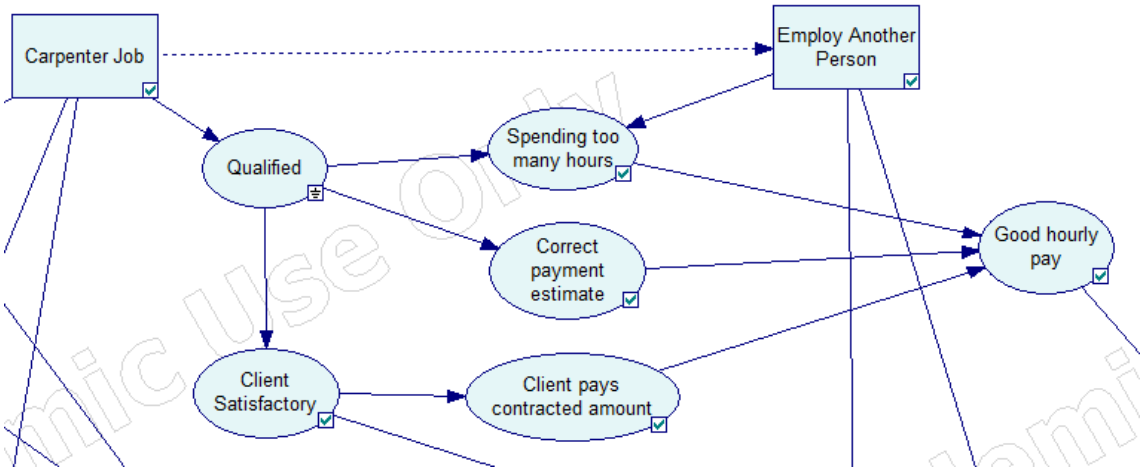


Figure 6: Part of network that determine good pay

The other variable that determines the total utility is how comfortable or fun the working environment is. Working with a colleague provide a high social utility that contributed largely to a fun working environment. Client satisfactory also plays a role. Also physical discomfort lead to a worse working environment. My probabilities for this variable is given below.

Physical discomfort is dependent on coldness, wetness, noise and the amount of heavy carrying at work. Both coldness and wetness are dependant only on the season and whether the job is performed inside or outside.

I assume I know the season in which the job is to be performed. For this example, I assume it is winter. The probabilities for wetness are given in fig. 7, where I used several sources to get statistics on the wetness in Norway in the different seasons. I have also assumed when working inside, you have 0 wetness. Considering often having to carry materials from the car, this is not entirely true, but I still think it is a decent assumption.

Node properties: Wetness

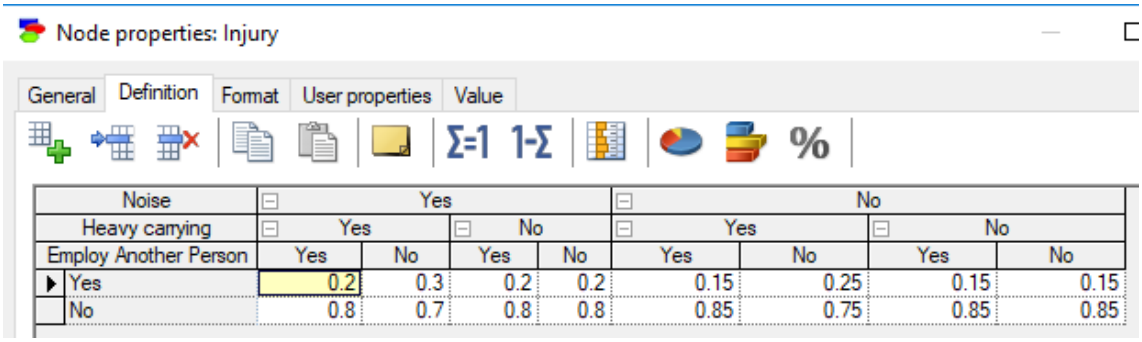
General | Definition | Format | User properties | Value

outdoor / inside	outdoor				inside			
Season	Summer	Winter	Spring	Autumn	Summer	Winter	Spring	Autumn
Yes	0.4	0.2	0.7	0.8	0	0	0	0
No	0.6	0.8	0.3	0.2	1	1	1	1

Figure 7: My estimated probabilities for wetness

Heavy carrying is only dependant on the type of job, where I have assumed that terrace-building demand a larger degree of heavy carrying than renovating bathrooms. I have assumed that noise only comes from power tools, and that one uses more power tools when building terraces. Other sources of noise might also exist, but I think that most of the noise that are able to injure the ears come from power tools.

Lastly, the injury variable, which is the third variable that determines the total utilization, is dependant on noise, heavy carrying and employing another person. I assume that noise has a very small probability of causing an injury, only adding 0,05 to the injury probability. An interesting part here is the influence on injury by including another person, given heavy carrying. I assume that having another person to help you carry, decreases the chance of getting injured as a cause of heavy carrying. If we know that there will be no heavy carrying, employing another person will have no influence on the injury probability. Employing another person will neither affect injury rate caused by noise. The probability table for the injury node can be seen in fig. 8.



Noise	Yes				No			
Heavy carrying	Yes		No		Yes		No	
Employ Another Person	Yes	No	Yes	No	Yes	No	Yes	No
Yes	0.2	0.3	0.2	0.2	0.15	0.25	0.15	0.15
No	0.8	0.7	0.8	0.8	0.85	0.75	0.85	0.85

Figure 8: injury probabilities

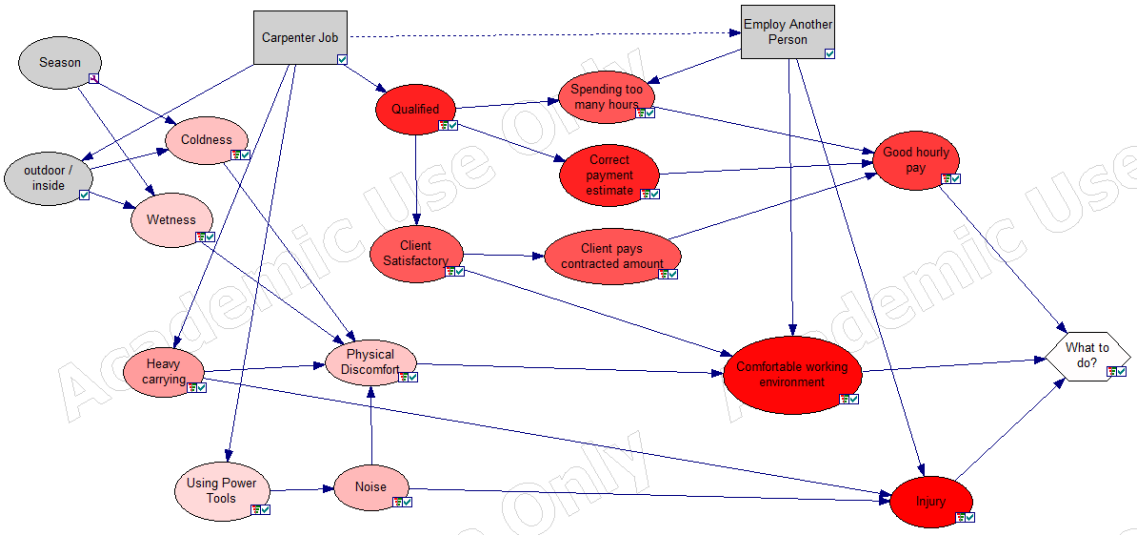


Figure 9: Sensitivity analysis

I also did a sensitivity test with the outcome seen in fig. 9. A sensitivity test is useful because you do not want small errors in your probabilities to cause the utilization to drastically change, and in turn change the decision. Another way to see it is that the whiter nodes only slightly contribute to the utilization. They could possibly just be removed, with very small effects. One can see that some of my nodes are very red, meaning they largely influence the utilization. Other, like noise, wetness and coldness, are paler, and contribute less. This is by design, as I personally do not care too much about wetness and coldness. Also, I have assumed that noise have a small risk of leading to injury, and therefore influences the utilization only to a certain degree. There could be a discussing whether I should have removed these nodes or not.

My system tells me that the decisions that gives me the highest utility is building a terrace and including a colleague. This can be seen in fig. 10. If I instead assume that I will be working in a comfortable working environment, and that I will get no injuries, I should do the job alone. This can be seen in fig. 11 If I assume that I am qualified for the job, I rather want to do the bathroom job, because I then do not have to suffer outside in the coldness and wetness. This can be seen in fig. 12.

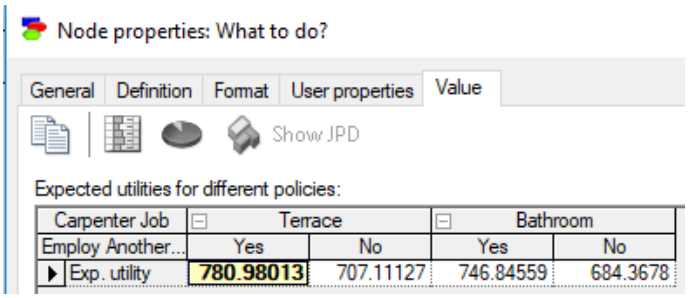


Figure 10: Utility under no evidence

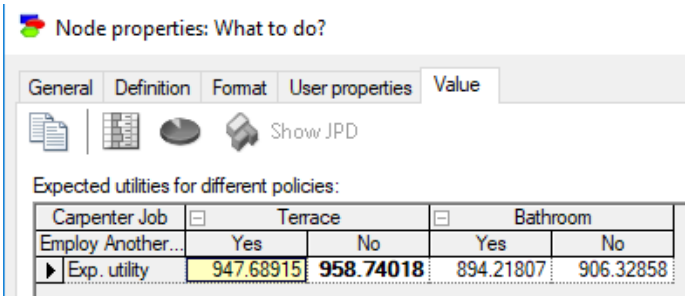


Figure 11: Utility assuming comfortable working environment and no injuries

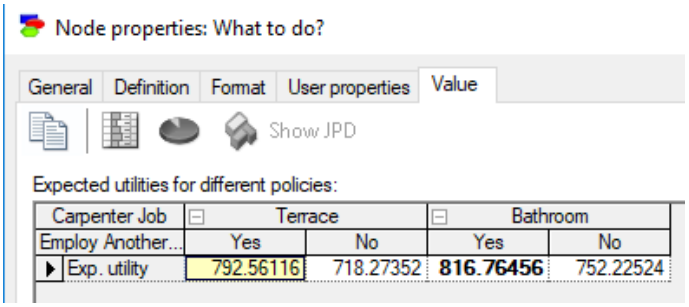


Figure 12: Utility assuming that I am qualified