TDT4171 Artificial Intelligence Methods
Assignment 3

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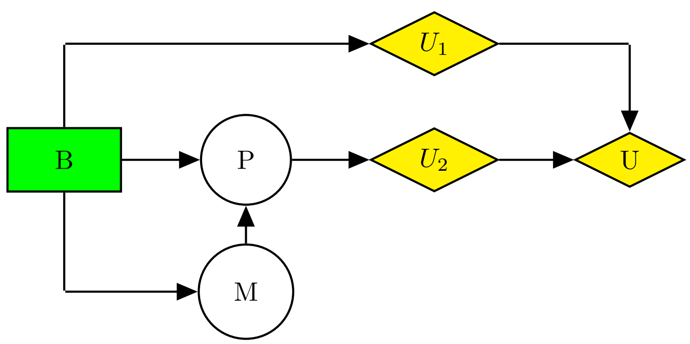
1 Decision Network

a) Draw the decision network for this problem.

The boolean decision node B indicates whether Geir chooses to buy the book or not. The boolean chance nodes M and P indicate whether Geir masters the material and passes the course respectively. The utility function $U = U1 + U2$.



$P(p \mid b, m)$	0.9
$P(p \mid b, \neg m)$	0.4
$P(p \mid \neg b, m)$	0.7
$P(p \mid \neg b, \neg m)$	0.2

$P(m \mid b)$	0.9
$P(m \mid \neg b)$	0.65

$U1(b)$	-150
$U1(\neg b)$	0

$U2(p)$	2100
$U2(\neg p)$	0

b) Compute the expected utility of the two decision alternatives B = true (buying the book) and B = false (not buying it) (show the calculations). What should Geir do?

Calculating for B=True, starting with U_2:

$$\begin{aligned}
U_2(P \mid b) &= \sum_p \sum_m P(P \mid b, M) * P(M \mid b) * U_2(P) \\
&= \sum_m P(p \mid b, M) * P(M \mid b) * 2100 + \sum_m P(P(\neg p \mid b, M) * P(M \mid b) * 0 \\
U_2(p \mid b) &= \sum_m P(p \mid b, M) * P(M \mid b) * 2100 \\
&= (P(p \mid b, m) * P(m \mid b) * 2100) + (P(p \mid b, \neg m) * P(\neg m \mid b) * 2100) \\
&= (0.9 * 0.9 * 2100) + (0.4 * 0.2 * 2100) \\
&= 2100(0.81 + 0.04) = 2100 * 0.85 \\
U_2(p \mid b) &= \underline{1785}
\end{aligned}$$

Since $U_1(p \mid b) = -150$, the actual utility of B=True is:

$$U(p \mid b) = 1785 - 150 = \underline{\underline{1635}}$$

Since $U_1(p \mid \neg b) = 0$ and $U_2(\neg p) = 0$, I can calculate $U(p \mid \neg b)$ directly:

$$\begin{aligned}
U(p \mid \neg b) &= \sum_m P(p \mid \neg b, M) * P(M \mid \neg b) * U_2(p) \\
&= P(p \mid \neg b, m) * P(m \mid \neg b) * 2100 + P(p \mid \neg b, \neg m) * P(\neg m \mid \neg b) * 2100 \\
&= 2100 * (0.7 * 0.65 + 0.2 * 0.35) \\
&= 2100 * (0.455 + 0.07) \\
U(p \mid \neg b) &= \underline{\underline{1102.5}}
\end{aligned}$$

If we assume that Geir is rational, then he should follow the MEU principle and choose to buy the book, as that gives the highest utility score. Geir could however be irrational and choose not to buy the book.

2 Decision Support System

For this task I decided to model a decision support system to help me decide what game I should play.

As a gamer, I tend to play a variety of different games ranging from single-player to multi-player. multi-player games are an interesting case, as you need multiple friends to play them, so to help me decide what to play I need to first check who (if any) of my gamer friends are online. As my gamer friends are also gamers, they too play a variety of different types of games, meaning that not all of my friends play the same games. This means that the people that are online may affect which game will be selected. People are also different, so there are different probabilities for each of my gamer friends being online or not.

The utility of multi-player games may also vary depending on how many of the friends that play the game are online, as a game may be more fun with a full squad than just with some of it.

Lastly, I may be too tired to interact with people, as I also am an introvert, so sometimes I might not want to play multi-player games, instead opting for a single-player experience.

The Russell and Norvig book outlines an approach for creating such a system on page 634-635. This approach assumes that domain experts and information engineers are present, which in this case they are not. The approach is also very formal, and would be used in critical situations like when designing a system which will actually be in use. As these are not the case for this exercise, I intend on using the approach outlined by my professor Helge Langseth in lecture 6 of the Methods in AI course, which is as follows:

Step 0	Decide what to model
Step 1a	Defining variables
Step 1b	Defining decisions
Step 2a	The qualitative part
Step 2b	The qualitative part - decisions
Step 3a	The qualitative part - BN
Step 3b	The utility function
Step 4	Verification

Step 0: The model has been explained in the introductory statements of this task, but to reiterate, I will be modelling a decision support system to help me decide what game I should play based on how I feel and which of my gamer friends are online.

Step 1a: The task requires there to be at least 14 variables, and at least half of those have to be observed after a decision is made. The unobserved variables are the friends that I play games with. All of them will with their permission be referred to by their gamer-tags as to preserve anonymity. In this model, I will have 8 friends. There is some overlap between the multi-player games played and the people who play them, making it interesting to see which game the system chooses based on the choices.

I am planning on having 5 different games for the model to choose from, 3 of which are multi-player. The multi-player games will be variables that are dependent on the decision node which chooses the game, but also the people that are online. This is done to "scale" the utility function of each game later by the amount of people that are online, as the multi-player games are more fun with a full squad.

There are two single-player games because I play two different single-player games, one of which is more taxing than the other to play. This means that if I'm not tired, but there are no people online, then I still have a choice between two games to play, making the model more interesting.

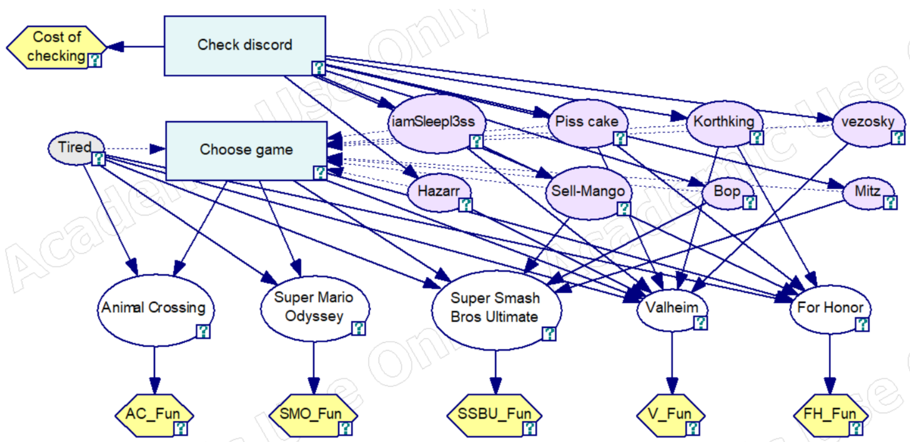
Lastly, there will be a variable that depicts whether or not I'm tired. This variable will be observable before any decisions are made, as I don't need to check whether I'm tired or not.

Step 1b: The model will have two decision nodes:

The first one is whether to check discord or not. This decision will illuminate who (if anyone) is online.

The second decision will be which game to play. This decision will depend on who's online, as well as whether I'm tired or not.

Step 2a and 2b: Both of these steps can be done in one go, as the graphical structure of both the variables and the decisions can be set up at the same time when modelling the system in GeNIe. The following figure shows this structure:



There is a lot going on in the model, so an walk-through is in order. The chance nodes are colored different to easily differentiate between the different groups. The lavender colored nodes are the nodes representing people. The white nodes represent the games to be chosen and the grey node represents my state of being tired.

The decision node of checking discord has a cost associated with it. This is meant to represent that when I log onto discord, some unwanted party may start a conversation with me.

After I decide whether to check discord or not, the probabilities of people being online are updated. All of the people probabilities arch towards the decision node of choosing a game, as the decision is dependent on who (if anyone) is online. The decision is also dependent on whether or not I'm tired, which is why the tired node also has an arch to the decision node.

Each game is its own chance node. This is because I want to scale the utilities based on the other chance nodes in the model. Besides the choice made by the decision node, all games are also dependent on whether or not I am tired. This is because if I'm tired, then there should be zero utility from the games that I will not play when tired. The multi-player games are also dependent on the people that I'm going to play them with. The model does a pretty poor job of showing who is playing what game, so here's a quick overview:

- **Super Smash Bros Ultimate:** Sell-Mango, Bop, Mitz.
- **Valheim:** iamSleepl3ss, Piss cake, Korthking, vezosky, Hazarr.
- **For Honor:** iamSleepl3ss, Piss cake, Korthking.

Step 3a: Assigning actual values to the chance nodes.

The probabilities for the people have been set based on their activity online and personality, as well as their life situation. If the choice to check discord is not taken, however, then all of the people might as well be offline, which is why $P(\neg person \,|\, \neg check\_discord) = 1$, where $\neg person$ means that any person is not online.

iamSleepless is a fellow NTNU student who tends to disappear from the internet when intensively working on school assignments, which is why I put the probability of them being online at $P(iamSleepl3ss \,|\, check\_discord) = 0.5$.

Piss cake is applying for a PhD at NTNU, meaning they have a lot of work to do in tandem with the regular assignments. They tend however to work in regular hours, meaning around 8:00-16:00, making it more predictable when they will be online. They also have a family they take care of as a stay-at-home parent. With these factors combined, I decided that it's reasonable to set the probability to $P(piss\_cake \,|\, check\_discord) = 0.6$ as, even though they are predictable, they are not very much online.

Bop has the same probability as Piss cake, $P(bop|check\_discord) = 0.6$, because they have a stable job where they work every day 8:00-16:00, and have to go to bed at 22:00 to maintain their daily routine, meaning they are not very much online either.

Korthking has a job that he has to maintain a daily routine for as well, but they are quite the sore loser, meaning that if provoked enough, they will stay past their bedtime to play more. The other people in this bunch may provoke Korthking making him more likely to be online. I therefore gave them the probability $P(korthking \mid check\_discord) = 0.7$.

vezosky, Hazarr and Mitz are all in a similar situation where due to the current world situation they are on work leave for some time, meaning that they have quite a lot of free time to spend on playing games. Therefore I decided to give them all the same probability of $P(vezosky \mid check\_discord) = P(hazarr \mid check\_discord) = P(mitz \mid check\_discord) = 0.8$.

Lastly, Sell-Mango is also a student, but at a different institution. They are constantly working on school work, making them very likely to be online, as their schoolwork is digital. I therefore gave them a probability of $P(sell-mango \mid check\_discord) = 0.9$.

The tired variable probabilities were set by using my gut feeling. I don't tend to be so tired that I don't want to interact with people very often, therefore the probability for $P(tired) = 0.2$.

The rest of the variables are the games. The multi-player games have a clear system for the probabilities, which is:

$$P(game \mid \neg tired) = \frac{m}{n}$$

where m is the number of relevant people to the game that are online and n is the total number of people relevant to the game. For instance,

$$P(for\_honor \mid \neg tired, iamSleepl3ss, piss\_cake, korthking) = 1$$

$$P(for\_honor \mid \neg tired, iamSleepl3ss, piss\_cake, \neg korthking) = 0.66$$

If I am tired however, then $P(game \mid tired) = 0$ for any multi-player game.

The single-player games are a bit different, however. Super Mario Odyssey is quite engaging, so it also has the caveat that the probability will be 0 if I am tired. If I'm not tired, then $P(super_mario_odyssey \mid \neg tired) = 0.8$. I will mostly opt for this game if nobody is online, as will be clear when I cover the utility function.

I might opt not to play Super Mario Odyssey, however, which leads into the last game, Animal crossing. Animal Crossing is a really relaxing and fun game to play, making it a fine substitute for Mario. The probability is set to $P(animal\_crossing \mid \neg tired) = 0.3$, since Mario is still preferred when I'm not tired. If I am tired however, then the probability for Animal Crossing is $P(animal\_crossing \mid tired) = 0.8$. The uncertainty is there because I might opt to play nothing at all.

Step 3b: The utility function.

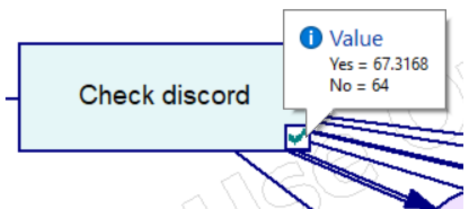
The utility function for this model is quite straight forward.

$$U = \arg\max\{AC\_Fun, SMO\_Fun, SSBU\_Fun, V\_Fun, FH\_Fun\} - CoC$$

or in a human language, "the cost of checking subtracted from the choice which yelds the most fun". For the actual numbers, the maximum amount of fun each multi-player game yields is 100. The single-player games yield 80. This small discrepancy in the amount of fun a game yields is there because a multi-player game is more fun than a single-player game, because you're playing with friends. The discrepancy is also the reason that Super Mario Odyssey will only be picked if/when no one or few people are online, as the utility for the Mario game will be lower than any of the multi-player games. The cost of checking discord is -15 if checked and 0 if not checked.

Step 4: Verification.

When running, the model calculates the potential utility gained by the first choice. It is clear that even though the choice to check discord costs -15, the potential utility is greater than if you don't check it.



When given the evidence that I'm not tired, the utilities for each of the games look like this [1]. If evidence is supplied that both Sell-Mango (who is only contributing to Super Smash) and vezosky (who is only contributing to Valheim) are offline, then these are the utilities of the choices [2]. If I am not tired, but nobody is evidence suggests that no one is online, then the utilities look like this [3]. If evidence is supplied that I am tired, then the utilities look like this [4]. These utilities are in-line with what is expected, which is, if the EMU principle is followed, then Mario odyssey will be played if I am not tired but there are no people online. If there are people online, and I am not tired, then the relevant game will be chosen. Otherwise, Animal Crossing will be chosen.

Animal_Crossing	9
Super_Mario_Odyssey	49
Super_Smash_Bros_Ultimate	85
Valheim	85
For_Honor	85

Figure 1: Not tired

Animal_Crossing	9
Super_Mario_Odyssey	49
Super_Smash_Bros_Ultimate	51
Valheim	65
For_Honor	85

Figure 2: No Sell-Mango or vezosky

Animal_Crossing	9
Super_Mario_Odyssey	49
Super_Smash_Bros_Ultimate	-15
Valheim	-15
For_Honor	-15

Figure 3: No one online

Animal_Crossing	49
Super_Mario_Odyssey	-15
Super_Smash_Bros_Ultimate	-15
Valheim	-15
For_Honor	-15

Figure 4: Tired