TDT4136 - Artificial Intelligence Methods
Assignment 3 - Making Decisions

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Problem 1 - Decision Network

1a

Drawing of decision network for problem 1:

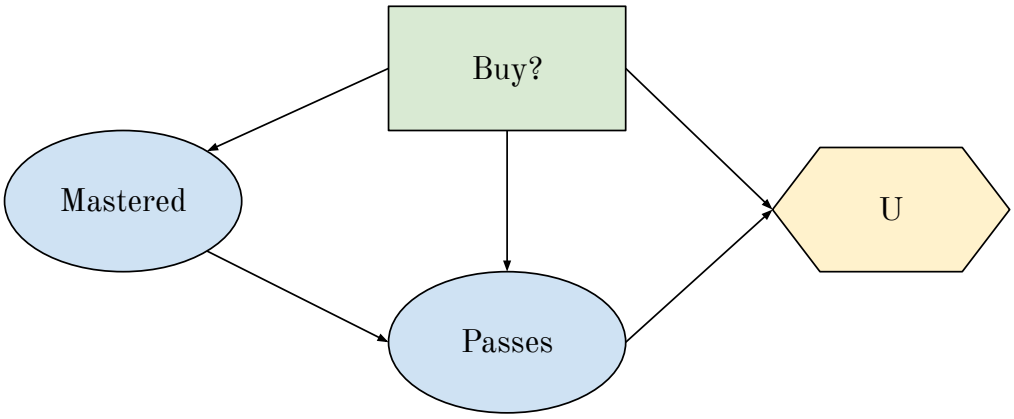

Figure 1:

1b

$$
\begin{aligned}
EU(B) = P(M|B)P(P|M,B)U(P,B) + \\
P(\neg M|B)P(P|\neg M,B)U(P,B) + \\
P(\neg M|B)P(\neg P|\neg M,B)U(\neg P,B) + \\
P(M|B)P(\neg P|M,B)U(\neg P,B) = \\
0.9 \times 0.9 \times 1950 + 0.1 \times 0.4 \times 1950 + \\
0.1 \times 0.6 \times (-150) + 0.9 \times 0.1 \times (-150) = \mathbf{1635}
\end{aligned}
$$

$$
\begin{aligned}
EU(\neg B) = P(M|\neg B)P(P|M,\neg B)U(P,\neg B) + \\
P(\neg M|\neg B)P(P|\neg M,\neg B)U(P,\neg B) + \\
P(\neg M|\neg B)P(\neg P|\neg M,\neg B)U(\neg P,\neg B) + \\
P(M|\neg B)P(\neg P|M,\neg B)U(\neg P,\neg B) = \\
0.65 \times 0.7 \times 2100 + 0.35 \times 0.2 \times 2100 + \\
0.35 \times 0.8 \times 0 + 0.65 \times 0.3 \times 0 = \mathbf{1102.5}
\end{aligned}
$$

The expected utility is greater when buying the book, respectively 1636 to 1102.5. Therefore, Geir should buy the text book.

Problem 2 - Decision Support System

The decision support system is built upon decision problems regarding a trip to a given ski resort, illustrated in Figure 7, where we have two decisions:

- **LiftTicket** - There are two kinds of tickets to chose from; half day ticket or full day ticket.
- **ChooseLift** - Due to a period of warm weather, there are currently only two lifts to chose from; lift A is a two-person T-bar, and lift B is a six-person express chairlift. It is assumed that ChooseLift is directly affected by **LiftTicket**, since one have to buy either of the tickets in order to take the lifts. For simplicity of the model, it is assumed that the skier will stick with the chosen ski-lift.

Furthermore we have the certain variables, which are observed before the decisions are made:

- **Weekend**, where observed state is *True*. Tells whether it is weekend or not.
- **Holiday**, where observed state is *True*. Tells whether it is holiday or not.
- **Sky**, where observed state is *Mixed*. Tells whether the sky is sunny, cloudy or mixed.
- **Level**, where observed state is *Intermediate*. Tells whether the skier is a beginner or intermediate.

The uncertain variables that are observed after the decisions are made:

- **Crowded**(True/False) - The probability that it is crowded is dependent of whether it is holiday or weekend. This is due to the assumption that it is more common to go skiing in weekends and holidays.

- **Slush**(True/False) - Furthermore we have that the probability of slushy snow is dependent on the amount of people in the resort, as well as the sky.

- **MomPays**(True/False) - From personal experience, the probability of mom paying the lift ticket, given that it is holiday can be around 0.9, and the pobability of mom paying, given that it is not holiday 0.05. Similar assumptions have been made with other uncertainties, as a result of observations from previous ski trips. Many of these uncertainties are able to be quantified more accurately through extensive research and historical data, but will in this model follow the assumptions as represented above. Representation of some of these uncertainties in the Genie Model:

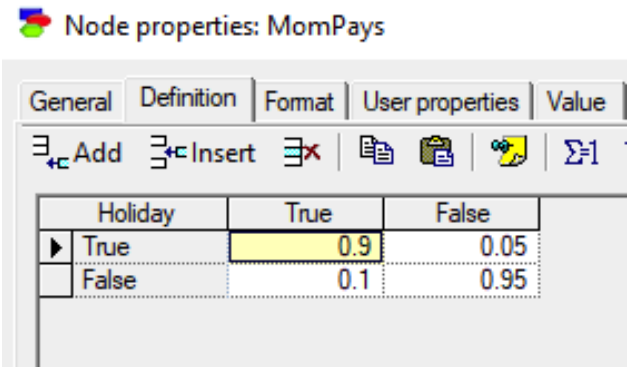

Figure 2:

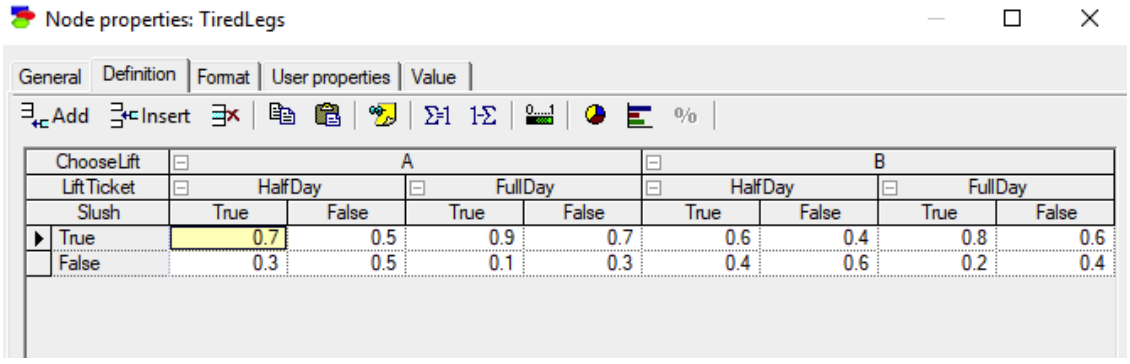

Figure 3:

- **TiredLegs**(True/False) - How tired the legs will be after a day of skiing will depend on for how long the session is, which again is determined by which lift ticket one chooses, how heavy/slushy the snow is, as well as which lift one chooses; the legs will get more tired when standing upright in the t-bar.

- **LiftStopped**(True/False) - Dependent of which lift one chooses, due to the fact that the T-bar is known as a more reliable lift, as well as it is less popular, making it less crowded i.e. less people to force a stop.
- **Queue**(Small/Medium/Long) - Dependent of chosen lift as well ass how crowded the resort is.
- **FallOff**(True/False) - Higher chance of falling of T- bar than a chairlift, as well as with tired legs.
- **Crash**(True/False) - Similarly a being a beginner and having tired legs make
- **Injury**(True/False) - Given that the skier crashes, it is more likely that the more experienced skier catches an injury.
- **CatchCovid**(True/False) - The probability of catching Covid outdoors in a ski slope is extremely small, however the associated utility is significant, as it not only will affect you, but can affect several others. As the actual probability, it is extremely challenging to give a good estimate, however in this case it is better to overestimate.

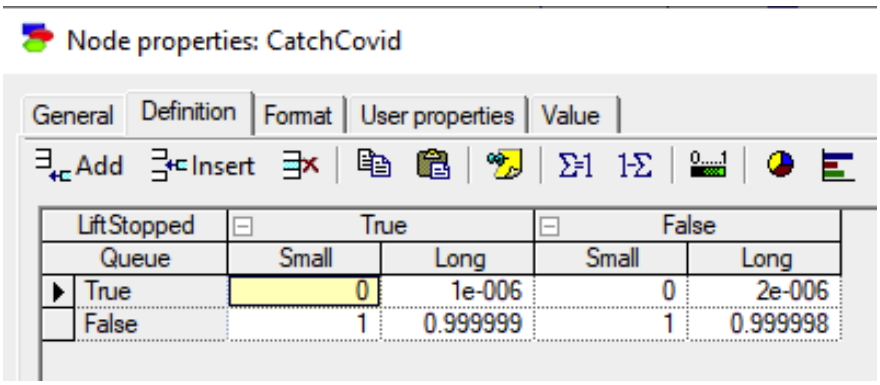

Figure 4:

The model uses an additive utility function $U = U1 + U2 + U3 + U4 + U5$ with the associated utilities:

- U1: A full day ticket costs 450 and a half day ticket costs 400, hence the utilities are -450 if a full day ticket is chosen and mom does not pay, and -400 if half day ticket is chosen and mom does not pay. If mom pays, the utility is 0 for both combinations.
- U2: The utilities associated with the chosen lifts ticket in terms of how much the skier enjoys the half or full day of skiing rests on assumptions that the lift tickets are priced according to the marginal utility of the time spent skiing; the first half day of skiing is more enjoyable than the second. Hence the utilities are 400 for a half day of skiing and 450 for a full day.
- U3: The utility of an injury is set to -500, which has a greater absolute value than skiing a whole day. If one knows that one is to get injured, one would stay home.

- U4: Falling of the ski lift is embarrassing, but is soon forgotten, hence compared to catching an injury, -40 would be a reasonable assumption.
- U5: As mentioned earlier, catching Covid will not only affect the individual, but usually several others as well. The associated utility is therefore set to -10 000 i.e. the same as 20 persons getting injured.

As shown in Figure 5 and Figure 6 the model suggests *with the given observations, as well as quantification of probabilities and utilities*, a higher utility related to choosing a full day ticket, and regardless of the ticket chosen, choosing the chairlift yields a higher utility.

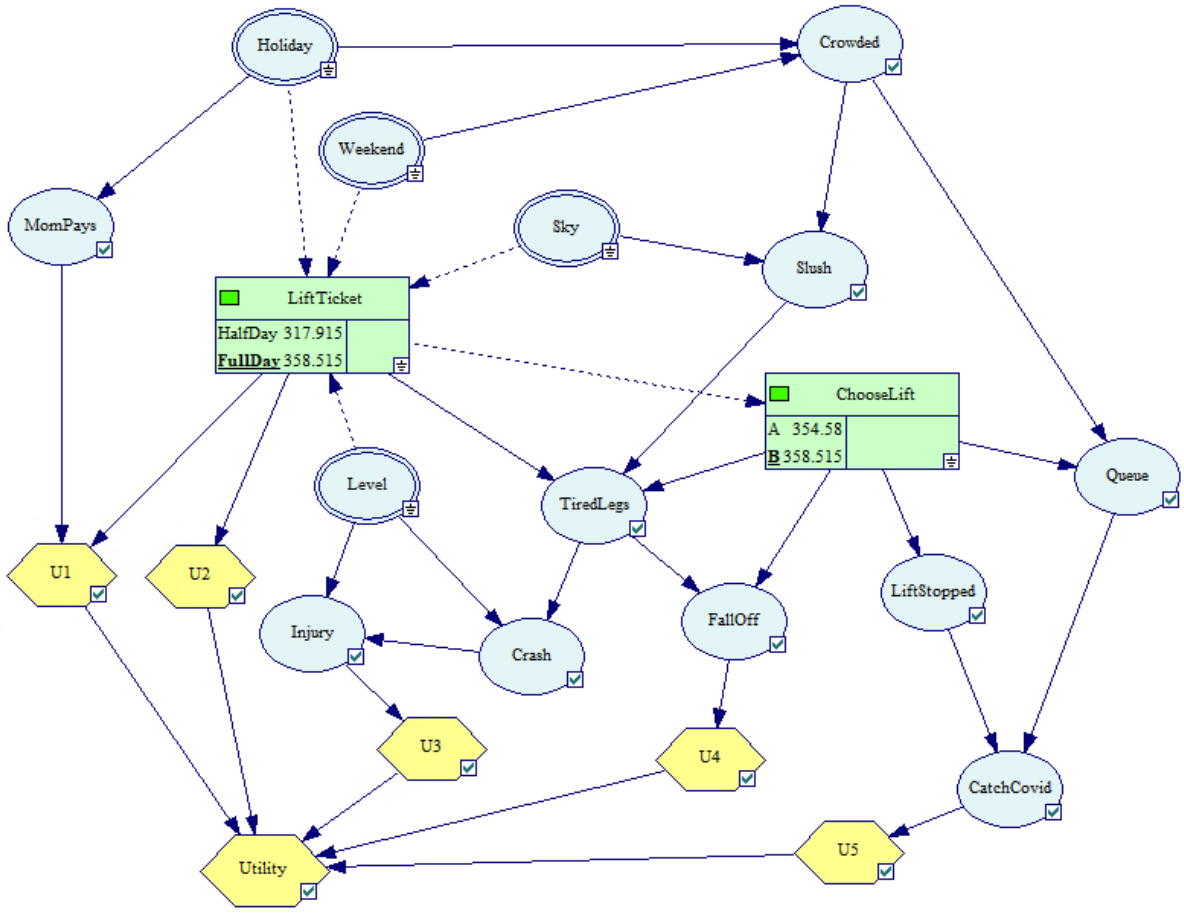

Figure 5: Genie representation of model with **FullDay** ticket chosen in first decision.

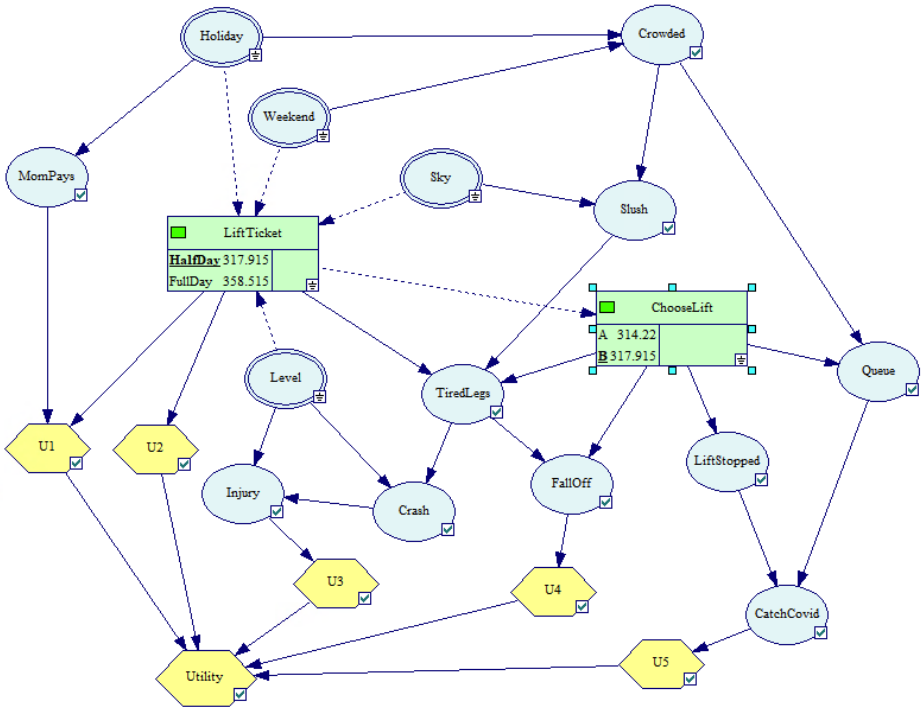

Figure 6: Genie representation of model with **HalfDay** ticket chosen in first decision.

Figure 7: Piste map of the given ski resort