Exercise 3: TDT4171 Artificial Intelligence Methods

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1 Decision Network

a)

The decision network is shown in figure 1.

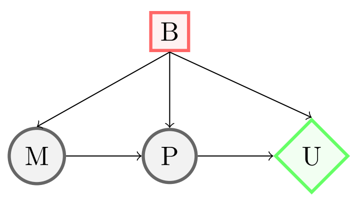

Figure 1: The decision network as described in task 1 with the corresponding node names. Red squares represent decision nodes, grey circles represent chance nodes and the green diamond represents the utility node.

b)

We first calculate the expected utility when $B = true$:

$$
\begin{aligned}
EU(B = true) &= EU_1(B = true) + EU_2(P|B = true) \\
&= -150 + \sum_{p\in\{t,f\}} P(P = p|B = true) \cdot U_2(P = p) \\
&= -150 + \sum_{p\in\{t,f\}} \sum_{m\in\{t,f\}} P(P = p|B = true, M = m) \cdot P(M = m|B = true) \cdot U_2(P = p) \\
&= -150 + 0.9 \cdot 0.9 \cdot 2100 + 0.4 \cdot 0.1 \cdot 2100 = \underline{1635}.
\end{aligned} \tag{1}
$$

Then we calculate the expected utility when $B = false$:

$$
\begin{aligned}
EU(B = false) &= EU_1(B = false) + EU_2(P|B = false) \\
&= 0 + \sum_{p\in\{t,f\}} P(P = p|B = true) \cdot U_2(P = p) \\
&= \sum_{p\in\{t,f\}} \sum_{m\in\{t,f\}} P(P = p|B = false, M = m) \cdot P(M = m|B = false) \cdot U_2(P = p) \\
&= 0.7 \cdot 0.65 \cdot 2100 + 0.2 \cdot 0.35 \cdot 2100 = \underline{1102.5}.
\end{aligned} \tag{2}
$$

Hence, buying the book maximizes the expected utility, and this becomes the rational choice for Geir.

2 Decision Support System

This task has been solved by use of the software GeNIe 2.0 and the model is therefore largely documented through the graphical interface of that software.

2.1 The Model

I have decided to model the problem of **what to do the day before an exam?** Is it for example a good idea to practice, or is this going to cause an unfavorable amount of stress? How about drinking coffee? Maybe it will make the practice more productive, but it may also lead to poor sleep quality. Finally, maybe it is advantageous (from a utility perspective!) to decide to cheat? This is what I have tried to capture in my model, which you can see in figure 2.

2.1.1 The Causal model and Assumptions

The decision support system has been modeled as a static Bayesian network, i.e. there is no transition model in time and every decision is only made once and is 'followed through to the end'. In other words, it is not allowed to change ones mind, which could be argued is a very strict restriction.

The model assumes the following temporal ordering of decisions: $Practice \rightarrow DrinkCoffee \rightarrow Cheat$. This ordering may seem arbitrary, but for me it seemed like the most natural alternative. The evidence nodes of course have temporal precedence over the decisions. In the following I will describe the causal relationships between some of the nodes in more detail. Note: All nodes are binary and are either $true$ or $false$.

- The $Practice$ decision naturally influences $ProductivePractice$ which also depends on the decision $DrinkCoffee$. The reasoning is that drinking coffee increases the probability of a productive practice session, which matches my experience. $Practice$ also influences $StressedOut$, which reflects my experience that practising right before an exam can make

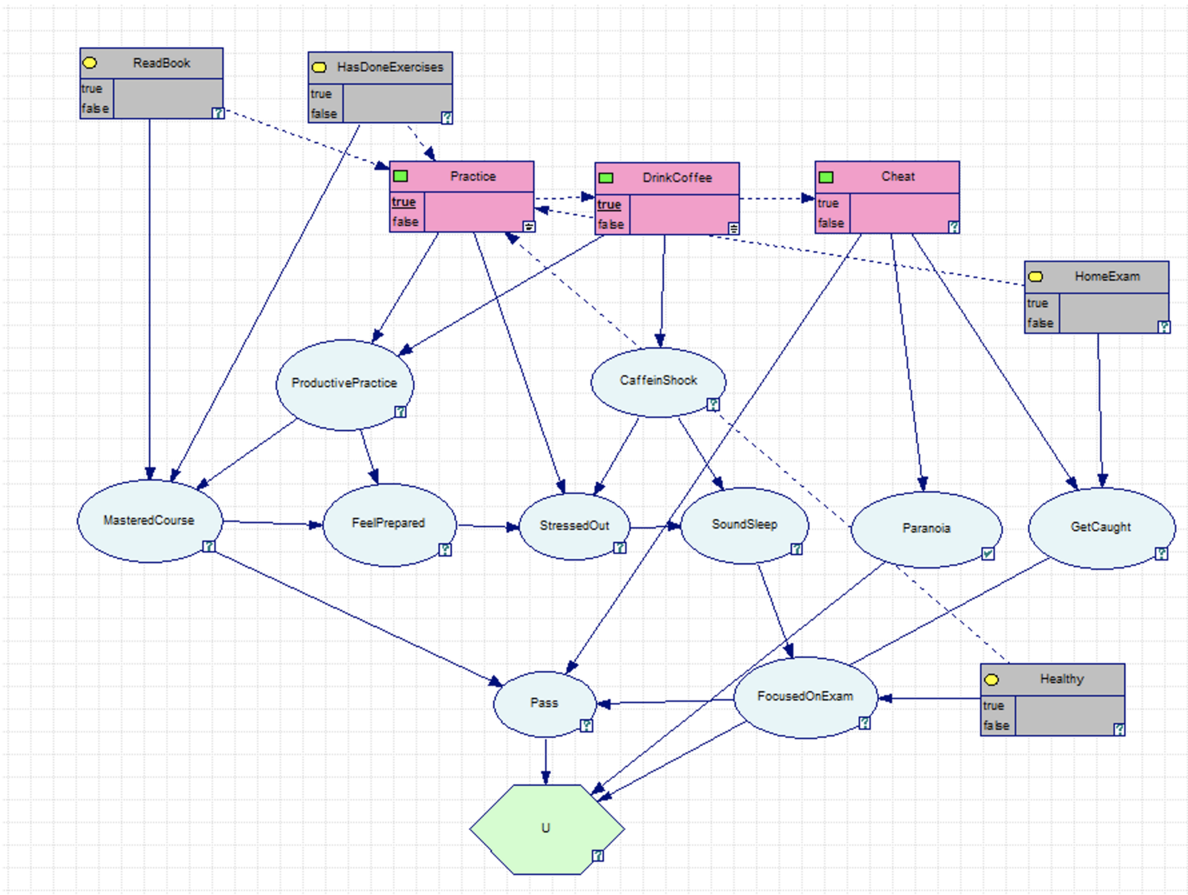

Figure 2: The decision network modeled in GeNIe. The grey boxes represent evidence nodes. The pink boxes represent decisions, the blue ellipses represents chance nodes and the green diamond represents the ultility node. The solid arrow lines represent parent-child relationships in the context of a Bayesian network, while dotted arrow lines represent temporal ordering.

me more unsure about my skills and cause me to worry. On the other hand, a productive practice session can make me more confident and less stressed. This effect is incorporated through the $FeelPrepared$ node, which depends on $ProductivePractice$ (and $MasteredCourse$) and influences $StressedOut$.

- $MasteredCourse$ is supposed to be one of the deciding factors if whether or not I $Pass$ the exam. I have modeled it to depend on $ReadBook$ and $DoneExercises$, which are fairly self-explanatory. I have also assumed that $MasteredCourse$ can be slightly influenced by a productive practice session. Mastering the course naturally influences whether or not I feel prepared.

- The decision $DrinkCoffee$ has the potential to make the practice productive, but it also has a potential drawback; it could cause a $CaffeinShock$! This in turn influences $StressedOut$ and $SoundSleep$ (good/bad sleep quality) in a non-favorable manner.

- The decision to $Cheat$ directly influences the probability of passing. We see that, given $Cheat$, $Paranoia$ and $GetCaught$ are assumed independent. This is reasonable, as being paranoid does not cause me to get caught and whether I get caught does not influence my initial paranoia.

- Whether the exam is a $HomeExam$ is considered known and influences the probability of getting caught. I assume here that it is more likely to get away with cheating if $HomeExam = true$. Another evidence variable is $Healthy$, which together with $SoundSleep$ determine $FocusedOnExam$. Intuively, if I am not healthy the probablility of being focused will be lower.

Every variable is assumed to be discrete, which could be a very crude simplification. Several of the variables, e.g. $MasteredCourse$ could have been modeled as a continuous variable, but this requires techniques that are not part of this course. The dependencies also reflect a simplified version of the real world (of course). For example, one could argue that $Healthy$ should also influence $SoundSleep$ and $ProductivePractice$, but this would in turn make the graph very cluttered.

2.1.2 Quantification Statements

To elicit the **probabilities** in the model I have used my own experience and intuition, as nearly all the random variables are strongly connected to my subjective experience. To give the elicitation some more structure I label all of the events with a qualitative 'probability':

- extremely unlikely $\sim < 0.1\%$
- very unlikely $\sim$ 0.1-5 %

- unlikely $\sim$ 5-15 %
- fairly common $\sim$ 15-30 %
- common $\sim$ 30-60 %
- likely $\sim$ 60-80 %
- very likely $\sim$ 80-95 %
- almost certain $\sim$ 95-99 %

This scheme is introduced to make the elicitation of probabilities more consistent over the chance nodes. It is also important to note that this specific scheme could lead to misinterpretations and bias the elicitation process. We will look at the conditional probability table for $FocusedOnExam$ as an example. Given that I sleep soundly and am healthy, I would say that it is very likely that I am focused on the exam, and assign $FocusedOnExam = true$ a probability of 90%. Given bad sleep and bad health, on the other hand, I deem it unlikely that $FocusedOnExam = true$, and assign it a probability of 15%. I evaluate the other scenarios in a similar manner. See table 2.1.2 for the full Conditional probability table.

$SoundSleep$	$true$		$false$	
$Healthy$	$true$	$false$	$true$	$false$
$true$	0.9	0.6	0.8	0.15
$false$	0.1	0.4	0.2	0.85

Table 1: CPT of $FocusedOnExam$.

Now we consider how the CPT of $GetCaught$ is constructed. $GetCaught$ has parents $Cheat$ and $HomeExam$. When both of these are true, i.e. cheating on a home exam, I consider it unlikely to be caught, and have assigned this a probability of 5%. Cheating on a non-home exam, on the other hand, I consider a considerably more risky endeavour and have labeled the probability of getting caught as common, giving $GetCaught = true$ a 40% chance. When I decide not to cheat, $Cheat = false$, I think the probability of 'getting caught' should be extremely unlikely, and I have given $GetCaught = true$ a probablilty of 0.1% regardless of $HomeExam$. The reason that there even is a probability that I will get caught is that I cannot know with absolute certainty whether I will cheat or not; maybe I get desperate and call a friend on a home exam or peek at my neighbours text on a school exam, even if I decided not to? See the CPT in table 2.1.2.

Moving on to the **utility function**, it is assumed to be a function of $GetCaugh$, $Pass$ and $Paranoia$. I assume it to be additive, given $GetCaught$, such that

$Cheat$	$true$		$false$	
$HomeExam$	$true$	$false$	$true$	$false$
$true$	0.05	0.4	0.001	0.001
$false$	0.95	0.6	0.999	0.999

Table 2: CPT of $GetCaught$.

$$U(GetCaught, Pass, Paranoia) = \begin{cases} -2000 & GetCaught = true, \\ U_1(Pass) + U_2(Paranoia) & GetCaught = false. \end{cases} \tag{3}$$

$Pass$ and $Paranoia$ are in other words assumed to be preferentially independent, given $GetCaught$. Furthermore, I assign the following utilities:

- $U_1(Pass = true) = 1000, \quad U_1(Pass = false) = 0$
- $U_2(Paranoia = true) = -200, \quad U_2(Paranoia = false) = 0$

2.2 Verification

To test and verify the model I will look at two cases. For the first case I assume that I **have read the book** and **done the exercises**, that I **am healthy** and that the exam is **not a home exam**. The expected utilities that GeNIe outputs for $Practice$ shows that it is slightly advantageous to decide to practice. Choosing this, we further get that drinking coffee also yields a slightly higher expected utility than not doing so. Lastly, if we decide to drink our coffee, we can see that cheating is not a good idea with respect to the expected utility. The full result can be seen in figure 3. This is a reasonable result, especially since cheating should not be necessary to pass the course when the evidence variables suggest that the probability of $MasteredCourse = true$ should be high. Whether I choose to practice or drink coffee seems not to have too much of an impact on the expected utility, which I would think is realistic.

For the second case, I assume that I have **not read the book or done the exercises**, that I am **not healthy** and that the exam **is a home exam**. In this case, $Practice = true$ is still favored. Choosing this, however, abstaining from drinking coffee is favorable with respect to expected utility, indicating that sleeping well is of more importance here. Choosing to not drink coffee, we see that $Cheat = true$ is actually the choice which maximizes expected utility. This seems realistic, as the chances of passing the course should be low, given the evidence, and the chances of getting caught are relatively low since the exam is at home (see table 2.1.2). The full result can be viewed in figure 4.

2.3 Discussion and Conclusion

First a little disclaimer: I have never and will never cheat on an exam, for ethical reasons. You could argue that this makes me 'unfit' to model the decision

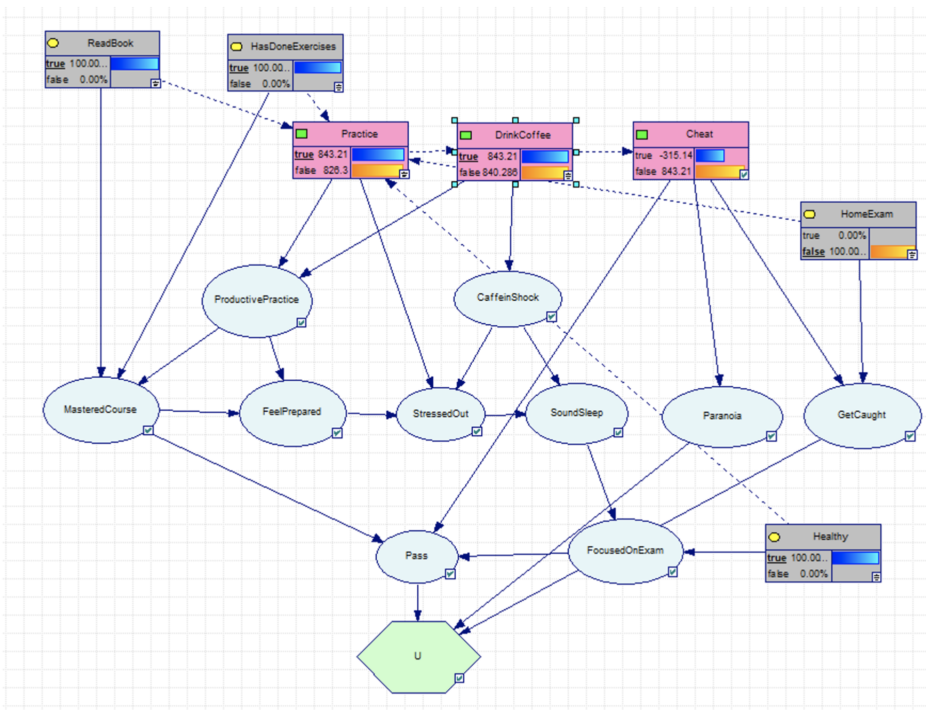

Figure 3: Case 1 in the verification viewed in GeNIe.

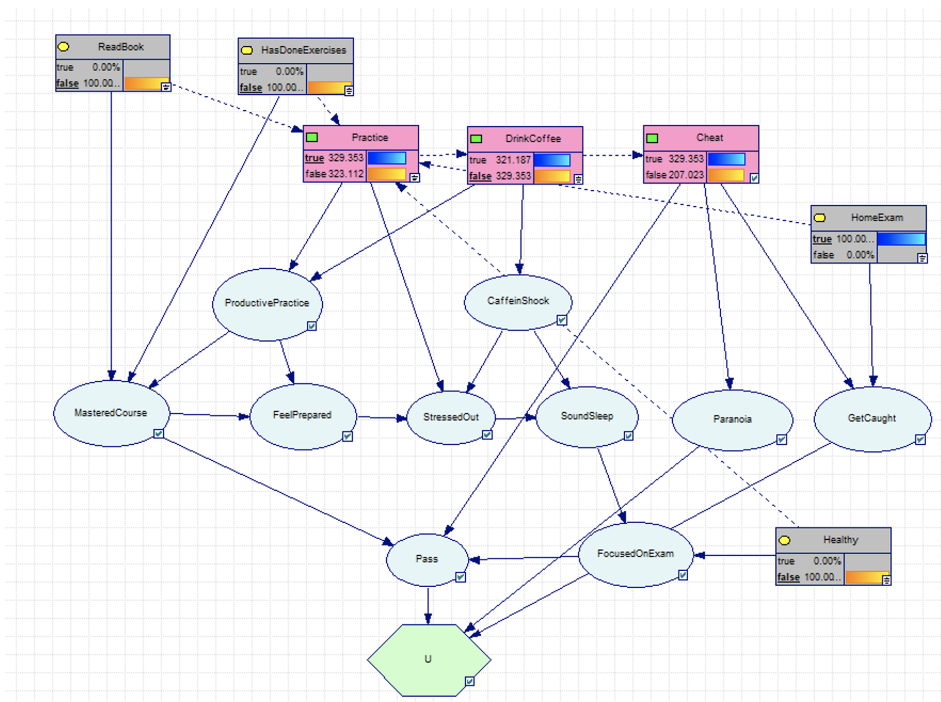

Figure 4: Case 2 in the verification viewed in GeNIe

of cheating, but I found it interesting and think I have been realistic (when considering the problem as pure utility problem). The decisions $Practice$ and $DrinkCoffee$ are perhaps more relevant for me. From the above verification and additional testing they seem to not impact the expected utility too much, which seems reasonable. After all, when the primary goal is to pass the course, what you do the day before will probably have a limited effect on the result compared to what you have done throughout the semester.