TDT4171 Artificial Intelligence Methods
Exercise 3

Decision Support System

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Contents

1 Introduction

In this exercise we are supposed to create and document a simple Decision Support System. We will see how observed and unobserved variables may infere with each other, and we will calculate utility values based on decisions.

2 Creating the Decision Support System

2.1 Choosing a problem

The first step in solving the task for creating a decision support system is selecting a problem for the system to solve. I have chosen to let the system help in deciding the every-day-decision of what to do now, for a regular student. For this kind of system, it is really hard to get real values for the utility function, and also difficult to set default probabilities for the environment. These values and probabilites must also be adjusted for each subject, as different persons have different personalities, preferences and work-effectiveness.

I have chosen the following activities that the system will help you decide between:

- Watch a movie with someone
- Watch a movie alone
- Do homework
- Eat dinner with someone
- Eat dinner alone
- Go to sleep
- Go outside
- Do excercise

of coure, there are a lot more things that could be added, but I think these are a representative overall of actions.

2.2 Decision parameters

Now that we have our problem defined, we need information about the current state, in order to promote a good decision.

I have chosen some attributes that I think is important in order to decide what to do, in the general context.

Lot to do
: Students have a lot to do, occasionally, but may also have a lot of spare time. Because how much you have to do is important deciding if you should do homework, I have included this parameter.

Hungry
: Whenever you are hungry, it is a good idea to eat food.

Sleepy
: You might be better off with sleeping than doing homework or doing excercises if you are sleepy.

Tired
: Tired is kind of a extended expression for sleepy, hungry, but also general "don't want to do nothing". I have included this as a way of telling you are tired, without beeing explicitly sleepy. If you are sleepy, of cource, this affects tired, unless specified otherwise.

Social needs
: Everyone has social needs from time to time, but sometimes, we also prefer beeing alone. This is important deciding wherever we are going to spend time alone, or meeting other people.

Weather
: The weather is more an environmental condition, but is also important for some decisions. We might say that it is more pleasing going out on a sunny afternoon, then if it is a full storm outside.

I would also state that there are somewhat better to do homework while it is raining outside, since it lowers the desire to go outside.

2.3 The effect of a choise

In order to calculate the utility value of a choise, we have to look at its consequences. I have chosen some attributes that work as outcome of a choise and a state. I have chosen to include the following consequence variables:

Usefullness
I will argue that you feel better if you have done something usefull. Something usefull depends on what demands you were having before doing an action, eg. if you where hungry, it may be more usefull to eat something than to watch a movie, and if you had a lot to do, it might be most usefull to do some homework.

Work left
How much work are we left with after doing our action. This is important because it may be difficult to relax if you have much on your mind. Typically doing homework leaves you with less to do, while sleeping leaves you with exactly the same amout.

Exhausting
You might be more pleased with yourself if you have done something that was not exhausting, since it leaves you with more energy. You might argue that it feels good to be real exhausted after a hard excercise, but I have put those values into *Usefullness*, leaving just "bad" exhaustnes into this variable.

Fun
The more fun we have had, the better. Often, fun goes against usefullness, but since some things might be fun and usefull, we need both variables.

Social
People have social demands, and this is important to how good we feel. If we have little contact with other human beeings, we might feel lonely, while over-stimulating the social life might not be too good either.

Hunger
Even though we allready have the state node Hungry, we need to know how hungry we will be given a decision. Since mood is much dependent on hunger, this is an important node.

Physiological feeling
This node is a merge between Exhausting, Fun, Social and Hunger, since I think all these represents how good your body feels. Fun and Social might be argued, but if you feel that you have a lot of friends, or you feel that this is a lot of fun, you tend to forget about hunger and exhastness. Because of that, we may combine these into one node, both simplifing the model and the caluculations.

2.4 Compiling variables into a system

The previous sections defined a set of variables and a set of choises that makes up to a mini-world. The consepts of mini-worlds is that they models the real world, or any world where we want to do computations. Of course, a more advanced mini-world would be able to model the real world with better accuracy, but would also (potensially) add severe complexity.

But since we have defined what our model contains, we have to model the releations between the different attibutes. I want to do this in a way such that the attributes and their relations make up a *Bayesian network*, since this is a datastructure that eases the computation needs in opposition to a *truth table*[1]. The consept of easing the computational needs in the Bayesian network is called *conditional independence*. What it means, is basicaly that a node is self-contained given its parents, and we do not need to go further on to grand parents and so on to find its real value. This is an assumption that we must take to avoid large tables, and is a property of the Bayesian Network.

An example of a *Bayesian network* is included in Figure 1. We see that the nodes represents states and

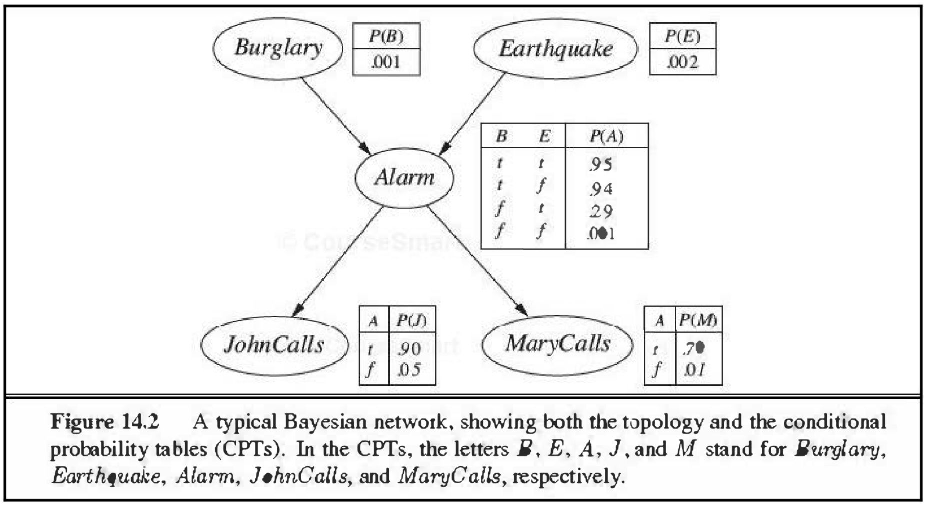

Figure 1: Example of Bayesian network, copy of figure from AIMA[1]

actions, each with probabilities that links together to a system.

From this, we can set up a system that maximizes the utility value[1] in such a way that it will chose those options with best outcome. Again, the AIMA-book has a great example of such a system, and I have included this in Figure 2.

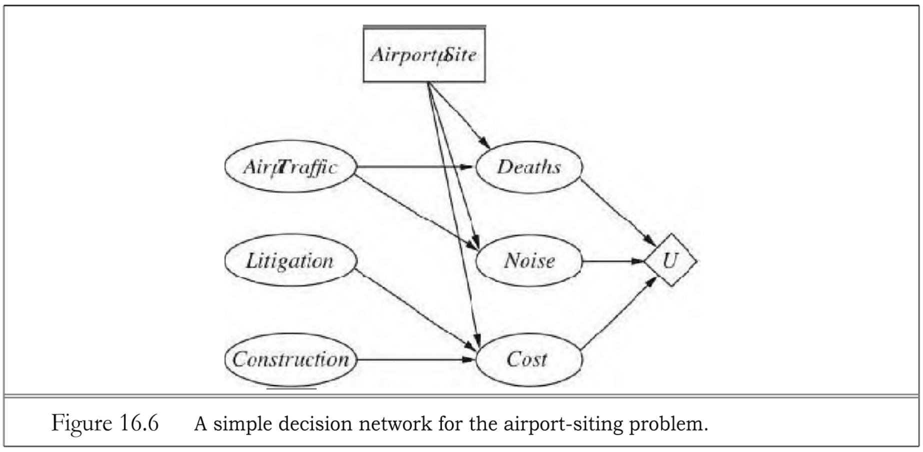

Figure 2: Example of a desicion support system, copy of figure from AIMA[1]

Now, our job will be to link the nodes that represents state and consequences into a network like that. A screenshot from my complete model from GeNIe 2.0 is included as Figure 3

Most of the work with setting up such a system, at least if you have a software like GeNIe[1], is filling the *truth tables*. I mentioned that Bayesian networks are better than large truth tables, but they does not eliminate them. A Bayesian network helps us minimizing the tables so that only related properties gets computed together. In the real world, we might have a tight or loose coupling between almost anything, in our mini-world, we separate the attributes from each other, again to simplify computation.

The nodes marked as gray in Figure 3 is the state nodes. These have simple tables, like this:

[1] http://genie.sis.pitt.edu/

Hungry	
Yes	0.2
Some	0.3
No	0.5

Table 1: Values from Hungry-node

The nodes marked as green are the state-nodes, which are affected by both the state nodes and the decision[2]. These nodes expand exponentially for each parent connection, and will occationally grow large. The good thing with the *Bayesian network* is that we reduce the tables extremely much from what they could have been if all values where to be stored in one table.

One of my tables with multiple parents looks like this:

		Exhausting		
What to do	Tired	Yes	Some	No
Watch movie together	No	0	0.1	0.9
Watch movie together	Some	0.1	0.2	0.7
Watch movie together	Yes	0.2	0.4	0.4
Watch movie alone	No	0	0	1
Watch movie alone	Some	0	0.1	0.9
Watch movie alone	Yes	0.1	0.1	0.8

...

Table 2: Some values from the Exhausting-node

with appropriate values for all decisions combined with the value of the state nodes. All values are defined in the the GeNIe network attached with this document.

2.5 The utility

This system calculates a value that we call the systems Utility Value. This value tells us how appropriate the given situation is. If we have already observed some variables or made a decision, the utility function takes this as input and will tell us how good the current given situation is. The utility function uses numbers from a table simmilar to the table above to weight the outcome. The values from my utility function can be found in Table 2.8. All the values are my opinion on a given decision combined with the set of consequences. A value of 1 is perfect, while a value of 0 means a situation I want to avoid. The numbers of the utility function are not limted to the range between 0 and 1, like the chance nodes, because it works more like a score. I like the range between 0 and 1 because it set limits for best and worst, and I think that makes it easier to express the values of situations.

2.6 Finding the right values

But what are all these values? These values are the probability of a state, or the probability of a consequense, given a descision and a state. Eg. how likely is it that we become exhausted given that we watch a movie together and we are tired already? This is the number in first column and third row in the table above. Each row make up probabilities for given situations, and since all possible situations are included, they must add up to one.

Allmost all the values in my decision support system are made up of my own opinions of things. An exception is the weather node, where I have calculated values from weather statistics[2]. Those values are stated in Table 3. More state-node examples can be found in Table 2.4 and Table 2.6 Examples of other values, that are entirely my opinion on state and consequences can be found in Table 2.4, but these

[2]The large square node, coloured light blue, stating “What should I do now?”

Weather	
Sunny	0.4605757196
Cloudy	0.2152690864
Rainy	0.1739674593
Snowing	0.1326658323
Storm	0.0175219024

Table 3: The Weather node, values calculated from met.no[2]

Sleepy	
Yes	0.2
some	0.2
No	0.6

Table 4: Values from the Sleepy-node

tables are so large that I have chosen not to include too much of them. Entire tables with values can be found in the GeNIe-file attached with this document.

2.7 Connection of the nodes

Now I will describe how I connected the nodes, and explain some of my choises. As we see from Figure 3, I have devided the world into state (observed), decision and consequences(unobserved) parts. The chosen colours are for just to tell the realms apart. I think that your mood depends highly on those variables, and your best choise is highly dependent on your mood. The values, again, are mostly chosen by how I see the world, and must be adjusted for other personalities. By example, having an infant at home usually makes the night shorter, and makes me more sleepy and tired than the average person. That is why my Sleepy-values are higher than it would be if you just were sleepy a few hours before bed-time. I also have connected Usefullness with Hungry, Sleepy and Lot to do, because if you are hungry, it may be more usefull to eat than to do anything else, same for sleepy and go to sleep. I you have nothing else to do, anything may be usefull, but having a lot to do, in other words, home work, then that must be done before watching a movie.

Likewise, how much work you have left leans on how much you have to do, how tired you are, and what you choose to do. Sleeping or watching movies leaves you with the same amount, while doing homework leaves you with somewhat less, depending on how tired you were before starting.

How much fun you have depends highly on what you do alone, but also depends on various factors. I have chosen to set your social needs and the weather as main parameters, since going outside might be bad if there is a full storm outside, and watching a movie with someone may also be bad if you just want to be alone.

Your social requirements are a major part of how good you feel, so if there was any unmet social needs, that will count bad for the utility function. The social requirements lean mostly on what you do, and how social you felt before doing something.

I have chosen to link the four nodes Hunger, Exhausted, Fun and Social into Physio logical feeling because I think they represent the way your body feels. Linking them into one node makes the utility node's value table a lot smaller[3], without lowering the acurracy that much. This is one example of conditional independence, where you know how your body feels given Hunger, Exhausted, Fun and Social, and there is no need for knowing what choises has been maid, neither what state we had before making a decision.

[3]From 243 to 27 different values

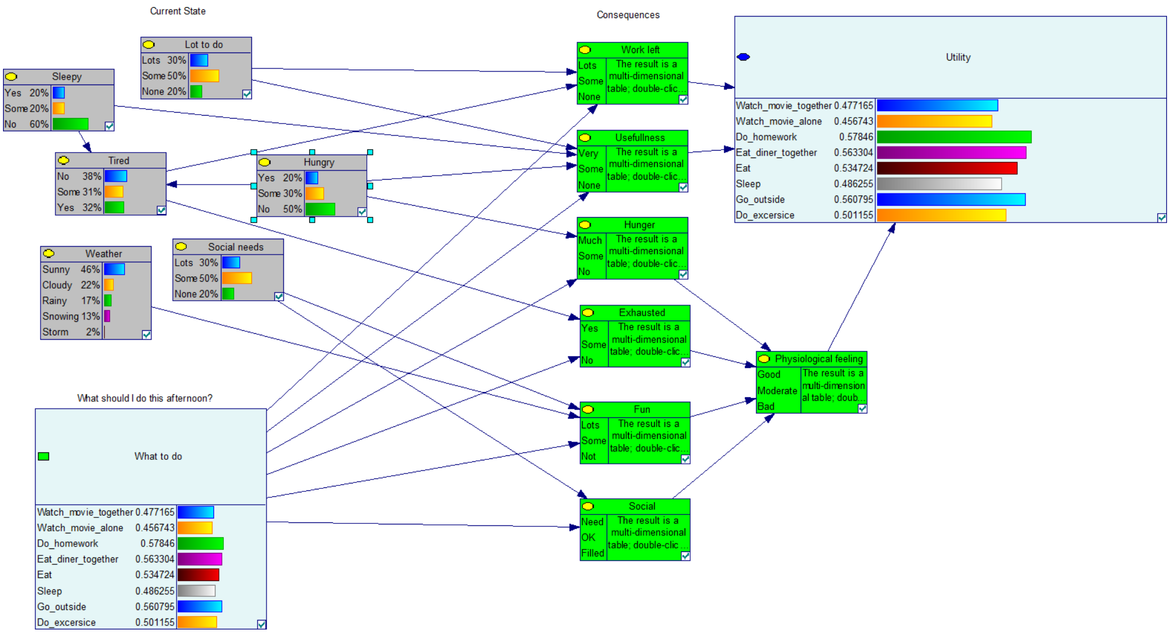

Figure 3: Complete Decision Support System in GeNIe 2.0

2.8 Observations and adjustments

After filling in all probability tables and values of the utility function, we still have a lot to do. These kind of systems needs to be adjusted so that they agree with the target. In real systems, it is usual to compare the decision of the sstem with a “golden state”, that is the decision made from a group of experts. In my system, I had to adjust the opinion-values until I felt I agreed with the system. I learned that I usually had the utility value to high, and had to lower many of them.

Some results from my system:

Hungry: No, Lot to do: Lots, Tired: No, Sleepy: no, Weather: Sunny, Social needs: None
Do homework has the highest utility, while go outside follows tight. This is mostly because it is sunny outside.

Hungry: No, Lot to do: Lots, Tired: No, Sleepy: no, Weather: Storm, Social needs: None
Setting weather to storm lowers the utility of go outside, while homework is raised a little. This is because it is better to do homework when you don’t want to go outside anyways.

Hungry: No, Lot to do: Lots, Tired: Yes, Sleepy: Yes, Weather: Sunny, Social needs: None
When you are sleepy and tired, it is better to go to sleep, rather than to do homework. The utility of go outside is actually higher than do homework, this is because you don’t want to do homework when you are tired, since you don’t learn any thing, and things may be wrong, lowering your grade. Going out may give you some energy, and it does not matter if you are tired. Anyways, sleep had a governing utility here.

Work left	Usefullness	Physiological feeling	Utility
Lots	Very	Good	0.6
Lots	Very	Moderate	0.4
Lots	Very	Bad	0.3
Lots	Some	Good	0.5
Lots	Some	Moderate	0.3
Lots	Some	Bad	0.2
Lots	None	Good	0.4
Lots	None	Moderate	0.3
Lots	None	Bad	0.2
Some	Very	Good	0.8
Some	Very	Moderate	0.6
Some	Very	Bad	0.3
Some	Some	Good	0.7
Some	Some	Moderate	0.5
Some	Some	Bad	0.2
Some	None	Good	0.5
Some	None	Moderate	0.3
Some	None	Bad	0.1
None	Very	Good	1
None	Very	Moderate	0.8
None	Very	Bad	0.6
None	Some	Good	0.9
None	Some	Moderate	0.7
None	Some	Bad	0.4
None	None	Good	0.8
None	None	Moderate	0.7
None	None	Bad	0.3

Table 5: Values of the utility function

3 Conclusion

To create a Decision Support System is no trivial task, though mapping it into GeNIe is not that hard once I got the grip on it. I spent most of the time on trying to understand the effect of the different values, as well as getting the arcs right. I think that in order to create a very good Decision support System, you have to spend a lot of time first thinking of what variables are important, since adding too much just adds complexity without adding value, second you have to tune all the values right. This is a task requiring very good domain knowledge, and usually you would test the system against a panel of experts.

All in all, Decision Support Systems may be a good tool in many situations, but may also be flawed in that they simplify the world in ways that often introduce errors. The best use is where we have a lot of hard data with deterministic, or almost deterministic outcome. In such a situation, this kind of systems will outperform any human.

References

[1] Stuart Russel and Peter Norvig,
Artificial Intelligence - A modern Approach, 3rd ed
http://aima.cs.berkeley.edu/

[2] Meteorologisk Institutt
Hvor vanlig er vt (Nord-Trndelag)? (Visited 2012-02-28)
http://retro.met.no/met/vanlig_var/nord/vernes.html

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