NTNU
TDT4171 ARTIFICIAL INTELLIGENCE METHODS

Assignment 3 - Decision support system for the choice of what to exercise tomorrow

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CONTENTS

1 Step 0 - Decide what to model

In this assignment I have chosen to make a decision network that analyses the answer to the question: What to exercise tomorrow? This question will have two different decisions, cardio or strength training.

2 Step 1 - Defining variables and decisions

2.1 Defining desicions

As mentioned I will have only one decision to make in this exercise network; what to exercise tomorrow, with two possibilities; strength training or cardio training. One might also extend the network with other decisions, like whether or not to test, for money, some of the random variables in order to increase knowledge.

2.2 Defining variables

Before making the decision there are some variables that may influence the choice I am going to make. After making the choice, on the other hand, there will be some consequences of the choice I made. The last mentioned variables will all influence the utility or happiness with the choice I made.

Observed before decision

- Temperature
- Time available
- Diet
- Water intake
- Muscle type

Observed after decision

- Asthmatic attack
- Sore muscles
- Exhaustion
- Dehydration
- Strain injury
- Training benefit

3 Step 2 - The qualitative part

In figure 3.1 you may see how I chose to structure the network, and which variables influence which. As described in the previous section, some of the variables are only observed after the decision has been made, and from the diagram we can see that the choice of decision, green box, influences these variables. Further, some of the variables that may be observed before the decision influences other random variables.

I have chosen a rather simple structure, by assuming that each node has no more than 3 parents. That way, the quantitative part where the probability tables are to be set will become simpler. To simplify further, I have chosen to have intermediate utility nodes where the preferential independence between the nodes are visible. The total utility node is then just a summation of the intermediate nodes. In addition, my model follows the 1st order Markov process assumption, that the future is conditionally indepedent of the past, given the present. Thereby, the next state is only influenced by the states and evidences today. Further, I have assumed a stationary process, that the probability tables are independent of the time step. Below follows an explanation of the relationship between children and parent nodes.

Temperature takes on two values; cold or warm. Right now, as it is winter and I am located in Norway, and it has been cold for several days, the probability of it being cold tomorrow is larger than it being warm. In this model, temperature will only affect whether or not I will have an asthmatic attack, and whether or not I become dehydrated during training. I consider these two nodes to be the strongest affected by temperature. Firstly, asthma is dependent on whether it is cold or not. The colder the air, the more likely it is for me to have an attack. Further, if it is very warm, I tend loose more fluid, and thereby creating a

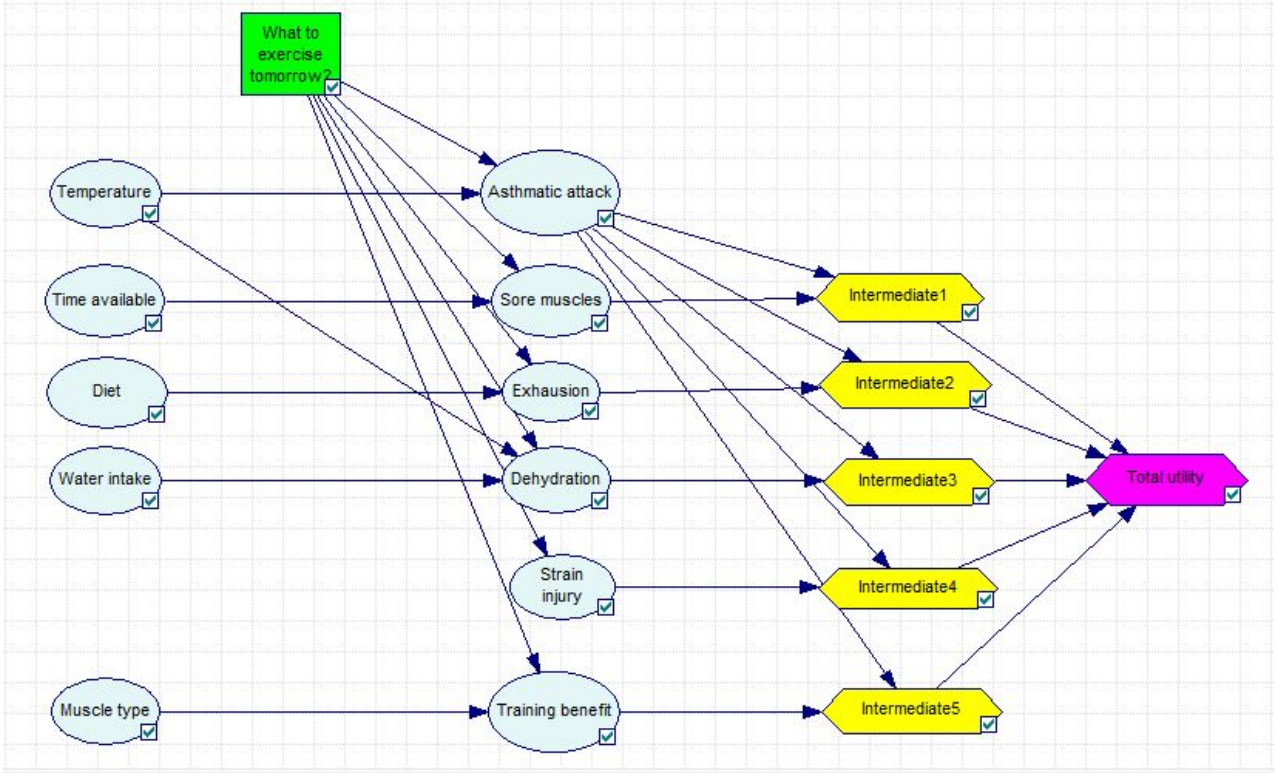


Figure 3.1: Influence diagram

higher probability of becoming dehydrated. As I am no athlete, and therefore train moderately when I exercise, I chose not to have temperature affecting how sore muscles I get, or the amount of exhaustion. This is despite the fact that the accumulation of lactic acid during exercise often is greater when it is cold than when it is warm, and the fact that if the temperature is very high, the probability of exhaustion is much greater that when it is cold. On the other hand, as I live in Norway, the posibility that the temperature is so high that it will effect exhaustion is minimal, but should probably be reavaluated if I suddenly find myself located in Africa during summer.

Time available takes on two values; little and much. As I am a student at Gløshaugen I am in general very busy. However, work tend to pile up and therefore there will be periods where there are much spare time and other periods where there are less spare time. I have chosen that this node should only affect how sore muscles I get from the training. With much time available there are a greater probability that the training session will last for longer and therefore increasing the probability of getting sore muscles. Again, as I am no athlete, I do not think that time available will significantly affect whether or not I am becoming dehydrated due to the fact that I will not train for too long anyways. Same argument goes for strain injury. Exhaustion however, are more dependent on the intensity of the training and not the time available.

Diet takes on three values; eat too little, eat appropriate, eat too much. What, when and how much I eat will greatly affect the amount of exhaustion I feel, and how useful this exhaustion is for me. As I am a student and have little money to spend, there is a probability that I eat too little. Same argument goes for eating too much. However, I know how important nutrients are for my body so I usually eat appropriate, but it can vary from day to day. Eating too little may result in the exhaustion being great and not in a good way. Eating too much over a longer time period may results in overweight, and the body will use extra energy to carry around the extra weight, hence creating a greater exhaustion.

Water intake takes on three values, much, approprate, little. I am usually very good at drinking the appropriate aomunt of water during a day, but sometimes I forget. This variable, together with temperature and the decision influences dehydration. The less I drink the more probable it is to become dehydrated.

Muscle type takes on three values; type 1, type 2A, type 2X. According to [1] the three types determine your endurance capabilities and whether or not you are quick. Type 1 gives long endurance but slow, type 2A a bit of both, and type 2X low durability but quick. [1] explains that the kind of muscle type you have are genetic but it is possible, with the right exercise, to increase one or the other. I have always been quite small, compact and quite strong relative to other girls my age which suggest that I perhaps have more type 2X muscles. However, I have mostly trained edurance training and should therefore have trained my type 1 muscles quite a lot. As a consequence, there is a higher probability of having type 2A. I have chosen that this node should only affect the training benefit I have for this exercise session. I believe that a body which is both strong and relatively endurant is the healtiest one, and therefore I believe that if one is born with type 1, the greatest training benefit would be strength training and vice versa. Of course, if I was an athlete, this node would also influence exhaustion and sore muscles, however, as I consider myself having a bit of both muscle types, this node will more significantly influnce the training benefit and not exhaustion and sore muscles.

Now, I have already discussed the variables that may be observed after the decision with respect to their (blue) parents. I will now briefly discuss them with respect to the decision node. As I have asthma, there is a quite high probability, relative to others without, of getting an asthmatic attack while exercising. This probability is, from experience, higher when training cardio than when training strength. Further, from experience, strength training tend to give more sore muscles than cardio. exhaustion on the other hand, tend to be greater from cardio training, as I often have larger breaks during strength training. When I train cardio, like running, I sweat quite a lot and therefore, without sufficient supply of water for example, the probability of becoming dehydrated are greater than when training strength. As I am not so experienced within strength training, it is most likely that I will achieve a strain injury from trainig that rather than from cardio. Lastly, as I mentioned earlier, I believe that the training benefit is larger when one train the opposite than what one is genetically born to be good at, and hence, the decision of strength or cardio will also influence the training benefit.

Lastly, I will discuss the different utilities, yellow nodes. I have given each utility node a value between zero and one. 0 indicating "worst possible scenario" and 1 indicating "best possible scenario". I have chosen to have asthmatic attack influence all of the intermediate utility nodes. This is because, due to experience, when I do get an attack, this effect tends to last for several days, destroying any happiness I might achieve with the training session. Therefore, if asthmatic attack is true, I want the utility of the decision to be zero. Beside from that, I have chosen the rest of the nodes observed after the decision to be mutually preferentially independent of each other to simplify the model with an additive value function, and making it easier to quatify values for each utility. Hence, my attributes are mutually utiliy independent, that is, each subset is mutually independent of others. This is of course, in the real world, not true as combinations of the nodes could have different utilites and must really be counterbalanced against each other.

4 Step 3 - the quatitative part of the BN and the utility function

Following the requirements for the probability of different scenarios I discussed in the previous section, I achieve the following probability tables, 4.1-4.16 through qualitive guessing and by weighing different states against each other.

Table 4.1: Temperature

Warm	0.2
Cold	0.8

Table 4.2: Time available

Much	0.3
Little	0.7

Table 4.3: Diet

Eat too little	0.15
Eat appropriate	0.8
Eat too much	0.05

Table 4.4: Water intake

Little	0.3
Appropriate	0.6
Much	0.1

Table 4.5: Muscle type

Type 1	0.1
Type 2A	0.5
Type 2X	0.4

Table 4.6: Asthmatic attack

Exercise	Strength		Cardio	
Temperature	Warm	Cold	Warm	Cold
True	0.05	0.2	0.2	0.7
False	0.95	0.8	0.8	0.3

Table 4.7: Sore muscles

Exercise	Strength		Cardio	
Time available	Much	Little	Much	Little
True	0.9	0.6	0.3	0.05
False	0.2	0.4	0.7	0.95

Table 4.8: Exhaustion

Exercise	Strength			Cardio		
Diet	Eat too little	Eat appropriate	Eat too much	Eat too little	Eat appropriate	Eat too much
True	0.7	0.6	0.4	0.95	0.7	0.8
False	0.3	0.4	0.6	0.05	0.3	0.2

Table 4.9: Dehydration

Exercise	Strength						Cardio					
Water intake	Much		Appropriate		Little		Much		Appropriate		Little	
Temp.	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold
True	0.1	0.01	0.3	0.05	0.6	0.2	0.2	0.1	0.4	0.1	0.9	0.4
False	0.9	0.99	0.7	0.95	0.4	0.8	0.8	0.9	0.6	0.9	0.1	0.6

Table 4.10: Strain injury

Exercise	Strength	Cardio
True	0.8	0.3
False	0.2	0.7

Table 4.11: Training benefit

Exercise	Strength			Cardio		
Muscle type	Type 1	Type 2A	Type 2X	Type 1	Type 2A	Type 2X
True	0.8	0.5	0.2	0.2	0.5	0.8
False	0.2	0.5	0.8	0.8	0.5	0.2

As can be seen from the utility tables, table 4.12 - 4.16, either having an asthmatic attack, becoming dehydrated or achieving a strain injury does not provide me with any happines, and therefore their values into the total utility will be 0. However, soreness of the muscles is mostly good (there exists degrees of soreness), it claims that what I have trained had some positive benefit and therefore it achieves a higher value than not having sore muscles. Similarily with exhaustion. Mostly it is a sign that your body has done well and benefitted from training, and being exhausted will therefore achieve a higher number than not being exhausted. My utility function will therefore be an additive function of the intermediate

Table 4.12: Intermediate1

Asthmatic attack	True		False	
Sore muscles	True	False	True	False
Value	0	0	0.8	0.2

Table 4.13: Intermediate2

Asthmatic attack	True		False	
Exhaustion	True	False	True	False
Value	0	0	0.6	0.4

Table 4.14: Intermediate3

Asthmatic attack	True		False	
Dehydration	True	False	True	False
Value	0	0	0	1

Table 4.15: Intermediate4

Asthmatic attack	True		False	
Strain injury	True	False	True	False
Value	0	0	0	1

Table 4.16: Intermediate5

Asthmatic attack	True		False	
Training benefit	Good	Poor	Good	Poor
Value	0	0	1	0

nodes and look like:

$$U_i(pa(u_i)) = I_1 + I_2 + I_3 + I_4 + I_5 \tag{4.1}$$

5 Step 4 - Verification

It is now time to verify that my model works in a rational way. Before setting any evidence variables the model gave the result shown in figure 5.1.

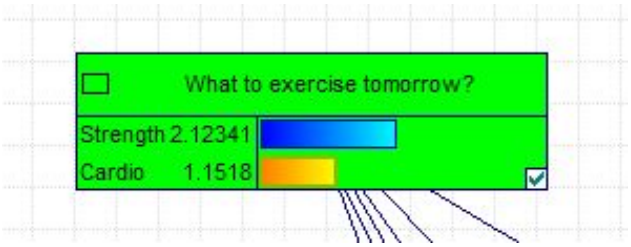


Figure 5.1: Initial decision, without evidence

As one can see, without any evidence set, the choice that maximizes the utility is strength training.
By setting all the pre-decision evidences; temperature, water intake, diet, muscle type, time-available to the most probable states, see table 4.1-4.5, the influence diagram still tells me to do strength. This is, I believe, mostly due to it beeing cold, and hence favourable to strength training as strength will least likely create an asthmatic attack. If I change the Temperature to Warm and change Water intake to Much, then the utility of training Cardio will increase. This is due to the fact that I defined the probability of having an asthmatic attack less likely when it is warm than cold, and that I could benefit greater from Cardio if I drank much. So far, the model seems to work the way I want it to, favouring strength due to low probability av having an asthmatic attack and due to the cold. If I however, suddenly realize that I do have mostly type 2X muscles, and not a bit of both, then I have defined that I would benefit more from training Cardio, which will then counterbalance the probability of having an asthmatic attack when it is warm and hence favour Cardio, see figure 5.2.

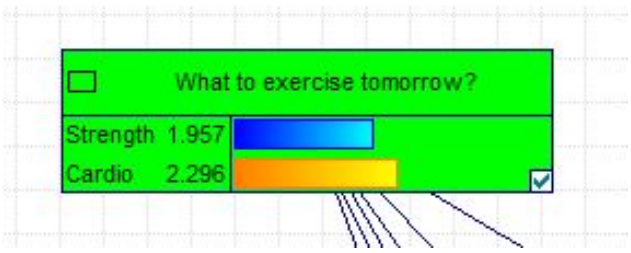
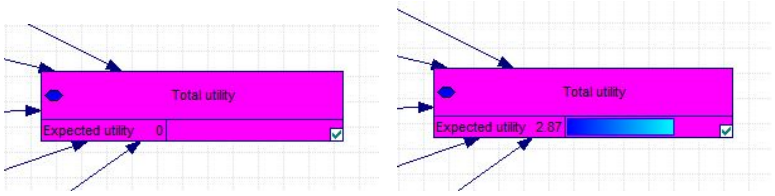


Figure 5.2: Decision when Temperature = warm, Muscle type = 2X

Now, from this state, choosing Cardio, I gain a total utility of $U = 2.296$ before setting any of the post-evidence variables. As expected, if I set Asthmatic attack = true, then the total utility becomes zero. But when I set Asthmatic attack = false, the total utility increases to $U = 2.87$, see figure 5.3.



(a) Asthmatic attack = true (b) Asthmatic attack = false

Figure 5.3: Result of utility when changing Asthmatic attack

The model seems to be working as the total utility increases when I set the post-evidence that influences the utility positively to true (sore muscles, exhaustion, training benefit) and negatively to false (asthmatick attack, strain injury, dehydration). It also decreases if I obtain some of the negativly affecting consequences like a strain injury or becoming dehydrated. One of the maximum values I managed to achieve when choosing strength training was $U = 4.4$ showed in figure 5.4

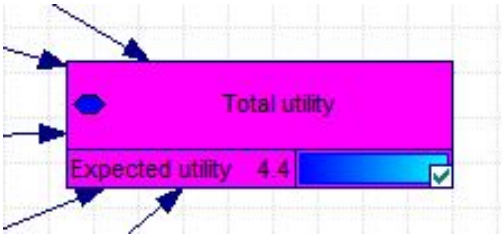


Figure 5.4: Maximum utility when choosing strength training

To further test my model, I will investigate whether the best decision is sensitive to small changes in the probability tables, so called sensitivity analysis. I used the initial scenario as starting point, showed in figure 5.1, and then I tried changing some of the probabilites that is mostly set in favour of strength training rather than cardio, for instance temperature. If I stated that it was a higher probability of it being warm than cold, and then also decreasing the probability of becoming dehydrated when it is warm slightly, my decision network did not seem to favour cardio over strength training. I also tried to increase the probability of having sore muscles when doing cardio, but yet again my network did not favour cardio. I also tried to change some of the utilities that favoured cardio before strength, like sore muscles and exhaustion, but the model still favoured strength before cardio. However, the utility for training cardio increased in every change. As a consequence I would claim that my decision is quite robust against uncertainties in the uncertainties, and I will therefore train strength training tomorrow.

REFERENCES

[1] Helene Høimyr, Studenttorget, 29.04.15 http://studenttorget.no/index.php?show=4940&expand=3797,4940&artikkelid=14635, Download: 27.02.17