TDT4171 Assignment 3

Anders Fagerli

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1 Decision Support System

The decision network modelled in this assignment is whether to take a car to service or not, based on uncertain variables for different failure modes of a car. The aim is to make a decision that benefits the owner, depending on the conditional probabilities of the occurrence of a failure mode. The network assumes a combustion car, and all variables and decisions are binary (with the exception of *Cost*).

1.1 Variables

Here the different variables of the model are listed, with some of the assumptions made for the model.

- *Gearbox* - uncertain variable depicting whether the gearbox is damaged or not. A damaged gearbox is usually the most expensive to repair.
- *Oil* - uncertain variable depicting whether there is a fault in the engines lubrication system or not. Faults may be leakage or oil in need of changing. The cost of repair depends on the fault in the system, but the network assumes all failures of this system result in a low cost.
- *TimingBelt* - uncertain variable depicting whether the timing belt of the engine is worn out or not. The timing belt is easy to replace with low cost, but may lead to critical motor failure and high costs when worn out and not addressed.
- *Cost* - uncertain variable depicting the cost of the choice, which depends on the state of the *Gearbox*, *Oil*, *TimingBelt* and the choice of the owner, making it unobserved before the choice is made. The *Cost* is separated into low, medium and high cost. Taking the car to service will always result in a medium cost or higher, as the service is assumed a medium cost by itself.
- *GearboxAlert* - deterministic variable depicting whether the indication light for a failure of the gearbox is illuminated. Can either be on or off. There is a small uncertainty whether the gearbox is damaged even when the light is on.
- *CarAge* - deterministic variable depicting whether the car is old or new. An old car tends to have a higher probability of damaged gearbox and engine lubrication system.
- *DrivingDistance* - deterministic variable depicting whether the car has previously driven a far or normal distance. A car that has driven a long distance tends to have a higher probability of a damaged gearbox, engine lubrication system and timing belt.
- *TimingBeltTeeth* - deterministic variable depicting whether the teeth of the timing belt are trapezoids or curves. A trapezoid-shaped tooth will endure more tear than a curved.
- *OilLeakage* - uncertain variable depicting whether there is leakage in the engine lubrication system or not.
- *Gasket* - uncertain variable depicting whether the gasket sealing the engine oil is loose or sealed. A loose gasket may induce an oil leakage.

1.2 Decisions

- *TakeCarToService* - binary decision of whether to take the car to service or not. This is the only decision in the model. The decision is based off the utility function of the model.

1.3 Utility function

The utility function assigns a satisfaction with a certain choice, given the state of the uncertain variables. This is here on a scale from 0 to 1, where 0 depicts the worst possible choice and 1 depicts the best possible choice.

The best possible outcome is that all systems are undamaged and the owner does not take the car to service. This is closely followed by the situation where all systems are damaged and the owner takes the car to service, as this decision may save the owner unforeseen costs and potentially his/her life.

The worst possible outcome is consequently when all systems are damaged and the owner does not take the car to service, closely followed by the situation where all systems are undamaged and the owner still takes the car to service.

The utility is a discrete function, as the variables affecting it are binary. The values of the function are assigned based on the scale (0 to 1), and the consequence of each failure in terms of cost and safety, the latter discussed in section 1.1.

TakeCarToService	Do								Dont							
Gearbox	Damaged				NotDamaged				Damaged				NotDamaged			
Oil	Bad		NotBad		Bad		NotBad		Bad		NotBad		Bad		NotBad	
TimingBelt	Worn	Unworn	Worn	Unworn	Worn	Unworn	Worn	Unworn	Worn	Unworn	Worn	Unworn	Worn	Unworn	Worn	Unworn
Value	0.99	0.9	0.95	0.9	0.85	0.5	0.8	0.01	0	0.1	0.05	0.15	0.2	0.3	0.25	1

Figure 1: Utility table

1.4 Uncertainties in the variables

Here the probability tables for two of the variables are listed. All can be viewed in the attached GeNIe file.

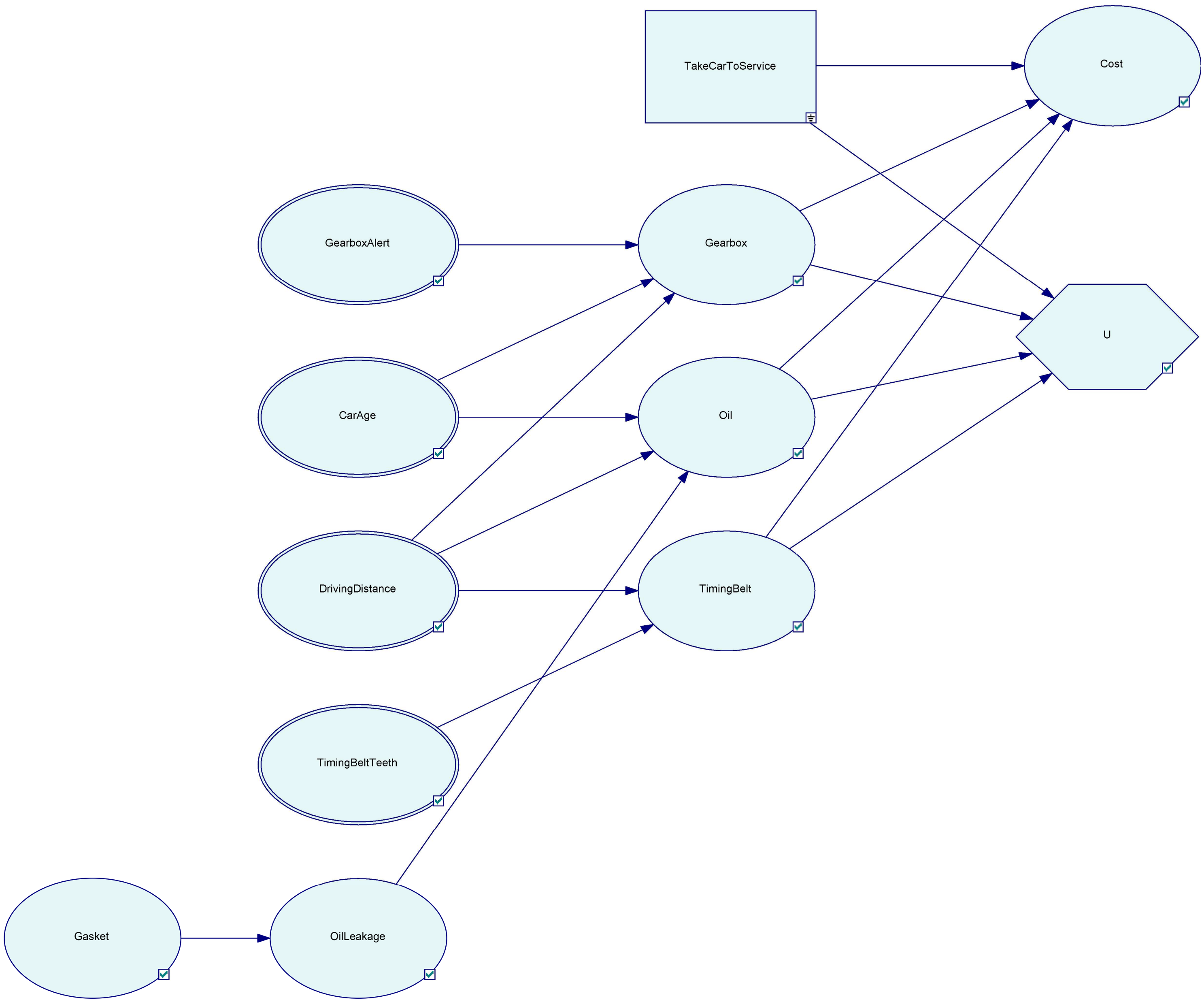
CarAge	Old				New			
OilLeakage	Leakage		NotLeakage		Leakage		NotLeakage	
DrivingDistance	Far	Normal	Far	Normal	Far	Normal	Far	Normal
Bad	0.95	0.93	0.3	0.2	0.9	0.89	0.05	0.01
NotBad	0.05	0.07	0.7	0.8	0.1	0.11	0.95	0.99

Figure 2: Probability table for the variable *Oil*

As with the utility function, the probabilities are based on intuition when we don't have any collected data to estimate a probability from. The above table shows the predicted state of the oil given the evidence from *CarAge*, *OilLeakage* and *DrivingDistance*. It is intuitive that worse evidence should give a higher probability of failure, so this scheme is employed throughout the table. The same is done for *TimingBelt* in figure 3.

DrivingDistance	Far		Normal	
TimingBeltTeeth	Trapezoid	Curved	Trapezoid	Curved
Worn	0.1	0.05	0.02	0.01
Unworn	0.9	0.95	0.98	0.99

Figure 3: Probability table for the variable *TimingBelt*


TakeCarToService
Cost
GearboxAlert
Gearbox
U
CarAge
Oil
DrivingDistance
TimingBelt
TimingBeltTeeth
Gasket
OilLeakage