Risk & Safety in Engineering

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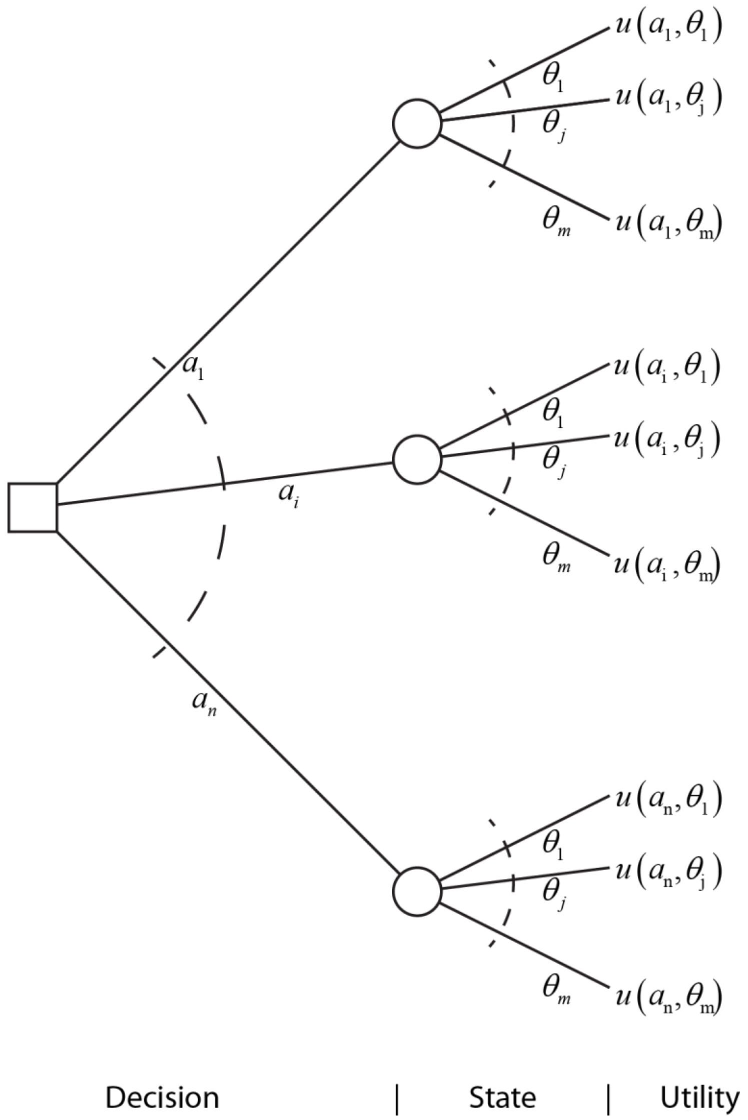
Contents of today's lecture

- Engineering Decision Analysis in a “nutshell”

- EXAMPLES

Engineering Decision Analysis in a "nutshell"



$$\boldsymbol{a_{opt}} = \max_{\boldsymbol{a}} \boldsymbol{E}[\boldsymbol{U}|\boldsymbol{a}]$$

$$= \max_{\boldsymbol{a}} \begin{cases} \sum_{\boldsymbol{\theta}} \boldsymbol{pr}(\boldsymbol{\theta}|\boldsymbol{a})\boldsymbol{u}(\boldsymbol{a},\boldsymbol{\theta}) \\ \int_{\boldsymbol{\theta}} \boldsymbol{f}(\boldsymbol{\theta}|\boldsymbol{a})\boldsymbol{u}(\boldsymbol{a},\boldsymbol{\theta})\boldsymbol{d\theta} \end{cases}$$

General approach:

1) Formulation of the problem in terms of decision alternatives and associated states of nature.
2) Assessment of the probabilities of the different states of nature conditional on decisions (and possible events).
3) Assessment of the utilities of the different possible outcomes (branches of the decision tree).
4) Optimization.

Example 1a

- **Concrete Quality**

  - **An old concrete structure has to be reassessed. There are doubts in regard to the concrete quality. Historical records suggest that the probabilities for different concrete qualities for structures with the same age are:**

Concrete Quality	
	$P(\theta_i)$
C15	0.3
C20	0.6
C30	0.1

Example 1a

- **Concrete Quality**

  - **An old concrete structure has to be reassessed. There are doubts in regard to the concrete quality. Historical records suggest that the probabilities for different concrete qualities for structures with the same age are:**
  - **An Engineer has to decide whether the concrete building can be used as a library or not. Alternatively, he has the option to re strengthen the slabs or he might limit the weight on the structure.**
  - **Find the optimal decision !**

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Example 1a

- **Concrete Quality**

  - **An old concrete structure has to be reassessed. There are doubts in regard to the concrete quality. Historical records suggest that the probabilities for different concrete qualities for structures with the same age are:**
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  - **Find the optimal decision !**

Concrete Quality	
	$P(\theta_i)$
C15	0.3
C20	0.6
C30	0.1

Consequences	
Strengthening	- 10 MU
Limited Use	- 5 MU
Use as planned	0 MU
Failure Cost	- 2000 MU

The probabilities of failure can be calculate for the different alternatives and conditional on the present concrete quality:

	Limited use			Use as planned			ST
	C15	C20	C30	C15	C20	C30	-
Failure	5E-03	1E-04	1E-06	5E-2	1E-03	1E-05	1E-06

Example 2 – at home

- ## Alternative Design Solution

During the construction of a bridge it became apparent that a departure from original design would safe a lot of money. Originally it was planned to base the pillars of the bridge on deep bedrock. Alternatively, a foundation on the river sediments would safe money, however, with corresponding implication on the probability of failure (scouring, as a function of the water flow in the river). Make a risk based decision! [Alt. design solution yes or no] (all values are given corresponding to a 50 year period).

- ## Data:

Exposure	
θ_i Max.Flow [cum/s]	$P(\theta_i)$
< 340	0.965
340 - 370	0.020
370 - 400	0.010
> 400	0.005

Consequences	
Original design / Safe	0 MU
Original Design / Fail	- 765 MU
Mod. Design / Safe	+ 150 MU
Mod. Design / Fail	- 615 MU

Original Design				
Perfor-mance	θ_i Max.Flow [cum/s]			
	< 340	340 - 370	370 - 400	> 400
Safe	0.999	0.99	0.98	0.9
Fail	0.001	0.01	0.02	0.1

Modified Design				
Perfor-mance	θ_i Max.Flow [cum/s]			
	< 340	340 - 370	370 - 400	> 400
Safe	0.99	0.9	0.5	0.2
Fail	0.01	0.1	0.5	0.8