Tutorial 05

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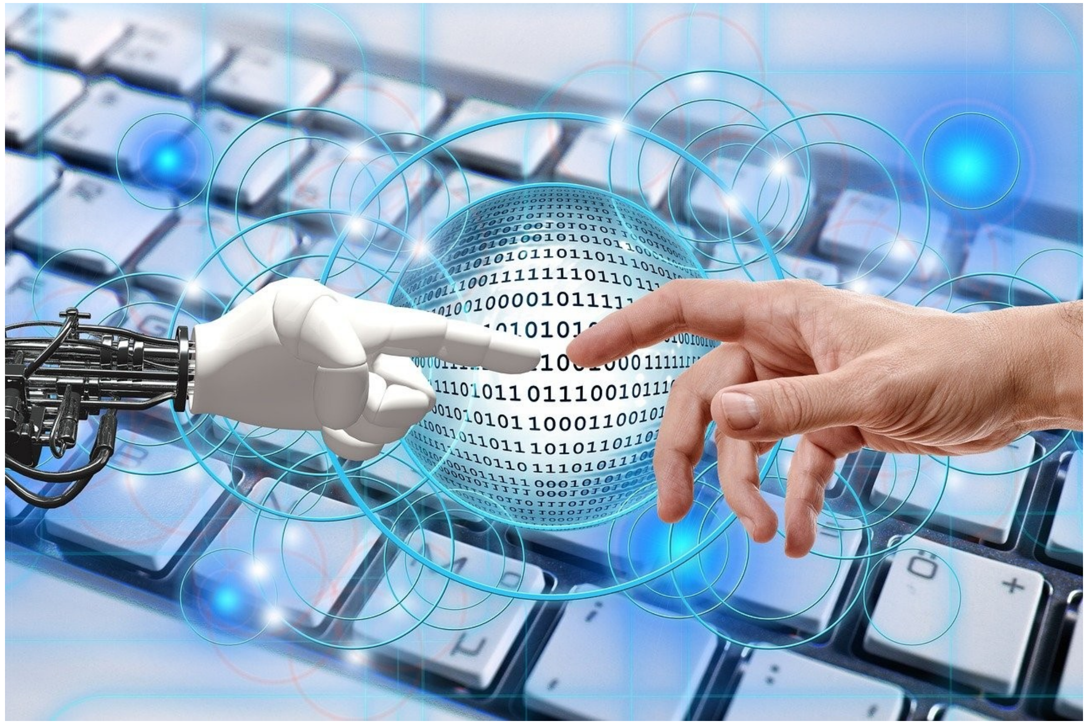


Content

- Bayesian Networks, ToM Modeling

Bayesian network

Bayesian network

A Bayesian network is a graphical representation of probabilistic relationships among a set of variables.

It uses probability theory and graph theory to model uncertainty and dependencies between variables.

In a Bayesian network, nodes represent variables and edges represent probabilistic dependencies.

The network structure helps in representing how variables influence each other.

They are particularly useful for reasoning under uncertainty, making predictions, and handling complex interactions between variables.

Further Reading: https://cis.temple.edu/~latecki/Courses/AI-Fall10/Lectures/ch15BayesNet.ppt

Bayesian network

Bayesian networks have the following properties:

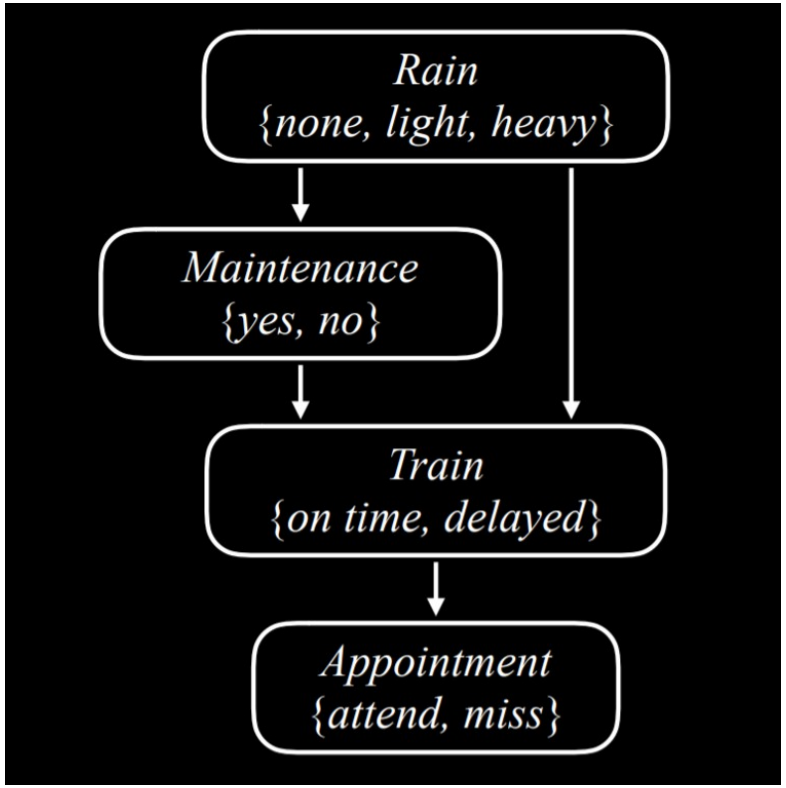
- They are directed graphs.
- Each node on the graph represent a random variable.
- An arrow from X to Y represents that X is a parent of Y, i.e. the probability distribution of Y depends on the value of X.
- Each node X has probability distribution P(X | Parents(X)).

Example

Let's consider an example of a Bayesian network that involves variables that affect whether we get to our appointment on time.

none	*light*	*heavy*
0.7	0.2	0.1

R	*yes*	*no*
none	0.4	0.6
light	0.2	0.8
heavy	0.1	0.9



R	**M**	*on time*	*delayed*
none	yes	0.8	0.2
none	no	0.9	0.1
light	yes	0.6	0.4
light	no	0.7	0.3
heavy	yes	0.4	0.6
heavy	no	0.5	0.5

T	*attend*	*miss*
on time	0.9	0.1
delayed	0.6	0.4

Example from https://cs50.harvard.edu/extension/ai/2023/spring/notes/2/

Use Bayesian Network?

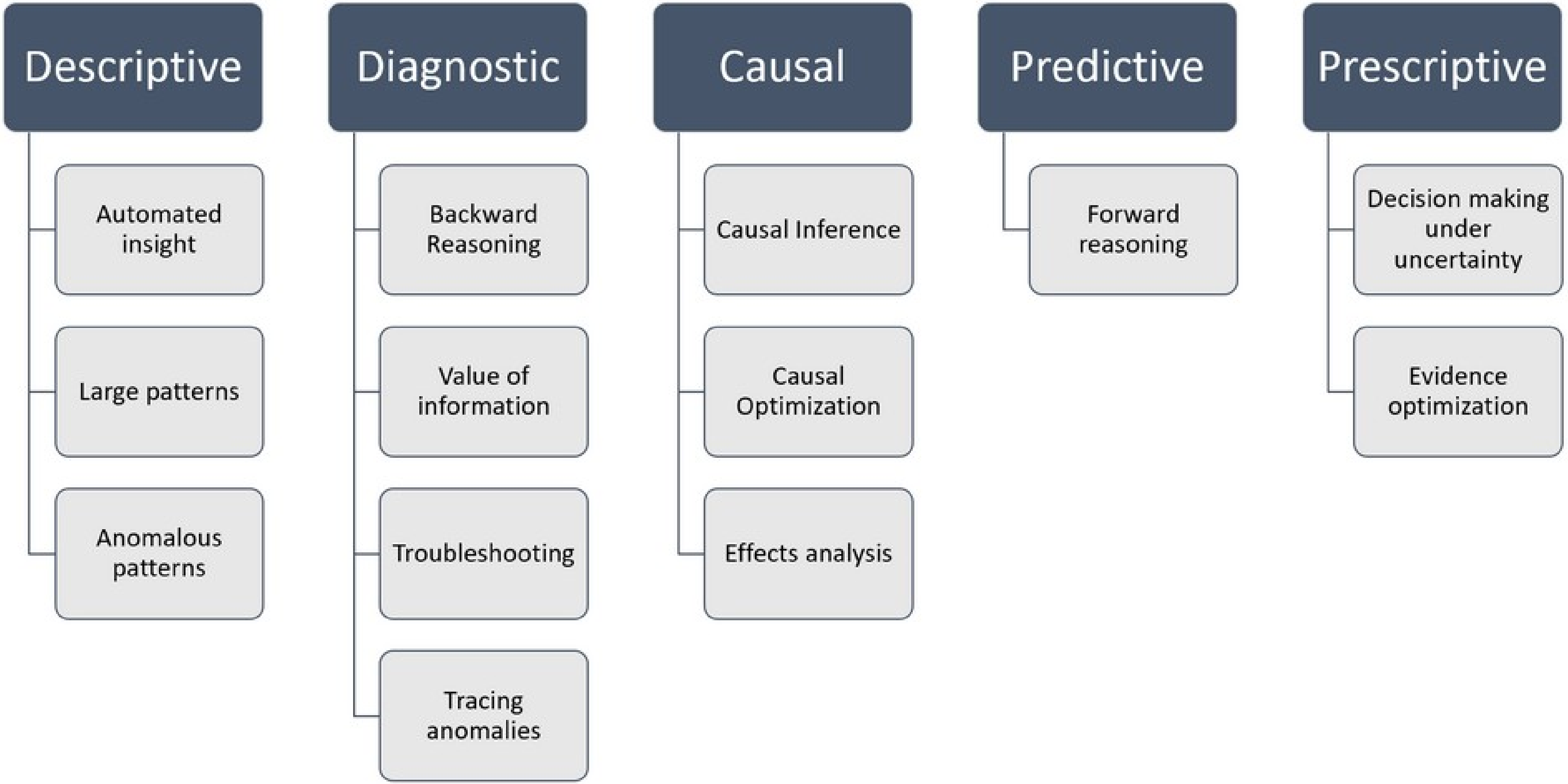


Figure 1 - Descriptive, diagnostic, predictive & prescriptive analytics with Bayesian networks

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From : https://www.bayesserver.com/docs/introduction/bayesian-networks

Use Bayesian Network?

Query: Inference without evidence

If we want to find the probability of missing the meeting when the train was delayed on a day with no maintenance and light rain, or

- **P(light, no, delayed, miss)**

We will compute the following:

- **P(light)P(no | light)P(delayed | light, no)P(miss | delayed)**.

The value of each of the individual probabilities can be found in the probability distributions above, and then these values are multiplied to produce

- P(no, light, delayed, miss).

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Use Bayesian Network

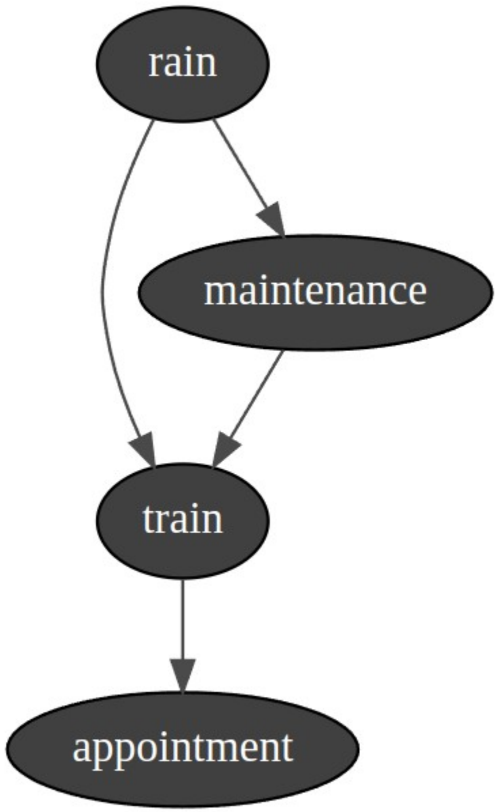
Inference through entailment
In the presence of new information infer about different states
Inference has multiple properties.

- **Query X:** the variable for which we want to compute the probability distribution.
- **Evidence variables E:** one or more variables that have been observed for event e. For example, we might have observed that there is light rain, and this observation helps us compute the probability that the train is delayed.
- **Hidden variables Y:** variables that aren’t the query and also haven’t been observed. For example, standing at the train station, we can observe whether there is rain, but we can’t know if there is maintenance on the track further down the road. Thus, Maintenance would be a hidden variable in this situation.
- **The goal:** calculate P(X | e). For example, compute the probability distribution of the Train variable (the query) based on the evidence “e” that we know there is light rain.

Introduction to PyAgrum Library w/ an Example

Jupyter notebook

```
[8] #Visualize the network
    gnb.showBN(bn,size='30')
```



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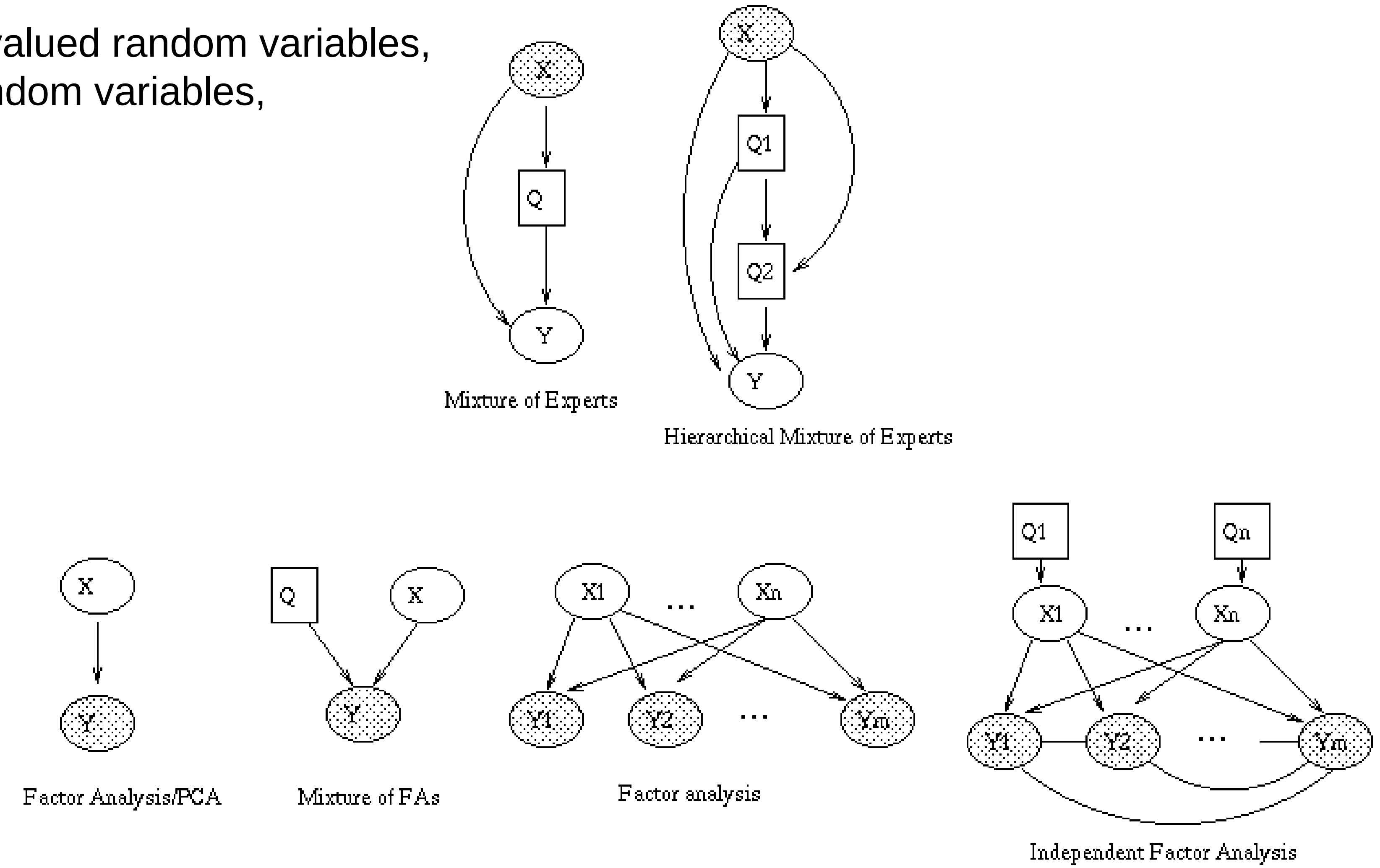
Popular Bayesian Networks

- Circles denote continuous-valued random variables,
- squares denote discrete random variables,
- clear means hidden, and
- shaded means observed.



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From: https://www.cs.ubc.ca/~murphyk/Bayes/bnintro.html

Other libraries

Bnlearn
Pymc
Pomegranate

Theory of Mind (ToM)

Theory of Mind (ToM)

Theory of Mind refers to the cognitive ability to understand and attribute mental states such as beliefs, intentions, desires, and emotions to oneself and others.

ToM modeling involves creating computational or cognitive models that simulate how individuals reason about the mental states of themselves and others.

This modeling helps understand how people predict and explain the behavior of others based on their perceived mental states.

Thank you!

For any queries:

- LEA Forum
- email to ritwik.sinha@smail.inf.h-brs.de