Graphical Models for Decision Making

Lesson 4, week 14, class 26

Juan A Fdez del Pozo (CIG-UPM)

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Contens

Outline of Contens

Genie (Graphical network interface)

- is a software tool developed at the University of Pittsburgh for Microsoft Windows and available free of charge
- is useful for decision analysis and for graphically representing the union of probability and networked occurrences
- can be used for the analysis of Bayesian networks, or directed acylic graphs
- occurrences in a web of happenings are conditionally independent of each other
- each Bayesian network belongs to a group of Bayesian networks known as an equivalence class. In a given equivalence class, all of the Bayesian networks can be described by the same joint probability statement.

Bayesian network theory

- Bayesian networks (also called belief networks, Bayesian belief networks, causal probabilistic networks, or causal networks) (Pearl 1988) are acyclic directed graphs in which nodes represent random variables and arcs represent direct probabilistic dependences among them
- can be thought of as a fusion of incidence diagrams and Bayes' theorem
- A Bayesian network, or belief network, shows conditional probability and causality relationships between variables
- Independence assumptions are implied in Bayesian networks by the absence of a link
- Both the structure and the numerical parameters of a Bayesian network can be elicited from an expert. They can also be learned from data

The advantages of Bayesian Networks are as follows:

- Bayesian Networks visually represent all the relationships between the variables in the system with connecting arcs.
- It is easy to recognize the dependence and independence between various nodes.
- Bayesian networks can handle situations where the data set is incomplete since the model accounts for dependencies between all variables.
- Bayesian networks can maps scenarios where it is not feasible/practical to measure all variables due to system constraints (costs, not enough sensors, etc.)
- Help to model noisy systems.
- Can be used for any system model - from all known parameters to no known parameters

The limitations of Bayesian Networks are as follows:

- All branches must be calculated in order to calculate the probability of any one branch.
- The quality of the results of the network depends on the quality of the prior beliefs or model. A variable is only a part of a Bayesian network if you believe that the system depends on it.
- Calculation of the network is NP-hard (nondeterministic polynomial-time hard), so it is very difficult and possibly costly.
- Calculations and probabilities using Baye's rule and marginalization can become complex and are often characterized by subtle wording, and care must be taken to calculate them properly

Applications

- Gene regulatory networks, Protein structure, Diagnosis of illness
- Document classification
- Image processing
- Data fusion
- Decision support systems
- Gathering data for deep space exploration
- Artificial Intelligence
- Prediction of weather
- On a more familiar basis, Bayesian networks are used by the friendly Microsoft office assistant to elicit better search results
- Another use of Bayesian networks arises in the credit industry where an individual may be assigned a credit score based on age, salary, credit history, etc. This is fed to a Bayesian network which allows credit card companies to decide whether the person's credit score merits a favorable application.

Graphical Models for Decision Making

GeNie, bn

Downloading and Installing Genie, genie2_setup.exe, Wine under linux

- https://dslpitt.org/genie/wiki/GeNIe_Documentation
- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_2_-_The_GeNIe_interface

Bayesian Networks

- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_3_-_Building_a_Bayesian_network
- Chance variable nodes, CPT
- Create a node and define properties for the node.
- Specify conditional probability dependencies between nodes.
- Update the model and view results after observing certain nodes.
- Saving a model to disk.
- Posterior probability distribution of any node in a Bayesian network
- Inference Algorithms

Influence Diagram

- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_4_-_Creating_influence_diagrams
- Chance, Decision and Utility variable nodes
- CPT, Utility function
- Optimal decision alternatives (Tables)
- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_7_-_Entering_and_retracting_evidence
- Set and clear evidence for each individual node.
- Clear evidence for the entire network using one command.

Analysis

- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_8_-_Evaluating_a_model
- Update a model with the selected inference algorithm.
- Specify target nodes in the model.
- Select from various inference algorithm supported by GeNIe.
- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_11_-_Value_of_information
- Evaluate Value Of Information.
- Examine decisions after information is obtained.
- https://dslpitt.org/genie/wiki/GeNIe_Tutorials:_Tutorial_15_-_Learning_structure
- Edit data files to learn Bayesian networks

¿Remarks and Questions?

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