Building Networks

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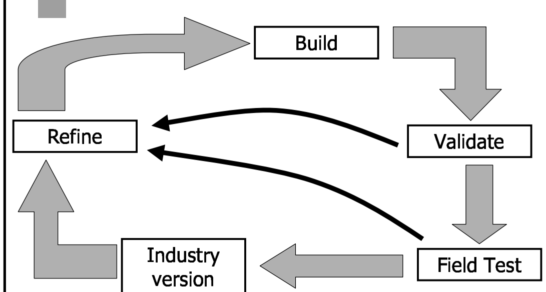
Overview

- Knowledge Engineering
- Model Construction
- Noisy OR
- Model Evaluation
- Case Studies

Knowledge Engineering

- Construct a model to perform a defined task.
- Involves collaboration of experts (domain experts and modelling experts)
- Process:
  - Define task
  - Construct model
  - Evaluate model

Lifecycle of Project



Model Construction

- What are the variables?
- What are their states?
- What other nodes?
- What is the structure of the model?
- What are the parameters?

What are the variables?

- *Focus or query variables.*
  - Variables of interest.
- *Evidence or observation variables.*
  - *What are the sources of information.*
- *Other variables.*

What are the states?

- States must be exclusive and exhaustive.
- Type of variables.
  - Binary
  - Qualitative
  - Numeric discrete
  - Numeric continuous
- Dealing with continuous variables.

What other nodes?

- What decisions and utilities are needed?
- What do the decisions depend upon?
  - Should the information that is available for one decision is available for all subsequent decisions?
- Are the utilities additive?

What is the structure?

- Minimize parameter elicitation:
  - Fewer nodes
  - Fewer arcs
  - Smaller state spaces.
  - Minimize interdependence between nodes.
- Draw arcs in casual direction if possible.
  - Increases conditional independence.
  - Results in more compact models.
  - Improves ease of probability elicitation.
- Divide model into smaller models using independence assumptions.
- Use mixtures of discrete and continuous variables with care.

Noisy OR

- Adds some uncertainty to logical OR.
- Assumptions:
  - Each cause has an independent chance of causing the effect.
  - All possible causes are listed.
  - The inhibitors are independent.
- Inhibitors are summarized as "*noise parameters*"
- Number of parameters linear in the number of parents.

Fever Example

Cold	Flu	Malaria	P(¬Fever)	P(Fever)
F	F	F	1	0
F	F	T	0.1	0.9
F	T	F	0.2	0.8
F	T	T	0.02 = 0.2*0.1	0.98
T	F	F	0.6	0.4
T	F	T	0.06 = 0.6*0.1	0.94
T	T	F	0.12 = 0.6*0.2	0.88
T	T	T	0.012 = 0.6*0.2*0.1	0.988

What are the parameters?

- Discrete probability distributions
  - Direct elicitation.
  - Odds.
  - Judgemental probabilities.
- Continuous probability distributions
  - Often useful to fit standard forms to experts judgements.
  - Most software require them to be discretized.
- What is the utility function?

Case Studies

- Medical Application
- Game Theory
- Augmentation Systems
- Multi-User Adventure Game
- BatMobile

Medical Application

- Computer-based Patient Case Simulation System (Pradham *et al.,* 1994)
- 448 nodes, 906 links
- Utilize
  - Noisy MAX (generalisation of Noisy-OR)
  - Leak probabilities

Game Theory

- Bayesian Poker (Korb *et al.*, 1999)
- Needs to model:
  - Incomplete hand information
  - Incomplete opponent information (strategies, bluffing, etc.)
- Multi-Agent Influence Diagrams (MAID) (Koller and Milich, 2000)
- Models multi-agent decision making.
- Computes Nash equilibria efficiently.

Augmentation Systems

- Nice Argument Generator (NAG) (Zukerman *et al.,* 1996)
- Bayesian Interactive Argumentation System (BIAS) (Zukerman, 2001)
- Bayesian Networks are used to:
  - Analysis arguments
  - Compose arguments
  - Generate rebuttals

Multi-User Adventure Game

- Keyhole Plan Recognition in a MUD (Albrecht *et al.,* 1998)
- Use Dynamic Bayesian Network to:
  - Predict current quest.
  - Predict next action.
  - Predict next location.

BatMobile

- Bayesian Automatic Taxi (Forbes *et al.,* 1995)
- Implement using various approaches:
  - Dynamic Decision Network.
  - Hand-coded explicit policies.
  - Combination of supervised learning and reinforcement learning methods.