Inference in Polytree Networks

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Overview

- Polytree Networks
- Backward-chaining
- Message Passing
- Holmes Alarm Network

Polytree Network

*A Bayesian Network is a **Polytree** (**Singly Connected**) if between any two nodes in the network there is only one path.*

Inference in PolyTree Networks

- Backward-chaining
  - Russell & Norvig (1995)
  - Similar to algorithms by Pearl (1988) and Shachter et al. (1990).
- Message Passing
  - Pearl (1982) for trees.
  - Kim and Pearl (1983) for polytrees.

Backward-chaining

*Working **back** from what you what to know to what you do know (ie the **evidence**)*

- P(X|E) depends upon:
  - P(U|E) where U is the set of parents of X,
  - P(E|Y) where Y is the set of children of X, and
  - P(Z|E) where Z is the set of parents of Y.
- Using this leads to a recursive algorithm.

Message Passing

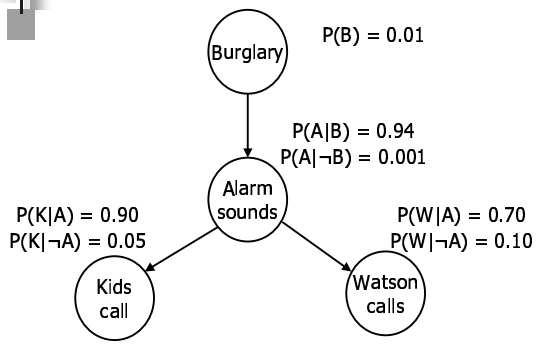
*Working from what you know (ie the **evidence**) to what you want to know.*

- Forward chaining.
- Messages *propagate* throughout the network.
  - Each node X has two messages, $\pi(x)$ and $\lambda(x)$, which can be used to calculate P(X|E).
  - X sends message $\pi_Y(x)$ to child Y, which is used to calculate $\pi(y)$.
  - Y sends message $\lambda_Y(x)$ to parent X, which is used to calculate $\lambda(x)$.

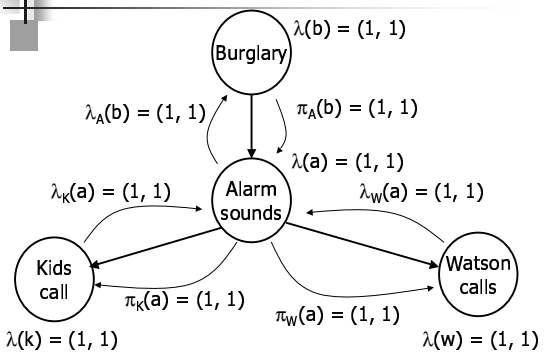
Holmes Burglary Alarm (Pearl)

- Holmes lives in an area where there is a 1% chance your house will be burgled.
- Holmes' alarm will sound 94% of the time he is burgled, and 0.1% of the time for no apparent reason.
- The Baker Street Irregulars (Kids in the neighbourhood) will call 90% of the time the alarm sounds and 5% of time when the alarm does not sound for other reasons.
- A friend Watson will call 70% of the time when the alarm sounds, and 10% of the time when the alarm does not sound.

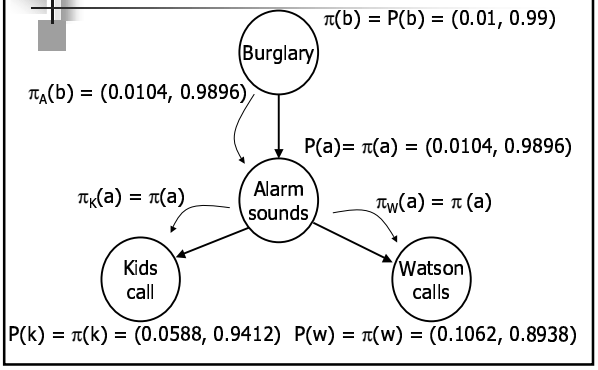
Holmes' Alarm Network



Initialize Network



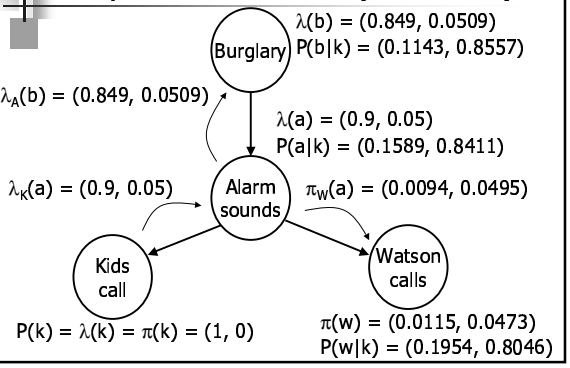
Initialize Network



Initialize Tree

- For each node X set:
  - λ(x) = (1,…,1)
  - $\lambda_Y(x)$ = (1,…,1)
  - $\pi_Y(x)$ = (1,…,1)
- For each root, R, set:
  - π(r) = P(r)
- Propagate π messages down the tree.

Update Network (Kids Call)



Update Tree

- Suppose V is a new evidence node.
- Update $\pi(v)$, $\lambda(v)$, and P(V|E).
- Propagate λ messages up the tree.
  - A node X receiving a λ message:
    - Updates $\lambda(x)$ and P(X|E).
    - Sends λ messages up the tree.
    - Sends π messages down the tree to other children.
- Propagate π messages down the tree.
  - A node X receiving a π message:
    - Updates $\pi(x)$ and P(X|E).
    - Sends π messages down the tree.
    - Sends λ messages up the tree to other parents.