Previous Approaches

- **Off-line knowledge assessment**
- **On-line knowledge assessment and limited plan recognition**
  - Limit the acceptable solutions
  - Make the student express all solution steps
  - Ask the student
  - Knowledge not taken into account to predict the student’s plans

Probabilistic Student Model

- Based on the probabilistic reasoning framework of Bayesian networks
- Performs on-line knowledge assessment, plan recognition and prediction of students’ goals and actions
- Performs plan recognition by integrating information about the available solutions and the student’s knowledge

Bayesian Networks - Definition

- Bayesian network: directed, acyclic graph
  - Nodes \( \rightarrow \) set of random variables \( X_1, X_2, \ldots, X_n \)
  - Links \( \rightarrow \) probabilistic dependencies among variables
  - Conditional probabilities \( \rightarrow \) quantify the dependencies

P(B) = 0.01
P(J | A) = 0.90
P(J | ¬A) = 0.05
P(A | B, E) = 0.95
P(A | B, ¬E) = 0.94
P(A | ¬B, E) = 0.29
P(A | ¬B, ¬E) = 0.001
P(E) = 0.02

Bayesian Networks - Inference

- **Diagnostic**
- **Predictive**
- **Intercausal**
- **Mixed**

Update algorithms exploit dependencies to reduce the complexity of probabilistic inference
Bayesian Networks - Advantages

- The probability of a complete instantiation $X=x$ of the variables in the network is given by
  \[ P(x) = P(x_1, \ldots, x_n) = \prod_{i=1}^{n} P(x_i | x_{pa_i}) \]
- If $|pa_i| = k$, only $n^2 2^k$ vs. $2^n$ probabilities to be specified
- Update algorithms exploit dependencies to reduce the complexity of probabilistic inference
- Structure allows to define when two set of nodes $X$ and $Y$ are independent given a set of evidence $E$

Components of Andes’ Student Model

- **Domain General**
  - Reflects the content of Andes’ rules
  - Defined once along with Andes’ KB
  - Maintained across problems
  - Assesses the student’s domain knowledge

- **Task Specific**
  - Automatically built when a new problem is opened
  - Assesses the student’s task specific knowledge and problem solving behavior

Architecture

Construction of the task specific BNet

Example

Solution

- Find the velocity by applying the kinematics equation
  \[ V_t = V_0 + a \cdot t = V_0 + a \cdot \sqrt{2d/a}, \]

- Find the acceleration of the car by applying Newton's 2nd law
  \[ \sum F = ma \]

If the student draws the axes and then gets stuck

- She could be trying to write the kinematics equations to find \( V \)
- She could be trying to find the car acceleration by applying Newton's laws

Importance of Automatic Generation
SE-Coach Architecture

- Problem Statement
- Problem Solver
- Domain
- Rules
- Task-Specific Student Model
- Domain General Student Model
- SE-Coach Help
- SE-Coach Interface

Identify Goal Structure - Plan Browser

- Encodes abstract solution plan

SE-Coach Hints