Applications of Artificial Intelligence

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Chapter 4:
Knowledge-Based Systems

4.5: Concluding Comparison of the Different Reasoning Techniques

Application from practice: Technical diagnosis

Run time system:

(knowledge-based systems call this **problem solver / inference engine**)

Input:

- Setting certain control inputs
- Observing values depending on this setting

Output:

- A unique instruction how to repair which component

This is where diagnostic systems do not differ !

Application from practice: Technical diagnosis

Knowledge-based diagnosis:

1) Knowledge acquisition: Input into knowledge base

- symptom-based (rule-based)
- model-based
- case-based (machine learning)

} as alternatives

2) Knowledge structure

- depends on knowledge acquisition

3) Knowledge processing be the problem solver

- depends on knowledge structure

This is where diagnostic systems may differ !

1. Symptom-Based Diagnosis

Input to knowledge base:

- Causing and manifest faults for the overall system
- Possible symptoms (measurements)
- Relations between faults and symptoms (rules)

Structure of knowledge base:

- Semantic network (e.g.,fault networks, decision trees)

Job of inference engine:

- Navigation in semantic network

This is „classical“ expert system technology

2. Model-Based Diagnosis

Goal:

- fast knowledge acquisition
- exact and provable solution of problem solver

Input to knowledge base:

- system model: hierarchical structure of the system (+ how the components are connected)
- component models

Structure of knowledge base:

- constraint network (assembled automatically)

Job of inference engine:

- GDE approach: conflict-based candidate generation
- sophisticated acceleration techniques in order to get resonable run time behaviour
  (only discussed for candidate generation, others not discussed in class)

3. Case-Based Diagnosis (Machine Learning)

Input to knowledge base (supervised approach only):

- Cases with complete symptom vector and associated faults (classified unambiguously)

Structure of knowledge base:

a) Classical AI, with similarity measure:

- Similarity measure for incomplete symptom vectors (often weighted between different types of symptoms)

b) with neural networks:

- Neural network with input layer (for symptom vector) and output layer (for faults) and (optionally) intermediate layer of nodes and edges, marked by variable weights.

Job of inference engine:

a)
- For a new vector given, find the most similar symptom vector of the knowledge base.
- Assign the same fault to the new vector as associated to the reference vector in the knowledge base (possibly with a probability value).

b)
- Apply new symptom vector to the input layer of the network.
- Read the associated fault from the output layer.

Systematic classification of inference techniques

- **heuristic:**

  `if <features> then <solution>`

  (usually the solution has got disjunctive alternatives)

- **causal:**
  - overlapping classification:

    `if <solution> then <features>`

  - structural classification:

    `local behavioural model => system function`

    (search for the best behavioural models being consistent with the observed overall system behaviour)

Systematic classification of inference techniques

- **case-based (machine learning approach):**

  Given cases with **`features`** and **`solution`**

  Apply regression technique **`(interpolation)`**

  - with similarity measure:

    arbitrary regression

  - in neural networks

    distributed linear regression

  - in data mining (unsupervised approach):

    `features from knowledge base => new correlations`

    Supplementary, apply one of the other methods (heuristic or causal)

Systematic classification of inference techniques

Classification of knowledge-based inference by depth

- heuristic — *for relatively flat knowledge*
- causal — *for flat and deep knowledge*
- case-based (similarity measure, neural network, data mining) — *for very flat knowledge*

In principle, this may be arbitrarily combined with other dimensions of knowledge quality:

- certain vs. uncertain (consider the <u>probability</u> of a statement)
- exact vs. fuzzy (consider the <u>accuracy</u> of a statement)

Concluding comparison for applicability in practice

	rule-based	case-based	model-based
fast run time component	**++**	**++**	**o**
fast knowledge acquisition	**o**	**++**	**+**
fits to systems of complex structure	**--**	**++**	**++**
fits to systems containing complex components	**+**	**++**	**--**
reusability of knowledge	**o**	**--**	**++**
fits to diagnosis of unknown faults	**--**	**a) -- b) -**	**+**
is readily available at product launch	**o**	**a) -- b) -**	**++**
provable reliability of diagnoses	**+**	**a) o b) --**	**++**