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

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

⎫ 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. Case-Based Diagnosis

Input to knowledge base:

- 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.

3. 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 reasonable run time behaviour

Systematic classification of inference techniques

- **heuristic:**

  `if <features> then <solution>`

- **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:**

  Given cases with `features` <u>and</u> `solution`

  Apply regression technique `(interpolation)`

  - with similarity measure:

  arbitrary regression

  - in neural networks

  distributed linear regression

  - in data mining:

    `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) --	++