Chapter Overview

Alternatives to Rule-Based Reasoning

Introduction

Semantic Networks

Frames

Blackboard Architectures

Chapter Review

Introduction

alternatives to rule-based reasoning

adequacy

rules are not suitable for all types of knowledge-based systems

structured knowledge

about physical objects or concepts

composition

of objects from components

relationships

between objects and components

reasoning method

opportunistic reasoning

cooperation

between relatively independent modules

Semantic Nets

also: propositional nets, associative nets

labeled, directed graph

nodes

stand for physical objects, concepts,
situations or
properties and their values

arcs (links, edges)

represent relationships between nodes

labels

describe associated objects / relationships

classic AI representation technique
originally proposed by [Quillian, 1968] for the description of human memory and language understanding

Links

in semantic nets

purpose

basic structure for organizing knowledge

formal basis for inferences

format

basically unrestricted, any type of link can be defined

common types

- `is-a` an individual is an instance of a class
- `a-kind-of` relates an individual class to a parent class
- `is` defines the value of an attribute
- `cause` expresses causal knowledge

Inheritance

in semantic networks

object properties

properties of the parent node are duplicated for the descendent node

representation

usually through is-a links

eliminates the need to replicate information

operation

queries about properties of a node can be passed to its parent node

exception handling

in some cases, the properties of ancestor nodes must be overridden

the respective property is represented locally

Semantic Nets

advantages and disadvantages

+ explicit and succinct statement of associations
+ reduced search times through explicit connections
+
- no standard interpretation (human / program)
- no standards for links
-

Frames

structure for representing typical knowledge about objects

extension of semantic nets

nodes can have an internal structure

purpose

a frame represents related knowledge for a narrow topic

commonsense knowledge

frames are very useful for causal and commonsense knowledge

very powerful and flexible, but sometimes inefficient and incorrect

Structure

of frames

name

designates the object to be represented

slots and fillers

slots define attributes, fillers contain values

facets associated with slots

additional control over property values
(e.g. range, data type)

procedural attachments special type of facets

procedures (or *methods* invoked in certain situations `if-needed, if-added, if-removal`

frames are somewhat similar to databases; the difference lies in the contents of the slots / fields, and the operations performed on them

Types

of frames

class frame (*generic frame*)

represents general characteristics of a set of objects;

an object with the properties of a generic frame is a *prototype*

instance frame (*specific frame*)

specific object within a class

inherits properties and property values from a class

situational frame

contains knowledge about situations

action frame

slots specify actions to be performed

causal knowledge frame

describes cause-and-effect relationship[s

Frames

advantages and disadvantages

+

+

-

-

Opportunistic Reasoning

flexible evaluation strategy

reasoning method

determined dynamically depending on the current status

architecture

independent modules cooperate in solving a problem

applications

complex problems requiring expertise from different domains

Blackboard Architectures usually employ opportunistic reasoning

Blackboard Architectures

several ES modules share information

distributed knowledge

different human experts,
different domains, different representations

distributed problem solving

cooperation among different systems
(”agents)

communication

exchange of information between rule sets

ES modules

for different tasks / subproblems

blackboard

forum for the exchange of information
accessible for all components

scheduler

controls modules
determines overall reasoning strategy

Knowledge Sources

individual ES units

domain knowledge

each source contains knowledge about a specific area

representation

may be different for each unit
e.g. frames, rules, procedures

preconditions

may have to be satisfied for a unit

independence

each unit decides if it can contribute knowledge, and what the contributions are

Blackboard

central communication mechanism

information sharing

central location for common information

problem description

data describing the initial problem to be solved

often organized hierarchically, with different representation mechanisms on different levels

problem state

contains relevant data for the current status

modifications

by knowledge sources as they work on their specific subtask

panels

the blackboard can be hierarchically structured and subdivided into *panels*

Scheduler

control and coordination unit

coordination

synchronization between knowledge sources

execution of actions

modifications of the problem description and solution

focus of attention

selection of the active knowledge source

selection of the current blackboard object

heuristics

granularity

attributes / side-effects of actions

changes in problem characteristics

strategy

emphasis on global issues instead of local subproblems

Operation

of a blackboard system

change of a blackboard object

knowledge source makes a change

recorded in the control data area

examination of changes

each knowledge source examines the change

determines possible actions

reports them to the scheduler

focus of attention

the scheduler examines the possible contributions, and determines the focus of attention (knowledge source, blackboard object)

execution

the selected knowledge sources applies its suggested actions to the chosen blackboard objects

How does the system know when to stop?

Blackboard Systems

advantages and disadvantages

+ flexibility: suitable for a diversity of problems
  diverse forms of input data
  large solution spaces
  pieces of knowledge from different sources must be coordinated
  goals may not be clearly defined, resulting in multiple lines of reasoning
+ distributed operation: very well suited for parallel and distributed systems
+ hierarchical organization
+ data abstraction
+ postponement of decisions
+ loose coupling: all knowledge is accessible through the blackboard
- very expensive: usually custom-built for each application

- partitioning of knowledge difficult
- complex development

Chapter Review

Alternatives to Rule-Based Reasoning

Introduction

inadequacy of rule-based systems

Semantic Networks

graph specifying relationships between objects

Frames

internal structure of objects

Blackboard Architectures

opportunistic reasoning, distributed systems

Chapter Review