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

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- 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

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

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