



## Review of Module 4

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## Types of Agents

- Simple Reflex Agents
- Model-Based Reflex Agents
- Goal-Based Agents
- Utility-Based Agents
- Learning Agents

## Types of Environment

- Fully Observable *vs* Partially Observable.
- Deterministic *vs* Stochastic.
- Episodic *vs* Sequential.
- Static *vs* Dynamic.
- Discrete *vs* Continuous.
- Single *vs* Multi-Agent.

## Wumpus World

- Environment:** partially observable, deterministic, sequential, static, discrete, single agent.
- Knowledge Base:** propositional or FOL formulae; facts and rules.
- New Knowledge:** from sensors or inference.
- Problem:** choose appropriate actions.

## Propositional Representation

**Representation:** propositional variables combined with connectives.

**Inference:** truth tables, Davis-Putnam, SAT, *etc.*

**Advantages:** inference decidable.

**Disadvantages:** finite domains; need many formulae; inference NP-complete.

## Planning: Situation Calculus

**Time:** extra argument; sequence of actions; called *situations*.

**Actions:** functions; combined with *Results* function.

**Plans:** = final situations.

**Action Effects:** described by conditional rules.

**Action Non-Effects:** need for frame rules.

**Planning:** by inference; prove existential theorem; existential witness is plan.

## First-Order Logic Representation

**Representation:** predicates/functions combined with connectives and quantifiers.

**Inference:** resolution, generalized modus ponens, *etc.*

**Advantages:** infinite domains, succinct representation.

**Disadvantages:** inference undecidable.

## Planning: STRIPS

**Time:** separate knowledge bases.

**Actions:** operator tables.

**Plans:** sequence of actions.

**Action Effects:** add/delete lists of operators.

**Frame Problem:** solved implicitly by KB inheritance.

**Planning:** search in KB or plan space.

## Partial-Order Planning

**Motivation:** Sussman anomaly; inefficiencies.

**Solution:** search in plan space; partial-order on actions.

**Representation:** STRIPS operators, partial plan.

**Plan Refinement:** operator proposal; resolving threats by promotion/demotion; backtracking.

## Event Calculus

**Motivation:** need more sophisticated representation of time.

**Representation:** time as intervals and points; fluents with time argument.

**Temporal Relations:** Meet, Before, During and Overlap.

**Advantages:** greater expressiveness, shared time for multiple agents.

**Disadvantages:** lost link to plan actions.

## Planning Issues

**Execution in Uncertain World:** triangle tables.

**Frame Problem:** STRIPS solution.

**Qualification Problem:** filters *vs* preconditions.

**Ramification Problem:** inference with truth maintenance.

## Modal Logic

**Motivation:** reason about knowledge, belief, time, deontics, *etc.*

**Modalities:** necessary and possible.

**Semantics:** possible worlds; accessibility relation.

**Accessibility Properties:** reflexive, symmetric, transitive.

**Knowledge Properties:** **K**, **T**, **4**, **5**.

## Communication and Common Knowledge

**Common Knowledge:** needed for collaborative acts; achieved by communication.

**Examples:** Muddy children; coordinated attack.

**Problem:** cannot be achieved by  $k$ -round handshake; requires synchronized clocks.



## Conclusion

**Coping with a Changing World:** agents; time; planning.

**Dealing with Other Agents:** knowledge and common knowledge; collaboration and communication.



## Formalizing Communicative Actions

**Motivation:** integrate communicative acts with other actions.

**Communicative Actions:** inform, query, request.

**Representation:** STRIPS operators.

**Planning:** multi-agent plans including communication.

