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Course: Agentic AI
(IS30056)

Rational Agent – Water Sprinkler System (Conceptual Modeling)

Introduction

This document presents the formal conceptual modeling of a Rational Agent designed to control an automated water sprinkler system. The objective of the agent is to maintain optimal soil moisture while minimizing water wastage and preventing over-irrigation. The agent makes decisions based on percepts obtained from the environment, namely soil moisture, temperature, and weather conditions.

1. The Environment

The environment is a garden irrigation system where the agent monitors and controls the water sprinkler. The environment consists of soil that requires periodic watering, external weather conditions, and temperature variations that affect evaporation and moisture retention.

Environment Type Classification (based on AI environment properties):

- Partially Observable: The agent cannot directly observe future soil moisture changes.
- Stochastic: Weather and temperature can change unpredictably.
- Sequential: Current irrigation decisions affect future soil moisture levels.
- Dynamic: Environmental conditions change over time.
- Discrete: States are categorized into finite levels (Low, Medium, High).
- Single-Agent: Only one agent controls the sprinkler system.

2. State Representation

The state of the system is defined as a tuple containing soil moisture, temperature, and weather condition. Formally, the state at time t is represented as:

$S(t) = (M(t), T(t), W(t))$

Where:
$M(t) \in \{Low, Medium, High\}$ represents soil moisture level,
$T(t) \in \{Low, High\}$ represents temperature,
$W(t) \in \{Sunny, Cloudy, Rainy\}$ represents weather condition.

This representation allows the agent to reason about irrigation needs using a structured and finite state description.

3. State Space Size

The state space is the set of all possible combinations of soil moisture, temperature, and weather conditions.

Number of possible values:
Soil Moisture (M) = 3 values (Low, Medium, High)
Temperature (T) = 2 values (Low, High)
Weather (W) = 3 values (Sunny, Cloudy, Rainy)

Total State Space Size:

$|S| = |M| \times |T| \times |W| = 3 \times 2 \times 3 = 18$ states

Therefore, the system has a total of 18 distinct states.

4. The Percept

A percept is the information received by the agent from the environment at a given time step.

The percept sequence at time t is defined as:

$P(t) = (M(t), T(t), W(t))$

Where the agent senses:

- Current soil moisture level using a moisture sensor
- Current temperature using a temperature sensor
- Current weather condition using a weather sensor

The agent uses only the current percept to decide its action, making it a simple reflex-based rational agent with internal performance evaluation.

5. Action Set

The agent controls the sprinkler system through a defined action set. Each action consists of two components: sprinkler status and water pressure level.

Formally, an action A is represented as:

A = (Status, Pressure)

Where:
Status ∈ {ON, OFF}
Pressure ∈ {LOW, HIGH}

Thus, the complete action set is:

- (OFF, LOW) – Sprinkler off, minimal water usage
- (OFF, HIGH) – Sprinkler off (pressure irrelevant but defined formally)
- (ON, LOW) – Irrigation with low pressure
- (ON, HIGH) – Irrigation with high pressure

6. Transition Model and Internal State Update

The transition model defines how the environment state changes from S(t) to S(t+1) after the agent performs an action.

The next moisture level depends on three factors:

- Irrigation effect (based on sprinkler action)
- Weather effect (rain increases moisture)
- Evaporation effect (high temperature reduces moisture)

Mathematically, the moisture transition can be represented as:

$$M(t+1) = \text{clip}[M(t) + I(A) + W\_effect - E(T)]$$

Where:
I(A) = Irrigation effect (0 if OFF, +1 for LOW pressure, +2 for HIGH pressure)
W_effect = +1 if weather is Rainy, else 0
E(T) = 1 if temperature is High (evaporation), else 0
clip() ensures moisture remains within {Low, Medium, High} bounds.

Internal State Update:
After each action execution, the agent updates its internal performance measure based on the resulting soil moisture. The agent aims to maintain 'Medium' moisture as the optimal state. If moisture is too low, it increases irrigation; if too high, it stops watering to prevent over-irrigation and water wastage.