Episodic Memory and Cognitive Capabilities

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Outline

- Review and Introduction
  - Definitions
  - Research Goals
  - TankSoar Domain
- Demonstrating Cognitive Capabilities
  - Action Modeling
  - Virtual Sensors
  - Learning from Past Success and Failure
Long Term Memory

- Episodic Memory
  - Memories of specific events in your past
Long-term Procedural Memory
Production Rules

When the agent takes an action.
A portion of working memory is stored in the episode
Current Implementation

Encoding
Initiation
Content
Storage
Episode Structure?
Retrieval

Episodes are stored in a separate memory
Current Implementation

Cue is placed in an architecture specific buffer.
Current Implementation

Encoding
  Initiation
  Content

Storage
  Episode Structure

Retrieval
  Initiation/Cue
  Retrieval

The closest partial match is retrieved.
Research Goals

- Explore the cognitive capabilities granted to an agent with an episodic memory
- Explore what’s necessary to build an effective episodic memory for a general cognitive architecture
  - Domain independence
  - Performance
- Take inspiration from cognitive psychology
Cognitive Capabilities: How do we use Episodic Memory?

- **Sensing**
  - Detecting Repetition
  - Virtual Sensing
  - Noticing Unusual Input
  - Sense of Identity

- **Reasoning**
  - Action Modeling
  - Recording Previous Successes/Failures
  - Modeling the Environment
  - Managing Long Term Goals

- **Learning**
  - Retroactive Learning
  - Reanalyzing with new Knowledge
  - Explaining Behavior
  - “Boosting” other Learning Mechanisms
TankSoar Domain

- Tanks in a maze
- Sub-goals
  - Shoot other tanks
  - Don’t get shot
  - Don’t run out of
    - Energy
    - Missiles
- Multiple sensors and actions
Action Modeling
Cognitive Capability: Action Modeling

- **Action Modeling**
  - **Definition:** Learning the immediate effect of an action
  - **Analog:** Case-Based Reasoning

- **Task: Conserve Energy**
  - Selecting proper radar setting to minimize energy consumption
Agent Implementation

Agent’s State

Radar Setting: 1
Radar Setting: 2
...
Radar Setting: max

Create Memory Cue

Episodic Retrieval

Evaluation Result:
Radar Setting: 5

Agent Confirms Location and Direction Match

X=11
Y=3
Dir=south

X=11
Y=3
Dir=south

X=11
Y=3
Dir=south
Initial Performance

Radar Tank Performance

Fraction Correct vs. Radar Settings (time)

Random
Episodic memory is an effective medium for action modeling

Requires agent have knowledge of whether a retrieved episode is useful
Virtual Sensors
Cognitive Capability: Virtual Sensors

- Virtual Sensors
  - Definition: Retrieving past sensing that is relevant to the current task
- Task: Locate the Battery
  - Using episodic memories to construct a path
Agent Implementation

Agent’s State

Move North
Move West
Move East

Create Memory Cue

Episodic Retrieval

Evaluation Result: Move North
Performance

![Energy Search Time Graph]

- **Number of Moves**
  - Random

- **Searches**
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12

- **Graph Description**
  - The graph illustrates the energy search time over different searches, comparing random and episodic memory approaches. The number of moves decreases as the searches progress, showing a trend towards more efficient search strategies.
Paths to Battery
Nuggets

- Episodic memory can be used as a virtual sensor

Coal

- Limited investigation of integration of episodic and semantic memory
Learning from Past Success and Failure
Cognitive Capability: Learning from Past Success and Failure

- Learning from Past Success and Failure
  - Definition: Using past performance to guide future behavior
  - More emphasis on long term

- Task: Combat
  - Using episodic memory to determine best tactics in the “attack” subgoal
Agent Implementation

Evaluation Result:
Move Forward + Fire = 2 points

Episodic Retrieval
Retrieve the Next Memory in Sequence

Agent’s State
Move Forward
Move Forward + Fire Missile
... Turn Right

Create Memory Cue
Compare Memories In the Sequence

Retrieve the Next Memory in Sequence
Performance

![Graph showing margin of victory vs. successive games](image-url)
Tactics Learned

- Fight or flight
- Back away and shoot
- Dodging
Without Heuristic Cue

Performance without Heuristic Cue Selection

-60 -50 -40 -30 -20 -10 0 10 20

Average Margin of Victory

Successive Games

1 11 21 31 41 51 61 71 81 91 101 111 121 131 141 151 161
Without Discount Factor

No Discount Factor

Average Margin of Victory vs. Successive Games
Nuggets

- Episodic memory can be effective at learning long term tactics

Coal

- Requires the use of a discount factor
- Requires heuristic cue selection
Summary

- Episodic memory enables multiple cognitive capabilities including:
  - Action modeling
  - Virtual sensing
  - Learning from past success and failure