Creating and Capturing Expertise in Mixed-Initiative Planning

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Why capture expertise?

“By three methods we may learn wisdom:
First, by reflection, which is noblest;
Second, by imitation, which is easiest;
And third, by experience, which is bitterest.”

- Confucius
Capture, Develop, Provide Experience

**Challenge:** Is it really possible to institutionalize the thought processes of a military commander?
- Prior efforts attempted to model and recreate the *reasoning* of military decision makers.
- However, many of the decisions made by human thinkers are founded in *intuition* and not readily modeled.

**Our Answer:** Augment the same recognition processes used by humans.
- **Mixed-initiative decision-making:**
  - Both the humans and the system are driving the process.
  - People and machines learn from each other.
  - Perform at a higher level of expertise together.
Case-Based Reasoning

1. User enunciates objectives and situation
   “I have a situation…”

2. Most similar case is retrieved from past experiences
   Case base

3. Case is reused and revised, adapted to the present
   similar case

4. The new plan is then implemented
   new plan

5. The experience is retained for future use
   The experience is retained for future use
**DEEP**

*Distributed Episodic Exploratory Planning in one sentence*:

DEEP enables planners to cooperate with other Air Operations Centers by using the experience of the past adapted to present situations, allowing for intuition-like mixed-initiative planning.

- **New AOC ConOps**
  - Smaller, separate AOCs
  - Supporting/ed relationships
  - Complex, ever-evolving ops environment

- **Technology**
  - Black Board Systems
  - Episodic Memory
  - Multi-Agent Systems

**DEEP**

Our Focus: Capturing Experience

• How do we collect experience in a way that is:
  – Understandable by a computer?
  – Amenable for mixed-initiative planning?
  – Supportive of drawing conclusions from knowledge?
Three Main Areas...

- *Context* of the situation
- *Decision* made by planner
- *Outcome* of that decision
The Context.

- We need to capture:
  - What needs to be accomplished (Objectives)
  - Details about the world (Situation)
  - How that space is bound (Constraints)
  - Assertions based on evidence (Assumptions)

- With this information, a decision (Plan) can be formed…
The Experience.

• Based on the decision (Plan), capturing the implementation of that decision requires:
  – What was done to realize the decision (Actions)
  – What was done by others in the environment (Events)
  – How both of those affected the situation (Effects)

• Now we can ask: are our Objectives met? (Outcome)
Developing Experience

- In order to encapsulate this knowledge within a computer, we can adapt previous research in plan representation
  - **Core Plan Representation**, developed by the ARPA Rome Lab Planning Initiative (APRI).

- However, CPR was designed to represent *plans*, not whole experiences.
From Plans to Experiences

Objectives | Assumptions
Situation   | Constraints

Plan

Actions | Effects

Events

Outcome

Features that need to be Adapted
Features that need to be Articulated
Features that need to be Created
Adapting CPR

- **Event**
  - What really happened when we tried the plan?

- **Assumption**
  - What if something’s very existence is assumed?

- **Outcome**
  - How do we know if we are successful?

- **Cost**
  - How do we measure the value of what is expended?

- **Location**
  - Is the question ‘where?’ always geospatial?
Forming Analogies with Experience

• Some Approaches…
  – **K-Nearest Neighbor**: are there characteristics that are very similar? How many?

  – **Semantic Similarity**: is there a meaning that is very similar? What taxonomy/ontology will answer that?

  – **Structural Mapping**: are there higher-order relationships at work that form an analogy? Is there ‘systematicity’?

  – **Many are Called, Few are Chosen**: will a first pass with feature matching allow for deeper analysis?

  – **Multi-Constraint Theory**: are the features, relationships, and purpose of these items the same? Is it ‘coherent’?
Summary and Future Work

• DEEP seeks to provide intuition-like planning by utilizing experience in a mixed-initiative environment.

• Future efforts will include:
  – Episodic Memory rather than Case-Based memory
  – Semantic and Structural analogy algorithms
  – Measuring trust/confidence in assumptions using CBR
  – Capturing a world state with enough richness for analogies
  – Capturing ‘war stories’ and lived history for new cases