Goal-Driven Learning

B551
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There’s an ML Tradition of Viewing Learning as Search

- Mitchell explicitly frames candidate elimination and decision tree learning as search
- Search is also the core of subsymbolic methods such as backpropagation
- Is this the only way?:
  - What are the problems with search?
  - Is there any way around them?
Hypothesis Spaces Grow Rapidly

- For a system learning a concept over boolean n-tuples, there are $2^n$ possible n-tuples
- For m examples seen so far, there are $2^n - m$ tuples remaining to be classified
- This means that the remaining hypothesis space has size:

$$2^n - m$$
Real Life Learning Confronts Staggering Amounts of Data

What data must a person learn from in a lifetime (estimates by Larry Hunter):

- Incoming info: $10^{10}-10^{12}$ nerve cells in body
- 1-10% of them sensory nerves
- Each capable of 100-1000 bits per second
- Result: Conservatively, $10^{10}$ bits per second over waking lifetimes, maybe $10^{13}$
- This is a lot.
What does this mean?

- How do people do this search?
- Do people do it?
- If not, what *do* they do?
- What familiar AI area has had to overcome a potentially overwhelming search space?
Possible Hints at an Approach

- How do people think about learning?
  - “Inquiring minds want to know”
  - “This course has a prerequisite”
  - “Motivation for learning”
Search vs. Planning

- What’s the difference?
- Planning differs from search in 3 ways:
  1. Planning opens up the goal representation to allow action selection
  2. Planning does divide-and-conquer by subgoaling
  3. Planning relaxes the requirement for sequential construction of solutions
Towards Goal-Driven Learning

- Can this apply to learning, at least for the overarching learning process?
- How would a planning-based view work?
- What might its effects be?
Effects on Learning

- Makes learning active and strategic
- Directed by reasoning about information needs and strategies in the context of:
  - Current tasks and goals
  - Prior knowledge
  - Capabilities
  - Environmental opportunities
An Example: Buying a Stereo

- Situation: You’ve never bought a stereo before
- Goal: Getting a good buy on a stereo
- What are the learning goals?
- What are their subgoals?
- How can they be achieved?
Some Learning Goals

- Learn the best sources for buying
  - Learn criteria for assessing stores
  - Learn specifics about prices, services, etc., in order to classify

- Learn how to judge stereos
  - Learn classes of stereos and alternatives
Some Possible Learning Strategies

- Ask for others’ opinions
- Read magazines
- Form inductive or explanation-based generalizations
- Disassemble equipment
- …
Factors Affecting the Choice

- Buyer’s prior knowledge
- Buyer’s resources (as they affect the top-level purchase goal and as they affect the learning strategies)
- Opportunities (e.g., meeting an expert at a party)
- Buyer’s capabilities (e.g., skill at disassembly, how threatening the buyer looks)
General Ways Goals Can Influence Learning

- Directly guiding the performance task (explanation, planning understanding, etc.), which gives rise to the learning goals
- Directly guiding the learning task
- Guiding retention of the results
Directly Guiding the Performance Task

- Determining resources for the performance task
- Guiding the control or search for the performance task
- Guiding retrieval of plans, problem solutions, and other types of knowledge
- Focusing attention on certain aspects of the input
- Guiding the evaluation of the outcome of the performance task
- Learning application conditions and other information about the methods available for the performance task
Directly Guiding the Learning Task

- Specifying the target of learning
- Selecting the learning algorithms
- Constraining the learning process
- Focussing search for needed information
- Determining when to learn
- Aiding evaluation of results
Guiding Retention of Results

- Deciding what to store
- Deciding how to operationalize it
- Deciding how to index it
Motivations

- Alleviating problems of computational complexity (as planning does)
- Providing a top-down/bottom-up bidirectional advantage
- Facilitating use of opportunities to learn
- Improving global effectiveness of learning
- Increasing flexibility of learning
- Improving management of interactions between learning processes
A Key Question

- Where do learning goals come from?
What Determines Interestingness?
Steps Towards a Theory of Interestingness

- What makes things interesting?
- Schank proposed that sex, violence, and load noises are intrinsically interesting
- MetaAQUA and other systems consider anomalies interesting
- Can we get a richer picture from Knowledge Goals?
- What types of knowledge goals are there? (After we work out ours, we’ll look at Ram’s)
Ram’s Three Types of Knowledge Goals

- Memory goals, prompted by potential generalizations, etc.
- Explanation goals, prompted by knowledge gaps
- Relevance goals, prompted by specific active tasks
Some Questions for GDL

- How Goal-Directed is Human Activity?
  - Is goal-driven behavior a good way to account for singing in the shower?
- Can “built-in” criteria carry much of the load for guiding learning?
- How do goal-driven and non-goal-driven learning processes interact?
- Which of the tasks we looked at in the papers could benefit from a goal-driven view?