Utilizing Case-Based Reasoning and Automatic Case Elicitation to Develop a Self-Taught Knowledgeable Agent

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Introduction

Knowledgeable agents are routinely used to enhance game play by providing challenging and adaptable opponents. Unfortunately, agents’ knowledge of their gaming world is typically domain specific and therefore not adaptable to evolving or changing domains. Ideally, a game agent could be self-taught without access to predefined domain knowledge, by being introduced into a new domain and spending a relatively short amount of time acclimating itself to the new environment and learning the behavior needed to succeed. The agent would only need the ability to act within its environment (e.g., the abilities to move or manipulate objects, and observe the consequences of the actions). This research argues for the automatic capture of agent knowledge using a technique called automatic case elicitation, and demonstrates and evaluates the performance of this approach in the system CHEBR (CHEckers case-Based Reasoner).

Challenges

♦ Generic domain representation.
♦ Automatic domain learning without expert knowledge or interaction.
♦ Efficient agent training and development of usable knowledge base.
♦ Efficient evaluation of case worth.

I. Algorithms

Requirements: Ability to construct novel or previously unsolved solutions when prior experience does not provide an optimal solution to a given domain state. When prior experience suggests a reasonable action to be taken in a given state, actions must be chosen based on past performance.

Case-Based Reasoning was chosen for its ability to acquire a knowledge base of past experiences as well as its ability to quickly recall and apply prior knowledge to new situations.

Automatic Case Elicitation was employed for its capability to automatically acquire knowledge in a changing environment.

II. Case-Based Reasoning and Automatic Case Elicitation

Case-based reasoning (CBR) systems rely on a knowledge-base of cases (i.e., past or prototypical scenarios) that are most often captured manually through interview sessions with domain experts. While this manually-guided approach has demonstrated merit, it may not be applicable to all domains, such as continuous, partially observable, or time-dependent environments.

Automatic case elicitation is a learning technique in which a CBR system acquires knowledge automatically during real-time interaction with its environment with no prior domain knowledge (e.g., rules or cases). CBR is particularly well suited to automated real-time learning due to its ability to acquire experiences in the form of cases and rapidly recall and apply these prior experiences to new situations. This is especially true for domains in which knowledge is incomplete or doesn’t exist and is suggested as an alternate to brute force search techniques which do not transfer easily to new problem domains.

Future Work

♦ Apply k-nearest neighbor approach to case selection.
♦ Improve learning reinforcement.
♦ Apply Automatic Case Elicitation to various domains.

Results

Two configurations, CHEBR-Exact (cases and board must match exactly) and CHEBR-Region (model-based matching) each with initially empty knowledge bases, were pitted against one another for 2000 games (approximately two and one-half hours worth of game time on a machine running an AMD Athlon XP2000+ processor). As expected, CHEBR-Exact’s case-use ratio grew at a much slower rate due to its requirement for exact case matches. Results suggest that with a sufficiently large case base, CHEBR-Exact could replace pre-coded, model-based knowledge.

Conclusion

CBR is one approach to developing knowledgeable agents. Unfortunately, most CBR systems rely upon previously and manually gathered expert knowledge. An alternate approach, automatic case elicitation, represents a less costly learning technique (for acquiring agent knowledge) in which a CBR system acquires knowledge automatically during real-time interaction with its environment with no prior domain knowledge (e.g., rules or cases). For problems that are observable, discrete and either deterministic or strategic in nature, automatic case elicitation can lead to the development of a self-taught knowledgeable agent. Automatic case elicitation is demonstrated within CHEBR, a CHEckers case-Based Reasoner that employs self-taught knowledgeable agents. CHEBR was tested using model-based versus non-model-based matching to evaluate its ability to learn without predefined domain knowledge. The results suggest that additional experience can substitute for the inclusion of pre-coded model-based knowledge.

Key References