Reasoning by Agents in Computer Bridge Bidding

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Abstract. The authors propose an agent oriented model for a bidder in the auctioning stage of bridge. Each agent selects a bid according to the criteria: Cooperate with the partner to get maximum profit and compete against opponents to minimize loss. Since bridge auction is a task of imperfect information, each agent has hypothetical reasoning ability and generates images of other players’ hands by abduction from the observed bidding sequence. This paper shows a framework for reasoning about each others’ knowledge and the details of analysis on typical examples. It is shown that the difference between one’s own real hand and its image in a partner’s knowledge motivates an agent to continue bidding. We also analyze an example of reasoning by an agent to select a sacrifice bid where the expected score of the bid is better than the score of an opponent’s possible contract. Experimental results show that the reasoning by the agent is flexible enough to play with a human partner and other computer bridge programs.

Keywords: Computer bridge, Bidding, Imperfect information game, Agent, Hypothetical reasoning, Constraint logic programming

1 Introduction

Auction in the game of bridge is an interesting field for a case study of a multi-agent system. There are only 4 agents/players, but cooperation with a partner and competition against opponents happen in this small world. Language for communicating with each other is restricted (38 possible bids: 1 club to 7 no trump, pass, double, redouble) but a bid may have various meanings according to the context. The goal of each bidder agent is to reach a reasonable contract in the auction.

Wasserman wrote a bidding program in ALGOL with the collaboration of bridge experts [1]. It is reported that the operation was satisfactory so long as all bids were determined by the program, but the program was weak when the bidding took a course (as in a quiz) different from the choice made by the program. There will be similar problems when a human player bids as a partner of the program. Lindelöf proposed COBRA, a new bidding system, and showed through a series of computer experiments that the system has excellent ability [2]. Unfortunately, there are few players who can bid with his system as the partner. This paper aims at a more humanlike program than the program of Wasserman or Lindelöf. Each player is modeled as an agent shown in Section 2.

Gambäck and his colleagues claimed that it is important to estimate the hand based on the bid [3]. They described the inference rule to estimate the hand in Prolog. Uehara
described a bidding system in a constraint logic programming language, and used the same description for both selection of a bid and estimation of the hand [4].

Since bridge is a game of imperfect information, deductive inference is not so useful in this game. The hypothetical reasoning implemented in a constraint logic programming language is used in this paper. A framework and typical examples of reasoning by bidder agents are explained in Section 3. When a bid has several meanings, the agent may misunderstand the situation. Methods to prevent misunderstanding are discussed in Section 4. Some experimental results on partnership with a human player and competition against other computer bridge programs are shown in Section 5. Rule-based approaches to bidding are fairly common. Many implementations attempt to construct some kind of model of their own partner's hands, but using the same techniques to reason about the opponent's hand isn't so well advanced. We use the same technique to guess the opponent's possible contract in order to make a successful sacrifice bid.

2 Bidder Agent

Figure 1 shows the agent model proposed by the authors [5]. The agent has knowledge of a well known bidding system, that is, the summary of Charles Goren's book [6]. The bidding system is described as rules in the constraint logic programming language ECLiPSe [7]. In the case where the bidding system knowledge says nothing, general criteria are used for an agent to select a bid. This is what most human players do. The action criteria are often used because the bidding system summary says little about bids after the opener's rebid. The important feature of our agent is a hypothetical reasoning mechanism. The agent generates an image of the other agents' hidden hands by abduction from the observed bidding sequence. If the agent finds a consistent hypothetical image, it is used for selecting a bid according to the action criteria.