Toward a Statistical Characterization of Computer Daihinmin

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ABSTRACT

The purpose of this article is to clarify the fundamentals of the card game Daihinmin. By collecting logs of Daihinmin games on a large scale and analyzing them, the authors illuminate the game's characteristics. They discuss the content required from the game to this end and examine the types of logs that must be collected. They then report on the collection of various logs and the calculation of certain features to characterize Daihinmin. Furthermore, the authors investigate the relationship between the initial hands and rankings of players, as well as the influence of the exchange rule, through a computer experiment.

KEYWORDS

Daihinmin, Games of Imperfect Information, Log Collection, Statistical Analysis

1. INTRODUCTION

Many attempts have been made to enable computers to play games. For certain games, such as Go or Japanese Chess (Shogi), computers have attained the skill levels of professional human players. These games are games of perfect information, meaning all players have access to all information.

In contrast, in games of imperfect information, information is partially hidden from players. The card game Daihinmin is one such game. It is characterized by the fact that the rankings of players in each game affect the hands dealt to them in the subsequent game. The framework of Daihinmin represents political and economic interactions, unlike many other multiplayer games of imperfect information. Computer Daihinmin involves the use of computers to play Daihinmin. Since 2006, the University of Electro-Communications Computer Daihinmin Convention (UECda) has been held annually to bolster the progress of this technology (Nishino & Okubo, 2009). The competition features computer programs playing Daihinmin against one another and has two main purposes. One is to seek ways to use the game as a teaching tool for newcomers to computer science. Computer games are already used in several universities to this end. The other is to study algorithms related to games of imperfect information, such as the work in (Ohto & Tanaka,2016; Suto, Narisawa & Shinohara,2010; Tagashira,

Tajima & Kikui, 2016; Wakatsuki, Fujimura & Nishino, 2016). The outcomes of these studies have been used in UECda-participating programs and show significant improvement every year.

The prominent programs for Daihinmin employ the Monte Carlo method and other randomized algorithms. When these programs are executed, even the developers who wrote them cannot predict the next cards that will be played by the programs. Furthermore, because of the high-speed matches that characterize the convention and the absence of professional human players, there are no established gameplay tactics or styles, whereas such characteristics are often observed in other popular games.

Furthermore, little research has been conducted on the essential components of Daihinmin. For example, one of the features of Daihinmin is that the initial hands may be random. Such elements strongly influence rankings in the game, but the strength of this influence is not obvious. Similarly, almost no research has been performed on the despotism rule, which is a unique rule in Daihinmin. Therefore, it is important to analyze relevant programs to clarify the essential components of Daihinmin. We clarify the characteristics of Daihinmin by collecting and analyzing game logs on a large scale. We first examine the features of Daihinmin, determine the types of data that should be collected, and then perform the collection. Using these data, we perform an initial analysis where we examine initial hands and submission cards. The results reveal several important characteristics of Daihinmin.

2. COMPUTER DAIHINMIN

Daihinmin is a card game mainly played in Japan, but similar games are played around the world. It is a multiplayer game of imperfect information that has been extensively studied in recent years. Computer Daihinmin refers to playing the game on a computer. The UEC Computer Daihinmin Convention is an annual competition for computer Daihinmin programs. Several thousand games are played in the competition each year by computers with extreme computational capabilities. The competing algorithms seek to win without the influence of an initial hand over the course of many games.

In this study, we adopt the framework utilized by the UECda. While there are numerous sets of localized Daihinmin rules, the UECda implements the specific rules outlined below:

- **Game Procedure:** The game is played by five players and uses a total of 53 cards: 13 (ace-king) hearts, clubs, spades, and diamonds, as well as a joker. The cards are ranked in the order of 3, 4, 5,···, 10, jack, queen, king, ace, 2, where 3 has the lowest value and 2 has the highest value. At the start of each game, each player is dealt 10 or 11 cards. Players take turns in clockwise order to discard (play) the cards in their hands. The first player to get rid of all their cards is the winner;
- **Start of the Game:** The game starts with the player who has the 3 of diamonds. The player either plays (discards) their card(s) or passes the turn. This process is repeated for each player. If there are no cards on the table, a player may play any type of card in turn (a single, pair, or kaidan [sequence]). If a previous play is on the table, the current player can play their card(s) to defeat the previous play;
- **To Close a Round:** When all players have played their respective turns, the round ends. The last player to play a hand begins the next round without any cards on the board;
- **Pass:** A player may pass their turn if they have no card(s) to play or would prefer to pass. Once a player passes a turn, that player does not have another turn until the round ends;
- **Eight-ender (8 Rule, 8 Giri):** A round ends when a player plays a hand containing an 8;
- **3 of Spades:** When the joker is played as a single card, a player may end the round by playing the 3 of spades;
- **Revolution (Kakumei):** When a player plays a set (pair) of four or more cards with the same number, or a sequence with five or more cards, a revolution occurs, and the strengths of all cards are reversed until the end of the game;

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