Comparison of Human and AI Bots in StarCraft with Replay Data Mining

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***Abstract*— When you prepare an entry for the StarCraft AI competitions, it is important to understand the difference between human leagues and AI bots' competitions. Simply, you can watch a lot of replays from the two leagues and compare their plays. Unfortunately, it takes much time to review them and also requires expertise for the game. Recently, it is possible to access a lot of replay files from the Internet for the two leagues. In this paper, we propose to use replay-based data mining algorithms to identify the difference between human and AI bots. It shows that the AI league has unique property compared with the human competition.**

Keywords—StarCraft; Data Mining; Fog-of-War; Replay; Scouting

I. INTRODUCTION

StarCraft has been one of the successful real-time strategy games with huge number of users over the world. The game provides a function to store all gaming events into a separate file and to replay the game from it. You can find a lot of web sites to share the replay files of good players. As a result, the StarCraft community has accumulated their experience in the form of replays for several years.

Recently, the game has gained interest from academic research groups as a programmable real-time strategy (RTS) platform. It is possible to write your own program using open-source library (BWAPI). Since 2010, there have been several international AI competitions for the game (IEEE CIG and AAAI AIIDE). It has been known that the design of AI for the game is not a trivial problem but requires a lot of modules and expertise on the game.

Replays are great source of information to design the AI but it is challenging to transform the raw data into meaningful knowledge. Initially, you need to download replay files from famous web portals. Using replay browsing software (Load Martin Replay Browser or BWChart), you can export game events into a text file from the replays. Weber *et al*. showed that the machine learning models trained from the replays could predict the strategy of players in the early stage of games [1].

In this paper, we argue that the replay data mining is useful to compare the human players and AI bots. Although most of replays are from the human vs. human games, the number of replays from computer vs. computer games has been increasing due to the competitions. The competitions have produced a lot of replays and they're accessible to public. In this study, we use 1) a simple statistical analysis of single game event 2) distribution of strategies and 3) predictability and utility of machine learning algorithms for the comparison.

In the replay data mining, we also consider the "fog-of-war" that limits the visibility of the opponent's region. Although "fog-of-war" is a default setting in the game, the replay browsers extracts all the gaming events ignoring the "fog-of-war" [1][2]. To simulate the "fog-of-war," the previous works assume that some portions of opponent's player are randomly missed from the replay data. On the other hands, in this work, we develop a software using BWAPI (Brood War API) to extract realistic (with "fog-of-war" setting) gaming events from the replays.

II. COMPARISON OF HUMAN AND BOTS IN STARCRAFT

A. Data Collection

The first step is to collect replay files for the human vs. human and computer vs. computer games. In the analysis, we focus on the "PROTOSS" race and all the replays are "P vs. P" games. For human games, we download 570 games from YGOSU.com. For computer games, we use 142 replays from AIIDE 2010, AIIDE 2011 and CIG 2011 competitions. With the customized replay extractor, it is possible to get the event name and the time with or without the "fog-of-war."

B. Simple Statistical Analysis of Gaming Events

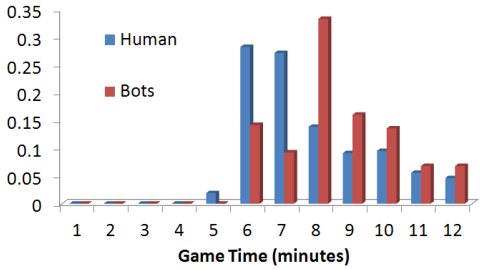

Fig. 1. Histogram comparison of the first "Observer" unit production time (Y-axis: the ratio of replays (0~1))

There are 51 types of game events in the "PROTOSS" race which represents the time of unit production and building

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construction. It stores the type of event and time stamp. For example, "PROBE Production 3:00" means that a worker unit is produced at the 3:00 time stamp.

In Fig. 1, the difference of histogram between human and bots is big for the first production time of the "Observer" unit. It means that the Human usually starts the scouting in the early stage of the games. In other words, the scouting is not yet important in the games of Bots. Recently, there are some works to implement the scouting for the bots [3].

C. Distribution of Strategies

In [1], they categorize the strategies of "PROTOSS" into seven groups. Fig. 2 shows the difference of strategic decision in the games. Because human players produce the "Observer" in the early stage of the game, the "Fast Dark Templar" (undetectable without the Observer unit) strategy is not popular. However, for the Bots, "Dark Templar" approach is still popular (30%).

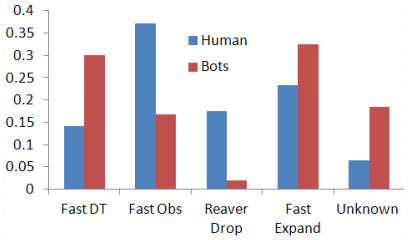

Fig. 2. The distribution of five strategies in replays (two unpoupular strategies are not included.)

D. Predictablity and Utility of Machine Learning Algorithms

In previous works, a lot of machine learning algorithms have been applied to predict the strategy types in the early stage of the game [1][2][3]. Based on the prediction, the player can make decision on the change of build orders. For example, if you recognize that opponents plan a fast attack, you need to replace the current build order with "defensive" one.

Because of the "fog-of-war," in the game, the opponent's region is not visible to the player. It is essential to send a scouting unit to the enemy's territory in the early stage of the game. When the scouting unit is successfully in the enemy's area, it makes the small areas around him visible to the player. Because it offers only partial view of the enemy's area and the scouting unit usually is likely to be killed by the first attack unit of enemy, the information collected from the scouting is limited.

Fig. 3 compares the accuracy of the strategy prediction over game times. In the results, the "fog-of-war" is considered. If scouting is not available to the players, the amount of information about the opponent's behavior should be very small and makes difficult to predict their strategy. The results show that the human's replay logs are more predictable than the one from the Bots. The gap is bigger in the early and later stages of the games than the middle stage. Fig. 4 shows the utility of machine learning prediction. If the player changes its build order based on the prediction, the estimated win ratio is calculated. It shows that the human's are not successful to get benefit from the change of build orders based on the prediction. It means that humans already consider the relationships among the build orders. However, there is still enough room for the improvement by applying the build order change based on predictions.

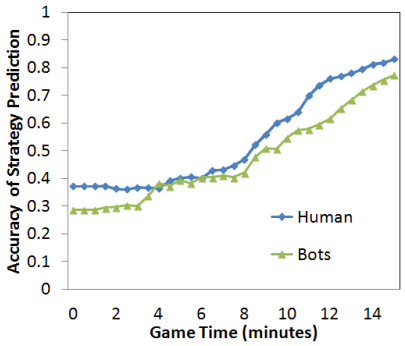

Fig. 3. In fog-of-war, comparison of precision of strategy prediction between human vs. human and bots vs. bots (RandomForest algorithm is used to predict in the early stage of the games and later, a rule set defined by Weber *et al*. is used)

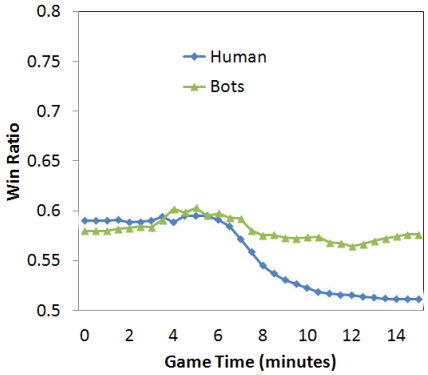

Fig. 4. "Estimated" Win ratio of the players when the player change the current strategy based on the prediction of machine learning algorithms.

III. Conclusions

In this paper, we propose to use the replay data mining in the comparison of human and bots games. It shows that the bots still use different styles of playing (for example, less scouting, and single build order). From the analysis, there is more chance to increase win ratio if the bots are able to recognize opponent's strategy and change build orders successfully. In this work, we incorporate the realistic "fog-of-war" settings in the replay data extraction.

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