Event-driven Learning Classifier Systems for Online Soccer Games

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ABSTRACT
This paper reports on the application of classifier systems to the acquisition of decision-making algorithms for agents in online soccer games. The objective of this research is to support changes in the video-game environment brought on by the Internet and to enable the provision of bug-free programs in a short period of time. To achieve real-time learning during a game, a bucket brigade algorithm is used to reinforce learning by classifiers and a technique for selecting learning targets according to event frequency is adopted. A hybrid system combining an existing strategy algorithm and a classifier system is also employed. In experiments that observed the outcome of 10,000 soccer games between this event-driven classifier system and a human-designed algorithm, the proposed system was found to be capable of learning effective decision-making algorithms in real time.

Categories and Subject Descriptors
J.0 [**Computer Applications**]: General

General Terms
Design

Keywords
Learning classifier systems, Event-driven, Real-time learning, Soccer game, video-game.

1. PROPOSAL OF AN EVENT-DRIVEN LEARNING CLASSIFIER SYSTEM
It is common in the production of video games for human designers to explicitly specify the decision-making algorithms to be used by game agents. It is also common to use IF-THEN type of production rules as a format for describing these algorithms. This is because production rules of this type make it relatively easy to describe algorithms at design time and to understand them during maintenance. Game programs developed by this production technique have achieved positive results based on a fixed usage environment. In recent years, however, the video-game environment has begun to change due to the explosive growth of the Internet. Because of the Internet, it is becoming increasingly easier for anyone to use video games, and the number of game users is increasing dramatically as a result. User knowledge is also diversifying ranging from children to adult playing levels. These developments have two main consequences. First, a single algorithm cannot possibly satisfy all users, and as the number of users increase, differences in strategies that users prefer and excel in can no longer be ignored. The need is therefore felt for simultaneous support of multiple strategy algorithms. Second, the appearance of users with advanced techniques has generated a need for decision-making algorithms under even more complicated environments. And finally, as the Internet makes it easy for new users to appear one after another, it must be possible to provide and maintain bug-free programs that support such complex decision-making algorithms in a time frame much shorter than that in the past.

In this paper, we use soccer as a video-game target and propose an event-driven learning classifier system to solving the above problems. Figure 1 shows the configuration of the proposed event-driven classifier system. This system differs from standard classifier systems [1-3] in three main ways. First, the proposed system adds an event analysis section and creates a table that records event frequency for each game player. Second, the classifier discovery section using genetic algorithms targets only actions while conditions are generated by adding new classifiers in accordance with the frequency of actual events. Third, the system updates the strength of classifiers by the bucket brigade algorithm starting with high-frequency events and continuing until learning can no longer be completed in real time. The proposed system also adopts a hybrid configuration combining a conventional algorithm and classifier system. This system applies conventional algorithm for conditions that algorithm can be applied to and applies learning using a classifier system to only actions not described by an explicit algorithm. Finally, the system provides for two types of rewards that can be obtained from the environment: a large reward obtained from winning or losing a game and a small reward obtained from succeeding or failing in a single play such as passing or dribbling the ball. In short, the above system focuses only on strategy that actually occurs with high frequency during a game and limits learning space to the range that learning can be completed in real time.

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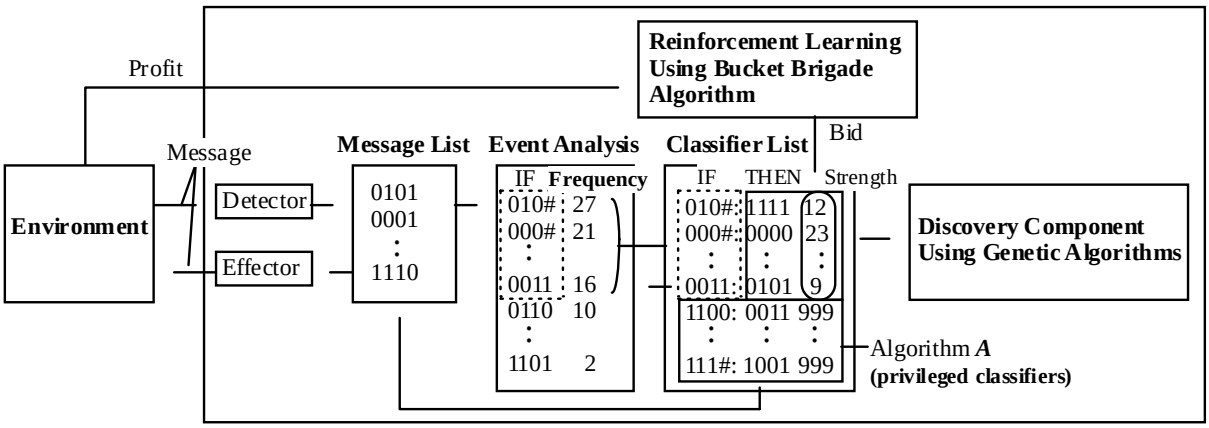


Figure 1. The configuration of the event-driven learning classifier systems.

2. EVALUATION EXPERIMENTS

We prepared three strategy algorithms beforehand to help generate data for evaluation purposes. The first one is strategy-algorithm *A* as a product prototype. The remaining two are strategy-algorithm *B* and strategy-algorithm *C* both based on strategy-algorithm *A* but modified to place weight on offense and defense, respectively. These three strategies were made to play against each other beforehand and each was set to have about the same winning percentage.

In the experiments, the outcome of games played between two teams in a soccer environment was observed. The players on one team used one of the above conventional algorithm-type decision-making systems while those on the other team used the event-driven classifier system. The duration of one match was 20 seconds during which time learning was applied to constructing a classifier system. Each pair of teams played 10,000 matches and team effectiveness was evaluated from its winning rate.

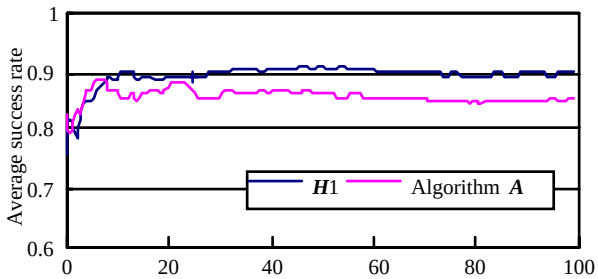
Table 1 shows the results of evaluating the ability to deal with a diverse environment and Table 2 shows the results of evaluating the ability to adapt to a dynamic environment. In either case, the event-driven classifier system could adapt to the conventional algorithm in question in about 80 matches. As reference, Fig. 2 shows the relationship between number of matches played and success rate of dribbling. These results reveal that an event-driven classifier system can improve the success rate of dribbling by about 5%.

Table 1. Ability to deal with a diverse environment

	Won	Lost	Drew
Algorithm ***A*** v.s. ***H***1	32%	17%	51%
Algorithm ***B*** v.s. ***H***1	32%	14%	54%
Algorithm ***C*** v.s. ***H***1	23%	12%	65%

Table 2. Ability to a dynamic environment

	Won	Lost	Drew
(***A*** ->) ***B*** v.s. ***H***2	31%	14%	55%
(***B*** ->) ***C*** v.s. ***H***3	22%	12%	66%



(b) Average success rate of dribbling

Figure 2. The relationship between nymber of matches played and success rate of dribbling and shooting.

3. REFERENCES

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