Human-like Computer Agents using NeuroEvolution with Statistical Penalties

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Recently, many of things in modern life are inspired by the nature. Humans tried to create AI, which refers to things such as machines with intellect, to solve real life problems, and AI is currently attracting many people in the world. AI is important to modern life because it can be used not only to help humans doing tough, complex, repeated works, but also to entertain humans.

Typically, the term AI often appears in the game domain because games provides simple, well-defined and easily evaluating environment, so approaches such as supervised/reinforcement learning, optimization, tree search, reasoning for making computer agents are usually proposed through game environment.

Recently, there are some common trends in making game AI agent. Developing a strong AI computer agent is one of them. In 1997, the first computer champion in chess game won against human champion. In 2016, a method, which utilizes deep neural network, successfully created a strongest computer player in a very complex game of Go. Therefore, the ending of this trend is approaching.

Other than making strong AI computer agent, developing human-like AI computer agents is also interesting. Various approaches are used to develop human-like computer players and many competitions are held in

order to find the most human-like computer agent. Developing a human-like computer agent, especially in games, is essential for many reasons. One of a reason is the human-like behavior of a computer agent can make game more engaging and interesting. A computer agent, which is able to behave in a human way, can be used to teach human players to play a game by guiding and supporting. Moreover, a human-like computer agent can be employed to simulate how a human player play a game for suitable game level evaluation.

NeuroEvolution is an training method for AI, and it has a potential to create human-like computer players for not only one particular game. Thus, this research focuses on developing human-like computer agents using NeuroEvolution, and statistical penalties are introduced to improve the human-likeness of NeuroEvolution. The term *Penalty* represents the differences in behaviors of human players and computer players. Penalty calculation is applied to limit mechanical actions, so the human-likeness of the computer agent might increase.

The goal of this research is creating human-like computer agent which can behave as intermediate human players. In order to create human-like computer players, two objectives are tackled. The first one is that a computer agent should be at the intermediate level of human players, and the other is that the computer agents behavior should be enough to pass the Turing Test, which is the test for human-likeness evaluation. To sum up, our proposed method employs NeuroEvolution to address the first objective, and optimizing statistical penalties is for the second objective.

Training computer players to produce human-like actions requires human data, so an analysis of human players' characteristics in the game domain was conducted. Rather than directly used human data for training, our proposed method requires only statistical data from analysis. The performance of the computer agent was tested on a two-dimensional action game, and the human-like behavior was evaluated by judgments from human subject.

In this research, a modified version of the Super Mario Bros. game is used as a testbed. Super Mario Bros. is a famous two-dimension action game. In this game, players control Mario character to move right from the left of levels to reach a goal. The game is made into a benchmark

for competitions and research purposes. Many times the benchmark of this game is put into competition to find the best controller, in term of strength. Since Super Mario Bros. is a deterministic game, the A* search algorithm has shown its outstanding performance. Besides, competition on the most human-like controller is also held, but the winner controller, in term of human-likeness, is not at the level of the least human-like human players.

The proposed method in this research is based on NeuroEvolution approach because this approach is proved to be the most human-like controller in Super Mario Bros. game. Even though A* search algorithm with some biological constraints can be successfully introduce with the human-likeness as human expert players, we do not employ A* search algorithm because NeuroEvolution has a potential to be extended to another problem domains. Thus, our proposed approach is not limited to only 2D action games.

In order to developing human-like computer agent in a 2D action game, or Super Mario Bros. in particular, we first do analysis on human player characteristics by giving instruction to human player and asking them to play some levels provided by the benchmark of Super Mario Bros. game. Our analysis has shown that even human players play in various styles given different instructions. Therefore, statistical information of human behavior is used in our method to minimize the difference in behavior between human players and computer players.

After gathering statistical data of human characteristics, some features, which describe the behavior of players, are used for penalties calculation. The penalties are the differences of features, for example, the average number of pressed button and frequency of changing actions, in the behavior of human players and computer players. If the behavior of a computer agent is significantly different from the behavior of human players, then a penalty is given to the computer agent. Consequently, by introducing the objective of minimizing penalties along with the main objective of the game, NeuroEvolution is utilized to train the computer agent so that the computer agent can solve the game and behave like human players.

The trained computer player is evaluated through two tests: a performance test and an extended version of the Turing Test. The performance

test evaluates the strength of the computer agent and its behaviors. The strength is measured by the average score obtained from the game environment, and the behavior of the computer player is statistically compared to analyzed data of human players. For human-likeness, Turing Test is conducted by asking human subjects to rate the behavior of the computer player.

The experimental results shows that the human-likeness of agents created by using NeuroEvolution can be improved, and the computer agent is able to achieve the number of actions partly similar to human players. The average human-likeness value of NeuroEvolution computer agent is 2.38. Our proposed method scores 3.02. However, human player score was 1.08 points higher than our proposed method.

Our method successfully enhances the human-likeness of a computer player. Further, if better features and training strategy are used, the human-likeness of computer players is expected to be higher.