Automatic Play Gaming With Deep Learning

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***Abstract*—Deep learning techniques are growing in all fields, and game playing in not an exception. With this paper we review how different deep learning methods to understand how the can be used in gaming environments. Along this paper we will show how deep learning can be applied for a real world example, focusing in the development of the well known Tic-tac-toe game. We also share the results of the comparison using deep learning techniques against coding the the same game in a classical way.**

***Index Terms*—Deep learning, Automatic Play Gaming, Tic-tac-toe, Minimax, Neural-networks.**

I. Introduction

Video games industry is becoming an important part on people's life, not only by offering entertainment, but also by offering sense of belonging and interconnecting people [1]. Reports of the Entertainment Software Association (ESA) on 2020 showed that nowadays, and boosted by the corona-virus lockdown not only young males, but also women, adults and even retired people is attracted by this industry [1].

Deep learning algorithms and Artificial Intelligence (AI) have been used in may fields, including the video game industry since 1971, starting with Computer Space and Pong on the Atari 2600 [2].

Artificial Intelligence is defined the study of "Intelligent Agents", as any device that can perceive its environment and based on it attempt to take actions to succeed in a goal by maximizing its chances of success [3]. Machine learning and deep learning algorithms are the tools used to generate these so called intelligent agents [3].

II. Artificial Intelligence On Games

As described on I, AI has been present in games since the earlies seventies, [7]. However, in the 1957 a team at Carnegie Mellon University predicted that in 1967 a computer would have been capable of defeating a chess world champion [4], but they did not anticipate the hight complexity to predict the correct order of movements required for this task. But at the end of the decade of seventies, a computer defeated for the first time a world champion level chess player [5].

In the same way, Artificial Intelligence has been used to defeat humans in other games, such as Mahjong and Go [7]. These kind of games required a lot of computation and learning algorithm, but they have the possibility to take the time to perform all the necessary calculations. But more advance games, such as Sony's Gran Turismo, have an increased difficulty to master the correct algorithm to drive a race car since many decisions have to be made in real time [7].

III. Chess

The British mathematician and computer scientist Alan Turing was one of the scientist that developed the first algorithm for playing chess. The design of the algorithm was made to be run on a computer that did not exist at that time [6].

On 1951 Alan Turing with David Gawen Champernowne deigned a heuristic algorithm and they try to run in on a 1951 Ferranti Mark 1 computer, but due to the limitations of the computational power of the machine the task was impossible for the computer [6].

Each position on a chess game can be represented as outcome of all the previous positions and moves. For this reason, a chess program do not only need to take into account the current move but the previous and even most important, the possible next moves [6]. In Figure 1 we can see a tree of how each move can generate a limited number of moves, and how the tree grow deeper after every move, so the chess program can select the best next move [6]

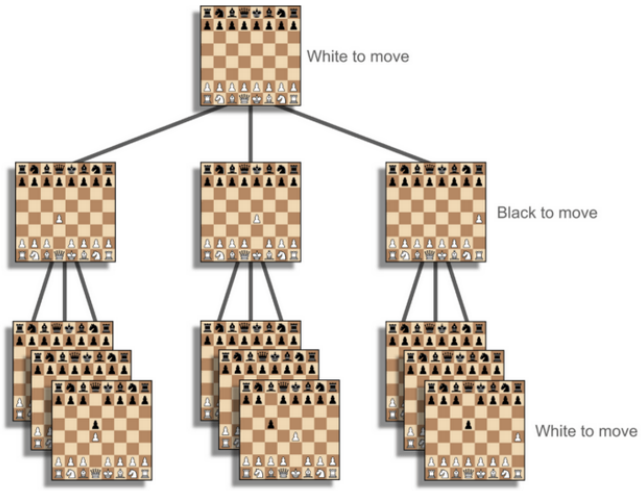

Fig. 1. Searching tree on a chess game [6]

According to Claude Shannon there are two main ways of searching on a chess program, brute-force and selective searches. The first one takes a look at every movement on the board but with a fixed depth of movements, while the second one search for the best candidates going through all the moves and ignore the other branches [6]

Some of the most important algorithms include Chess Challenger, Chessmaster, IBM's Deep Blue and Alpha-Beta Pruning, but since they will be let out of the scope of this research to focus on Deep Mind, which uses *Residual Policy and Value Networks* and *Reinforcement Learning*

Deep Mind is an artificial intelligence laboratory that have successfully created an algorithm based on reinforcement learning capable to defeat world champions in games as chess, go and shogi [6].

The algorithm *Alpha Go* is a neural network that defeated for the fist time a Go's world champion, a game that is significantly more complex than chess. Alpha Go was trained using human data and due to its success, it was object of the award-winning documentary [6]. Alpha Zero, its successor, defeated Alpha Go with a score of 100 - 0 games, but Alpha Zero was trained with no human data a it uses less computational power [6].

Alpha Zero generalizes a network to play three different games, chess, go and shogi. The Alpha Zero algorithm uses reinforcement learning, a field of deep learning that gives rewards for winning or uses penalties for losing in the environment emphasising self-playing [6]

The foundation of most popular neural networks are the *Residual Networks*. These networks let us decode and encode information in the data. One of the advantages of these structures is that the gradient signal regarding the loss function can travel further, allowing a deeper neural network training [6]. These kind of networks to predict the next move, enhances the future maps, information that can be used to improve the present position and move [6]. Also, another kind of networks, *Policy Networks*, select the best possible network and search deeper through the tree, which added with the Residual network limits the searching space and time [6]

There are three machine learning paradigms, *supervised learning, unsupervised learning* and *reinforcement learning* [6].

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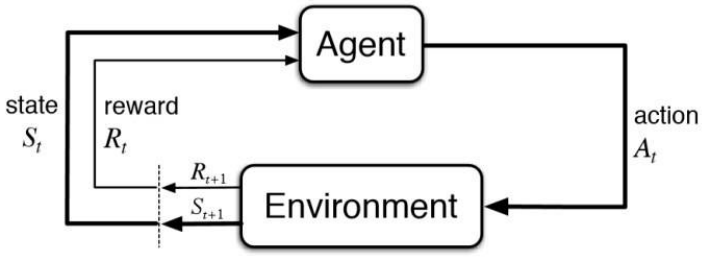

Fig. 2. Reinforcement learning on Deep Main algorithm [6]

IV. Racing games

Since the introduction of deep learning for racing games, reinforcement learning and supervised learning have been the two principal ways to train a network to learn how to drive a car [9].

For the reinforcement learning process, the computer learns on its own by trial and error [9]. Consequently, it is not required to have a big set of data before starting with the training [9]. The most important attributes to train a network with reinforcement learning are an agent and an environment [9].

Gran Turismo, a racing simulation video game, made its debut in 1997 and has sold over 80 million units. According to Sony, it took about 20 PlayStations running simultaneously during 12 days to train Sophy, the Gran Turismo artificial intelligence

V. Drawbacks

The introduction of artificial intelligence and deep learning algorithms do not only offer advantages in the different fields that we have talk about in the previous sections, but it also brings different risks. Since the focus of study of this paper is gaming, an example on how AI can represent a risk in the development of a chess software that can identify unique styles of playing and it is able to point out with no previous information, who it is playing with, what represent a serious privacy risk [12].

VI. Case Of Study - Tic-Tack-Toe

Neural networks, genetic programming, computer vision, heuristic search, knowledge representation and reasoning, Bayes networks, planning, and language understanding are each revealed through the growing capabilities of these agents.

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