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Use of AI in Complex Applications: Deep Blue as an Example

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Abstract: **Artificial Intelligence is considered one to the most dynamic computer science fields. It has a very wide spectrum of applications that includes but not limited to self-driving cars, robotics, healthcare, education, and gaming. This paper sheds light on the use of AI in Chess and how the machine was able to defeat the human brain. It gives a brief overview of AI. Then, it talks about Deep Blue supercomputer and explains its software and hardware aspects and AI principles that were utilized to achieve this goal.**

Keywords: **Artificial Intelligence, AI, Supercomputer, Chess, Applications, Deep Blue, Garry Kasparov.**

I. INTRODUCTION

Computer scientists are working hard to achieve their dream of designing a computer or a robot that can think like a human brain. In other words, they want their machines to have the ability of solving problems without humans help. The first attempt was Brutus I that was designed to compete authors in telling stories starting from a single sentence. However, the attempt failed and Brutus I did not accomplish the mission. Then, computer scientists came up with their next challenge – Deep Blue.

The idea of Deep Blue was to build a supercomputer that can play chess and defeat chess grand masters. Why chess? Chess is a game that requires a number of mental skills such as concentration, calculation, planning, rational thinking, pattern recognition, logic, recall and visualization.[6] However, the most important skill is prediction because a move may result in a sequence of unforeseen outcomes. It basically depends on speed and strategy. Every player is given an average of three minutes to make one move. This goal requires running the chess program as fast as possible to evaluate all possible moves and choose the best move. A team of engineers, grand masters, computer scientists and programmers started the mission in 1985 by a request from International Business Machines (IBM). The team worked for 12 years to be able to beat the world chess champion Garry Kasparov.

II. ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is one of the most recent computer science fields. Improving the quality of computers is the main goal of AI. This goal can be achieved by finding new ways and methods to do tasks that need cognitive abilities.[3]

Computer scientists divided AI into two types: strong AI and weak AI. Strong AI supporters claim that they can replicate the human brain to design a computer with feelings. On the other hand, weak AI supporters say that the human brain is too complex and it cannot be replicated.[1] But AI is still useful in both cases for many applications.

The application of AI can be classified into three main categories: simple, fairly difficult and very difficult. The lower part of the simple applications includes arithmetic operations, simple spelling checks and database retrieval. Symbolic calculus, expert systems, robotics and machine vision are considered as part of the high end of simple tasks and low end of fairly difficult tasks. Playing chess against grand masters is the most famous application at the high end of the second category. Finally, speech recognition and vehicle steering are regarded very difficult tasks.[7]

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III. DEEP BLUE

The first Deep Blue, which was built in 1985, had an ability of evaluating 50,000 board positions per second which did not match Kasparov. However, the team did not stop at this limit. They improved Deep Blue to be able to evaluate 100 million moves per second and played the first match against Kasparov but they could not defeat him. In 1997, Deep Blue won the game with a brute force of 200 million moves per second. The ability of Deep Blue increased, as shown in table I below, by a factor of 4000 through 12 years.[4]

TABLE I: Deep Blue's Brute Force [4]

Year	Board Positions per Second
1985	50,000
1987	500,000
1988	720,000
1989	2 million
1991	6 - 7 million
1996	100 million
1997	200 million

A. Credits

Many people from different universities and fields of work were behind Deep Blue. The original code was written by Thomas Anantharaman who is a computer science doctoral student at Carnegie Mellon University. His colleague Feng Hsiung Hsu hard-coded the routines used in the custom Very Large-Scale Integration (VLSI) chips. The leader of this project was Chung Jen Tan. Murray Campbell, who is a research scientist in IBM and a computer-chess expert, was a part of the team. The team needed a full-time grand master, so they included Joel Benjamin. Three more engaged grand masters were Miguel Illescas, John Fedorvich and Nick De Firmian.

B. Hardware

Deep Blue is a powerful machine. It weighs 1.4 tons.[4] The machine that the team chose was an IBM RS/6000SP supercomputer. This supercomputer has 1.1 billion transistors, 32 processors and 512 coprocessors. Each processor is an IBM power2 Super Chip (P2SC) while each coprocessor can evaluate two to three million moves per second.

An IBM P2SC is composed of eight old Power2 Chips and contains 15 million transistors. Two Pentium II processors are equivalent to one P2SC. The 32 processors are connected in parallel which provides a high speed and low latency connections.[4]

The processors are designed to perform different tasks. Two of them have a speed of 135 MHz and are used to afford a "high-band width data access". One 135 MHz P2SC controls the other 31 processors and can be used as a back-up Input/Output (I/O) for the 64 GB Serial-Storage Architecture (SSA) disk. The other 135 MHz P2SC functions as a primary I/O support for the SSA disk. The remaining 30 processors are used for computations with a speed of 120 MHz.

C. Software

The amazing hardware of Deep Blue enabled it to evaluate 200 million moves per second or approximately 36 billion moves in three minutes.[4] This performance will force Kasparov to think for around four centuries continuously. The designers of Deep Blue utilized these abilities very well. They developed a systematic search process starting by a simple search done by the master processor. Then, it partitions the tree and offloads a deeper search to the 30 computation nodes. Finally, the hardware is offloaded an exploration by the computation nodes.[5]

Deep Blue played two matches against Kasparov. The first match was held in 1996 and ended with a win for Kasparov. After the match, the team made two changes on Deep Blue. They tweaked the move-evaluation functions of Deep Blue to enable it to alter between different plans and procedures in different games. They also added all Kasparov's historic games and other grand masters' games to the database of Deep Blue.[4]

In 1997, Deep Blue defeated Kasparov in the revenge match and became the world chess champion. It was able to search 75 plies, possible moves, but this number is reduced to 30 plies because the allowed time is only three minutes. By comparison, the fastest chess programs, such as chess master 5000, can search 11 to 12 plies at the same time interval.

D. AI in Deep Blue

The team of Deep Blue used simple AI principles as a basis for their work. The first principle is joining knowledge with speed to increase the ability of pattern recognition and to search selectively. Another base is playing differently depending on the board position. Moreover, the small board, which has eight by eight positions, and the huge database they are using resulted in an increase in the ratio. But these principles did not solve some AI problems such as combinatorial explosion.

Combinatorial explosion is an AI problem caused by the exponential growth of things. In the case of Deep Blue, possibilities are growing exponentially. Computer scientists solved this problem by developing an algorithm called "the alpha-beta" algorithm. First, they assign values to the endpoints. Stronger positions mean higher values. Then, they exclude small values. After that, a shallow search is done for the remaining possibilities. Finally, promising possibilities are searched deeply.[2]

IV. CONCLUSION

Although Deep Blue defeated Kasparov, it is still weak. This is also the opinion of Yasser Seirawan, who is an International Chess Grand master and the publisher of Inside Chess magazine in the United States, who says: "Computers are really great tools with perfect recall, but they are quite weak and have to be guided".[6] For this reason, we should guide powerful computers, such as Deep Blue, to satisfy our needs and save time, money and effort.

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