PEEK INTO THE FUTURE: A BREAKDOWN OF THE VARIOUS IMPLICATIONS OF ALPHAGO'S SUCCESS OVER THE TRADITIONAL BOARD GAME, GO

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ABSTRACT

This paper aims to present a collection of the several implications of AlphaGo's victory against the top professional Go player, Lee Sedol. The implications were studied through three different aspects: (1) technological, (2) social, and (3) economical/political. The study of the technological implications was done through the lens of understanding what makes AlphaGo work, as well as the differences between AlphaGo and Deep Blue. The social implications are viewed through the perspective of the Go community in general, with a discussion on the fears and optimistic outlooks by different professionals. The economic/political aspect is viewed on a global perspective, integrating business and political mindsets as well as an inquiry into how the Chinese think about issues of war and diplomacy.

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History and Background of AlphaGo's Success

Prior to the unveiling of AlphaGo by the Google Deepmind team, the ancient game of Go has been an endeavor that computer programmers have continuously tried to crack. In 1997 after Deep Blue defeated the international chess grandmaster, Gary Kasparov, the big question was whether or not machines will begin to dominate against humans in terms of these games that showcase the calculating mind of humans (Weber, 1997). During that time, the programmers that were in charge of Deep Blue admitted that due to its complexity, Go still remained as one their greatest challenges (Lai, 2004).

On October 2015, the dream became a reality when AlphaGo made history by being the first Go program to defeat a professional player, Fan Hui, on a full-sized 19x19 board without any handicaps (Silver, et al., 2016). The result was 5-0, which showed that the program was consistent and did not win through a fluke or through sheer luck. There were several skeptics regarding that match due to many players questioning Fan Hui's abilities despite being the European Go champion as he was only ranked 663rd in the world ratings and he is only at the strength of 2 professional dan (Metz, 2016). Most players however, considered this an interesting opportunity and started speculating how the program would fare against the top professional players. This event shares a lot of similarities during Kasparov's defeat in 1997, as many chess players

also refused to believe that a computer was finally able to defeat humans at a game which was conceived to be impossible to learn by a computer, choosing to blame the inexperience or lack of skill of the participating player instead (Weber, 1997).

As with the events of disbelief, the players turn to the stronger players in Go who they thought could beat AlphaGo. One of the players they had in mind was Lee Sedol, a Korean professional Go player. Lee Sedol has the second most number of international titles (18) next to his former mentor, Lee Changho who won 21 international titles. Aside from that, he is widely considered the strongest Go player in the world especially during his stints in 2008 and 2010.

Amidst the speculations and analysis of many players and Go enthusiasts alike in the world, Lee Sedol was defeated by AlphaGo with a result of 4-1 in their five-game match held in Seoul, South Korea between the 9th to the 15th of March 2016. While the game proved to be a difficult one for him, their matches showed how the creative and the unconventional moves further improved both their game to the next level. Lee Sedol even reflected that "the typical, traditional, classical beliefs of how to play - I've come to question them a bit" ("A game changing result", 2016).

Impact and Significance of the Game Result

While most of the events surrounding AlphaGo mostly have direct impact on both Go players and computer engineers, the result

of this game has more implications compared to what it seems on the surface level. This paper aims to discuss the impact and significance of AlphaGo's success on three different aspects: (1) technological, (2) social, and (3) economical/political. One obvious impact would be on the world of technology as AlphaGo was created in the first place with that in mind. This makes the program a possible cornerstone for some new innovations for the future. Another impact would be on the social level as it affects areas with strong Go communities, like in Korea and Japan. Many Go teachers are very much curious as to how the game provided extra publicity and interest in the game due to the event. The final impact that this paper will also be discussing would be how the result itself can affect the world of economics and politics. As modern societies continue to grow and develop, the world of politics and economics will inevitably enter the realm of technology as well. With that in mind, AlphaGo's technology has a possibility to be used in those fields in terms of the global market as well as national development.

Technological Implications: How AlphaGo Works

After its unveiling, AlphaGo was predicted to be phenomenal in terms of tracking the technological progression in the next couple of years. While the events of 1997 with Deep Blue may not have produced a great technological impact during its time, most computer engineers and enthusiasts say that AlphaGo and Deep Blue

are two different things altogether (Nielsen, 2016). It is a fact that Go has more possible moves compared to chess so this contributes to the difference in terms of difficulty. However, Nielsen (2016) mentions that while those are legitimate observations that present a great leap forward for technology by being able to reach a new benchmark, there are broader implications to this event compared to just having a computer program that can play Go. In order to understand the broader implications, it is crucial to understand first the difference between Deep Blue and AlphaGo as well as the inner workings of AlphaGo.

Inner workings of AlphaGo. The fundamental principle behind AlphaGo's technology is "deep reinforcement learning" - a term Demis Hassabis (co-founder of DeepMind) and his team used to describe AlphaGo's system. Hassabis defines it as "the combination of deep learning, neural network stuff, with reinforcement learning: so learning by trial and error, and incrementally improving and learning from your mistakes and your errors, so that you improve your decisions" (Hern, 2016). In the paper published by the DeepMind team (Silver, et al., 2016), the team explained how AlphaGo utilizes two neural networks for its computation: a policy network and a value network. The policy network essentially assesses the probability of moves for optimal play that goes in line with the correct goal of winning games. The value network evaluates the board position and predicts the expected outcome of the board state.

In essence, the purpose of the value network is to narrow the search depth by evaluating the board state of the game, while the policy network's purpose is to select the optimal move that offers a high probability of winning. Both of these networks are efficiently combined with the Monte Carlo tree search (MCTS), a series of rollouts aimed to increase the accuracy of the value estimation of the search tree. The MCTS represents the actual thinking process of the program while the neural networks represent the system in which information is processed.

In addition to that, AlphaGo's neural networks were trained in two categories: supervised learning and reinforcement learning (Silver, et al., 2016). Supervised learning was used by the DeepMind team to feed AlphaGo numerous amounts of professional game records in order to train the program to predict the next move given under certain conditions. The second stage of training was to split AlphaGo into different versions of itself and then make them play against each other. This reinforcement learning method relied on the program committing multiple trial-and-error runs in order to learn the optimal play given the different factors and situations of the board (Silver, et al., 2016; Hern, 2016).

In summary, the core of AlphaGo's system is patterned closely with how a human player learns the game. The neural networks were created to replicate the way humans process information and decide on an action. Instead of relying on superior computational power,

the tools of machine learning and the deep reinforcement learning showed that despite technological advancements, the power of the human mind is the best template for solving everyday situations. This incremental innovation by the DeepMind team offers a new route in the research on the field of artificial intelligence. As people grow to accept more that machines will eventually best even the most intelligent humans in regard to certain matters, it is important to remember that these advancements are due to the use of our human minds as templates (Cho, 2016; Mackenzie, 2016).

Comparison of impacts between Deep Blue and AlphaGo. The difference between the two programs lies in the fact that Deep Blue's technology only extends to chess since it relies on brute-force searching - something that machines naturally have an edge over humans. AlphaGo's technology on the other hand, can extend to other intuitive systems as it uses deep neural networks to mimic human learning (Johnson, 2016; Nielsen, 2016).

The AI system used for computing chess is relatively simpler due to the reductionist nature of the game. This allows the computer to compute and compare the value of the existing pieces with the captured pieces. These ideas can even be applied with the more complex concepts of board positions and other factors. However, once applied to Go, the system will not work as well due to the larger number of possibilities as well as the large amount of intuition involved in the game (Nielsen, 2016).

While Deep Blue showcases the superior calculating power of computers, the intuitive systems behind AlphaGo are exactly what modern technology utilizes with applications and software that aim to make computers able to think like humans. Johnson (2016) mentioned that

> Back in 1997 I wrote, "To play a decent game of Go, a computer must be endowed with the ability to recognize subtle, complex patterns and to draw on the kind of intuitive knowledge that is the hallmark of human intelligence." Defeating a human Go champion, I wrote, "will be a sign that artificial intelligence is truly beginning to become as good as the real thing."

In contrast, AlphaGo has several more applications outside the game compared to Deep Blue, thus giving new perspectives in the way certain applications could be improved.

An example of a program that would benefit from AlphaGo's technology would be translation systems. While a brute-force algorithm is useful for mathematical applications, the deep principles of syntax, semantics, and phonetics are fields that demand a more delicate approach. The interactions of words with the grammar and context make it difficult for translation systems to accommodate a more natural way of translating conversations. However, with a deep neural network system approach, it is possible to create a system that

closely mimics actual human translation as the information were gathered from actual people (Johnson, 2016). This kind of approach can be applied to even very artificial systems in speech and facial recognition, capturing a level of intuition required for those certain fields. A good example of the application and research of such technology would be from the study of Gatys, Ecker, and Bethge (2015), where they used their version of a deep neural network to learn the different artistic styles of several painters by feeding the images to the system. Once the system is capable of deconstructing the main elements of an artistic style, it can apply the system to images that a user wants to alter to that specific style.

The Deep Mind team shares their optimism with the development of the technology by sharing that through AlphaGo's success in being able to "globally" view the task at hand, it is capable of seeing things that normal humans would not come to think of (Hassabis, 2016). In fact, in a post-game analysis with Ting Li, vice president of the European Go Association, and Jon Diamond, president of the British Go association, both professional players agree that AlphaGo is certainly doing moves that no player would ever think of (Wong & Sonnad, 2016). This kind of novelty in approaching problems may prove beneficial in terms of medical systems as well as other programs wherein people may have the chance to overlook new options due to either the lack of observation or personal biases.

In summary, AlphaGo's victory over a human in the ancient Chinese game of Go represents a great leap forward for both humanity and the realm of technology alike. Several people dubbed the matches in a man-versus-machine perspective, but overall, AlphaGo could not have won if not for the human developers that made it in the first place, as well as the conscious recognition that machines have to be patterned after our own neural systems in order to accomplish those tasks. AlphaGo parallels the personal growth of a flailing child to an adult who has learned from its past experiences.

Social Implications: The future of Go

While AlphaGo did make a large impact in terms of the technological world, the other community that faced the direct result of the match would be the Go players from all around the world. Most players did not anticipate Lee Sedol's loss against the machine, although the fourth game in the match did increase hope as it was the only game where Lee Sedol was able to defeat AlphaGo with a very innovative move that even the machine did not anticipate (Wong & Sonnad, 2016). This has become a point of discussion where several Go players take into consideration the possible benefit of AlphaGo to the community.

In the technological implications section of this paper, the focus of how AlphaGo's success retains to be a human one focuses on humans being the creators of it. However, in the perspective of the

social implications of AlphaGo, it can be said that it is a victory for humans as the program itself pushes the very limits of our thinking. This was exactly one of the reasons why the Deep Mind team looked forward to AlphaGo playing against the top professional player, Lee Sedol, as they acknowledge that both man and machine will be pushed to their extremes and will bring forth new ideas and new ways of thinking about time-tested theories (Hassabis, 2016).

Once AlphaGo is released to the public, it will serve the same purpose as the future iterations of Deep Blue had with helping their respective players improve their game further. However, there are several fears regarding the future of aspiring Go professionals due to the main fear that machines would come to replace humans since they will be capable of accomplishing tasks that require the uniqueness of human creativity, insight, and intuition (Chan, 2016). The reactions of several players are common fears that were also expressed during the time when Kasparov was defeated by Deep Blue in 1997 (Nielsen, 2016; Johnson, 2016). However, several professionals think that AlphaGo actually would offer more possibilities for learning if used in a productive way.

Hajin Lee, secretary general of the International Go Federation, commented that "I think Go still has, and I don't think the fact that computer AI can be stronger than humans diminishes the game at any level. I think people will accept that computer technology has advanced and find a way to use that to the advantage" (Gibney,

2016). Tobey Manning, treasurer of the British Go Association, expressed the view that AlphaGo will be used in the same way Deep Blue was after it achieved grandmaster status. Players will try to get a hold of the software and use it to help them analyze their own games and learn from them. While AlphaGo may never substitute the actual guidance of a professional teacher, it can prove to be a useful tool that can be available to everyone.

With the availability of AlphaGo becoming an eventuality, many players look forward to having an actual benchmark that will make the Go rankings and levels more uniform. Hassabis mentioned that he looks forward to seeing how strong AlphaGo can be and be able to observe how top players in the modern age compare relatively to the "maximum" potential of Go (Hern, 2016). Should AlphaGo ever reach the threshold of being "perfect" with no more improvements to add to its database, then it is very much possible to use it as a standard where all professional and amateur players can test their strength and have a good idea on how relatively strong they are with the game. In the long run, it will help in standardizing the actual strength level of the different rankings (dan and kyu) so that the strength levels of players are consistent and well-represented in the event of an international tournament.

Setting aside the long-term implications of AlphaGo to the Go community, the immediate question that several professionals are asking would be the query of increased interest in the game. As the

event was publicised, the game of Go has reached more people and several players look forward to the prospect of more people getting interested in the game. In fact, the Korean Baduk Association (KBA) is gathering data on AlphaGo's effect in sparking interest in the US ("Did the AlphaGo Match...", 2016). Andy Okun, the president of the American Go Association, stated that

> I suspect that it is not merely academic or journalistic interest, ... In years past, KBA and KABA have used information like this to argue for private and government resources to promote baduk [Go] around the world. The value of something interesting could be significant and pretty soon.

While information regarding the status in several countries has yet to be recorded and archived, Korea has recorded more people getting interested in the game. Daniela Trinks, a professor of Go in Myongji University, mentioned that aside from boosting public interest, the five-game match has increased the number of students registering in Go academies (Baek, 2016). Aside from that, she notes that it also will have a positive effect on the Western countries as they will be able to know more about the game due to the increased publicity as well as enthusiasm of the Go community in welcoming new players.

Overall, while there are certain fears regarding the future of Go, most players are optimistic with how the technology of AlphaGo can help improve the game further and boost interest. While the technology for artificial intelligence continues to grow, the same can be said for the development of Go in terms of the academic field as well as with the regular community of amateur players.

Economic/Political Implications: Subtle Influences in the Larger Scale

Aside from the direct impact of AlphaGo's victory on both the world of technology and Go, it has certain indirect effects in the world of economics and politics. As the modern world constantly develops further, any impact on technology will have possible effects on several aspects such the global market, international relations, and even matters of national defense.

Impact on the stock market. One major concern raised was a possible unethical use of the AI technology of AlphaGo in terms of the manipulation of the stock market. Several analysts look back to the events of the Flash Crash in 2010, where the stocks of several major companies rapidly crashed and then rebounded just as quickly in a matter of ten minutes (Loubriel, 2014). While the cause of the large disorder is not entirely known, speculations arise from the use of artificial intelligence manipulation in the stock market. As the economic unrest in Greece ensued during that time, the computers

in the system made a large sellout that their normal human counterparts would never have done. The situation was eventually diffused when the stockbrokers realized the large error and quickly stabilized the Dow.

In the more recent events of AlphaGo's victory, Jon Tapson, the director of the MARCS Institute for Brain, Behavior, and Development, expresses his concern over the re-evaluation of how we use artificial intelligence in the field of the stock market exchanges (Pett, 2016). Given that AlphaGo's technology is capable of doing things that humans do not expect, there is a possibility of a seamless manipulation as there could be subtle changes that humans would not immediately notice.

In light of this, many analysts have come to recognize that while machines can help ease certain functions in the stock exchange market, a sense of human authority overseeing everything is still needed. Frey (2014) points out that it would be senseless to scrap the system entirely just because it can be manipulated. He proposes that despite the machine intelligence, there still needs to be a sense of human "authority" to police any form of abusive and unethical practices that may ensue from such. This reiterates the points in the other implications that while machines can be superior to people on certain aspects, they cannot fully replace us as we have the agency to direct how these tools will be best used.

The technological and political race. Another subtly influential aspect of AlphaGo's technology would be on the affairs of both local government and foreign relations. While most of the news focus on the interaction of foreign powers over this new technology, the local government in Korea used the AlphaGo event as a form of leverage to capitalize on their inclusion of people with technical professions (engineers, mathematicians, scientists) in their political party lists (Yi, 2016). While this may appear strange, we need to take into account the historical and cultural significance of Go for the Koreans. Baduk, the term Koreans use for Go, has existed long before the game reached Japan, and so holds a significant place in their history. Kim (2007) has compiled in his article a few stories regarding the historical figures related to Go. In terms of modern significance, since the time of Cho Hoonhyun's victory as the sole Korean in the international Ing Cup competition in 1989, Go has been an outlet in which Koreans can be proud about (Lee & Baek, 2011). It became a matter of national pride as new Korean players continue to succeed their predecessors in the following years. When Lee Sedol accepted the challenge of playing against AlphaGo, he wasn't only representing the Go community as a whole; he was also representing the national pride of Korea as he can be considered on the same level of a national athlete. In addition to that, Korea's technological advancements in the fields of business and economics also make it appealing to their local politicians to consider adding more scientists

and engineers into their party list. The recent success of AlphaGo offers new opportunities for their local politicians to highlight their support for that particular field.

Moving on to the larger scope of the world, a Chinese computer programming team is expressing their challenge to AlphaGo by attempting to create an even better AI system by the end of 2016 (Reuters & Prigg, 2016). While this may seem to be a simple competition between different computer programming teams, it also holds an underlying link towards the quality of their respective country's technology. By being able to showcase that they are capable of creating an even better program than AlphaGo, the Chinese team will be capable to represent China's growing technological capabilities.

Aside from that, the Western world is opening up to study how Go can be the key to understanding the way Chinese think in regard to certain problems. The American Go Association wrote an article about a Go seminar they held at the U.S. Army War College in an effort to understand more about China's political and military strategy (Doss & Wong, 2016). The main source that has proven to be useful in their learning would be Dr. David Lai's work (2004) entitled "Learning from the Stones: A *Go* Approach to Mastering China's Strategic Concept, *Shi*."

In Lai's work, he showcases the difference between the Americans' ways of war and diplomacy that lean towards the use of

overwhelming force and direct confrontation through advanced capabilities, alongside the Chinese's ways that mostly rely on strategy and stratagems. Lai (2004) uses the concept of *shi* presented in one of Sun Tzu's chapters to emphasize and describe the Chinese way of thinking. These, paired with parallels in terms of the step-by-step procedure of a sample game he presented in his work, show how the game of Go captures many of the attitudes of the Chinese when it comes to war and diplomacy. Even the philosophy of the game of Go follows the Chinese perspective of creation through harmony as the game progresses from an empty to a full board through the interactions of the two players.

An article by Gosset (2010) explains and gives examples of how the three golden axioms of Go mentioned in the Classics of Weiqi connect with the Chinese way of strategic thinking. The first axiom states that "As the best victory is gained without a fight, so the excellent position is one which does not cause conflict." This represents China's non-confrontational opposition very well as it relies more on the strategies instead of brute force when dealing with unfavorable circumstances. Lai (2004) also mentions this as one of Sun Tzu's main ideas as war should only be done as a last resort if negotiations have failed and the casualties are deemed necessary.

The second axiom states that "At the beginning of the game, the pieces are moved in a regular and orthodox way, but creativity is needed to win the game." Gosset (2010) links this as a variation of

Sun Tzu's concept that at the beginning of an engagement, the action is guided by a set of accepted rules, but in order to achieve victory, it is necessary to think of unorthodox solutions. This axiom is very close to how AlphaGo is able to achieve victory, as it constantly pushed the limits by playing moves that no human would expect (Wong & Sonnad, 2016). Even most students of the game would often be taught with the traditional theories and standard opening moves, *joseki*, but eventually are encouraged to be creative in their own plays. In political and economic matters, China is able maintain its strength by being able to connect with its past roots while constantly being able to find ways to address the challenges of the modern world. An example of this axiom's application would be Deng Xiaoping's concept of "one country, two systems" as this allows China to maintain good relations with its autonomous regions of Hong Kong and Taiwan.

The third and last axiom is "Do not necessarily stick to a plan; change it according to the moment." This axiom of change pairs well with the creativity asked in the second axiom as it prevents a narrow adherence towards one system. It ensures that China is always ready to adapt and change its strategies should the need arise. Strategy is not simply about being able to plan ahead, but also being able to think fast on one's feet.

Through understanding these axioms, one can recognize further how Go is integral as a key to understanding the cognitive aspect of

the Chinese ways of war and diplomacy. The general non-confrontational trait, paired with willingness to try out an unorthodox method and constant flexibility represents the core of Chinese strategies in both business and politics.

Conclusion

Overall, AlphaGo's success in the five-game match opened a lot of possibilities and reopened some old cases as well. The machine may have defeated the human, but this marks a great leap in human advancement. For AlphaGo to succeed, it has to integrate one of humankind's greatest endowments - the ability for intuitive thinking. As technology progresses, humans should come to realize more that they still play a role despite machines being superior in certain aspects. The machines are tools and while they are more sophisticated, the human mind is still needed to direct the course of their usage. Alongside that, it also shows how much there still is to learn from the game of Go that continues to push the limits of humans in many different ways inside and outside of the game.

While the common layperson may not immediately feel the impact of the game to their own lives, it is crucial to understand its long-term impact in terms of technology and global politics. In that way, we become aware and responsible for ensuring that the new inventions in the future will be used for the greater benefit of humanity.

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