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“Man vs Moore’s Law: The declining relationship between chess and artificial intelligence 1950-1997”

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“Man vs Moore’s Law: The declining relationship between chess and artificial intelligence 1950-1997”

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Introduction:

"If One could devise a successful chess machine, one would seem to have penetrated to the core of human intellectual endeavour"[1]

On 22 October 1989 Garry Kasparov sat down to a match like many others in his career, the familiar 64 chequered squares of a chessboard separating him from the person opposite. However, this person was merely the operator of the pieces; Kasparov's actual opponent was hundreds of miles away. Despite emerging victorious, the Deep Thought exhibition match challenged Kasparov's conceptions of computer chess programmes, their capacity for creativity and even for thought. The Deep Thought exhibition match, won by Kasparov would mark a watershed for the emergence of competitive Grandmaster strength chess machines. By 1996, Kasparov was facing Deep Thought's successor Deep Blue. Kasparov would hold out for humanity in 1996 but in the 1997 rematch would succumb to Deep Blue's immense powers of calculation. Deep Blue in many ways represented the culmination of a project which began in the 1950s with the speculation of luminaries such as Claude Shannon, Alan Turing and Herbert Simon, of the possible application of computers or machine intelligence to the game of chess. It would be easy to see Deep Blue's achievement as the resounding success of the computer chess programming community and testament to the contribution of chess to artificial intelligence (**AI**) research. However the manner in which it was accomplished constituted a somewhat hollow victory.

This dissertation seeks to explore the unlikely relationship struck between chess and AI. It will seek to demonstrate how chess influenced the research and development of AI through the development of computer chess. It will show how perceptions of chess and its traditions influenced individuals and research institutions involved in the study of AI ultimately resulting in computer chess' declining relationship with AI culminating in the development of Deep Blue. Moreover, it will reveal how the ambitions of the 1950's luminaries represented not only a more ambitious approach to computer chess, as a proving ground for AI and its potential for future research, but also a conscious investigation of the nature of thought and intelligence. I will argue that computer chess programmes of the 1990s, despite their achievements, disappointed hopes expressed in the 1950s of exploring the potential for 'thinking machines' and therefore missed an opportunity to explore more pertinent questions surrounding the nature of human cognition and machine's ability to replicate it.

[1] Allen Newell, J.C. Shaw, Herbert. A. Simon, *Chess-Playing Programs and the Problem of Complexity,* IBM Journal of Research and Development 1958, vol.2, no.4 pp.320 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5392645 accessed 16/01/2021

Historical study on the development of science has, since Thomas Kuhn's *Structure of Scientific revolutions* 1962, aimed to analyse science through the lens of its social and political context.[2] His work is best known for its challenge of the Whig interpretation of scientific history in which science moves inexorably towards the discovery of truths about the natural world. A process commonly termed progress.

Similarly, the history of technology was, up to the 1980s, similarly troubled by this progressivist outlook which produced histories focused on novelties and innovation representing progress. The processes by which new technologies are created, tested and improved, have played a dominant role in the study of technology. From the 1950s to 1980s, the concept of "Invention-Development-Innovation" was the prominent theory regarding creativity in technology.[3] However, Thomas Hughes' *Networks of Power* (1983) which assessed developments in electrical technologies in America ushered in a change to this assumption by asserting that the characteristics of technologies design and development are subject to political, economic, technical and societal factors.[4] It is this approach I aim to adopt in the development of computer chess and its relationship to AI from 1950 -1997.

The field of AI is young in the history of technology having been formalised in the 1950s. Pamela McCorduck wrote the first expansive history of AI in 1979. Her work *Machines Who Think,* was an interrogation of AI's brief history and development which included commentary on the impacts it had on our understandings of human cognition and perceptions of intelligence.[5] McCorduck constructed a narrative of AI from its earliest fictional ideas in Homer's *Iliad* to its realisation in the mid-20th century. Whilst a seminal work for anyone seeking a humanist perspective on AI, it is light on technical details regarding computer chess and other programming advances. Brief descriptions are provided but it does not constitute investigation of the processes which drove and shaped research, as well as the outcomes.

AI researcher Daniel Crevier's *The Tumultuous History of the search for AI,* offers a different perspective to McCorduck.[6] His profession lent him technical insight into the development of AI from language processing to machine learning. However, despite its historical merit it fails to provide a detailed analysis of the trends driving the evolution of computer chess. Therefore, it overlooks the significance of the relationship between computer chess and AI.

Similar criticism could be levelled at Nils Nilson's *Quest for AI*, a history which is intended for three types of reader; the lay reader with scientific interest, those from technical or professional fields and AI researchers

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[2]Thomas S. Kuhn, *The Structure of Scientific Revolutions,* (University of Chicago press, Chicago, London, 1962)

[3] John M. Staudenmaier, *Recent Trends in the History of Technology,* The American Historical Review 1990, Vol, 95 No. 3 (Oxford University Press, June 1990) https://www.jstor.org/stable/pdf/2164278.pdf accessed 10/02/21

[4] Thomas Parke Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (The John Hopkins University Press, London and Baltimore, 1983)

[5] Pamela McCorduck, *Machines Who Think,* (CRC Press, Taylor and Francis Group 2018)

[6] Daniel Crevier, *The Tumultuous History of the Search for AI,* (Harper Collins, New York, 1993)

and students, or teachers.[7] Notably not aimed at historians of technology, although its documentation of where "AI has been, where it is now, and where it is going" is invaluable to any historical study of AI.[8] Nilson's analysis of AI's extraordinary achievement features discussion of how advances in AI were made through the use of games such as chequers and chess with treatment of the implications of systems such as Deep Blue, however this discussion is brief; something I aim to address in more detail.

Computer chess similarly has only been briefly touched on by historians of chess. The seminal work of the history of chess remains H.J.R Murray's of 1913 which for obvious reasons does not look at computer chess. It is a vast history of the game's development from its early origins, its cultural impact in the middle ages and subsequent development up to the 19th and 20th century.[9] Although he mentions computer chess, Richard Eales 1989 history of chess does not sufficiently explore the enormous impact of computers on the nature, practises and culture of chess nor does it seek to track its development.[10] David Shenk's is the first significant historical work concerning chess to consider computer chess' development, its implications for the game and its role as a "founding and enduring model for what became known as AI."[11] However, the selection of Kasparov's 2003 rematch against Deep Junior as a milestone in AI is odd, given its lack of significance compared to the 1997 match against Deep Blue. It also fails to include discussion of computer chess' contribution to AI. Two histories of note in this field are John Sharples *Cultural History of Chess Players* and Nathan Ensmenger's discussion of chess as AI's *Drosophila.* Both demonstrate the desire to subject technology, such as algorithms, to historical analysis; Sharples writes illuminatingly on the cultural impact of Deep Blue as a chess playing entity revealing the Man vs Machine narrative.[12] Ensmenger's fascinating work on the social history of the alpha-beta minimax algorithm, has also been insightful to my study of computer chess and AI development.[13] Ensmenger's work represents a contribution to a somewhat lacking field; namely the history of computer software and AI. Therefore, a more comprehensive study of the relationship between chess and AI, and its subsequent decline is necessary.

Computer chess remains an ongoing project to this day and is still involved with AI research. Although there have been frequent mentions of computer chess in histories of AI this has usually been attempted by

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[7] Nils j. Nilson "Extraordinary Achievements" in *The Quest for AI: A History of Ideas and achievements,* (Cambridge University Press, 2009) pg. 483 https://doi-org.bris.idm.oclc.org/10.1017/CBO9780511819346 accessed 17/03/21

[8] *Ibid*

[9] Harold James Ruthven Murray, *A History of Chess* (New York, Oxford University Press, 1913)

[10] Richard Eales, *Chess: the History of a Game, (Hardinge Simpole, 2002)*

[11] David Shenk *The Immortal Game: A History of Chess, or How 32 carved pieces on a board illuminated our understanding of War, Art, Science and the Human Brain*, (Souvenir Press, London, 2011) pg.144 https://ebookcentral.proquest.com/lib/bristol/reader.action?docID=710405&ppg=1 accessed 12/01/2021.

[12] John Sharples, "Future Shocks: IBM's Deep Blue and the Automaton Chess-Player 1997-1796" in *A Cultural history of chess players: Minds, Machines, Monsters (*Manchester University Press, 2017) https://www.jstor.org/stable/j.ctvn96hqj.8 accessed 14/02/21

[13] Nathan Ensmenger *Is Chess the Drosophila of AI? A Social History of an algorithm*, Social Studies of Science Vol. 42, No.1 https://www.jstor.org/stable/23210226 accessed 11/02/21

researchers involved in the field or social scientists. My aim is to explore the history of computer chess and its increasingly remote relationship to AI.

Methodology

In writing this history of computer chess and AI I have adhered to a contextualist approach to the history of technology.[14] This is a trend in technological histories where design characteristics and function are understood as products of a myriad of social and cultural factors. A result of the conscious desire to avoid the pitfalls of teleology and determinism in technological history, which is an all too often observed trait in histories of science in the West. Therefore, I aim to present the factors driving developments in computer chess and how these resulted in its diminishing relationship to AI in the 20th century. I'm opposed to presenting a narrative from Turing and Shannon's work to Deep Blue as the inexorable and steady advance of technology as "progress." This is not only inaccurate but would serve as a disservice to the value of chess and computer games as a proving ground for AI.

Pamela McCorduck's approach to the history of AI as one that can and should maintain a focus on the role of human ideas, motivations and actions is one that I felt leant well to the study of technological development in computer chess. Nathan Ensmenger's desire to see "the virtual black box" of computer programmes subjected to historical and sociological analysis influenced my methodological approach to sources.[15] Algorithms and software are often unseen; they are, in a sense, closed systems. However, this does not immunise them from societal and cultural factors particularly when you consider the people whose ideas, motivations and hard work go into their design and construction. Combining these approaches has been instrumental in my decision to engage with publications and personal reflections on computer chess and machine intelligence. These works published by prominent researchers and programmers reveal the motivations behind their work thus shedding light on the evolving nature of the discipline and the forces driving it.

I have also attempted to engage in cultural sources such as news articles particularly those surrounding Kasparov vs Deep Blue in 1996 to provide insight as to contemporary perceptions of the nature of Deep Blue and its contribution to AI. This paper demonstrates a dependence on the wealth of online publications regarding computer chess, such as the Turing Digital Archive and scientific journals which hold digitalised copies of computer chess' seminal works. This has been a considerable mitigating factor to the practical challenges presented to academic study by the COVID-19 pandemic. Notwithstanding, some elements of this subject do remain unexplored such as the role of government institutions and military funding through organisations such as DARPA (Defence Advanced Research Projects Agency). These topics of enquiry would require both accessible archives and international travel.

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[14] John M. Staudenmaier, *Recent Trends in the History of Technology,* The American Historical Review 1990, Vol, 95 No. 3 (Oxford University Press, June 1990) https://www.jstor.org/stable/pdf/2164278.pdf accessed 10/02/21

[15] Ensmenger, pg. 1

Section 1 : Great Expectations

"*The Study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it"*[16]

It was in this paper published in 1955 that the term AI was coined and the field was formalised with a mission statement; to simulate human intelligence and learning in a machine. Astoundingly it asserts that satisfactory solutions to the stated conjecture could be found if "a carefully selected group of scientists work on it together for a summer", an extremely ambitious prediction given the complexity of the problem at hand.[17]

This was not the first contribution to discussions over the nature of intelligence and a machine's potential to possess or simulate it. Complex discussions over the nature of consciousness and thought had been taking place in disciplines such as philosophy since Aristotle (384-322BC) developed theories of knowledge and rational thought including making a distinction between knowledge and action. Whilst this might seem a world away from AI, the assertion that intelligence implies not simply the ability to reason but also to act is a crucial concept.[18] Further contributions to the field came in the the 17th century with the inventions of calculation machines courtesy of Wilhelm Schikhard and Blaise Pascal. They demonstrated that reasoning, if purely mathematical could be carried out by means other than the human mind. Renes Descartes explored similar concepts in *Discourse on the Method of Rightly conducting the reason and seeking truth in the sciences* (1850) in which he discussed the possibility of a machine being able to imitate a man, in body and mind, well enough to make itself indistinguishable from the genuine article to an observer. He concluded that:

"*It must be morally impossible that there should exist in any machine a diversity of organs sufficient to enable it to act in all the occurrences of life, in the way in which our reason enables us to act"*[19]

The significance of this to AI and computer chess cannot be underestimated. In 1850 Descartes was discussing a quite similar concept to one breached by Alan Turing one hundred years later when he developed a curious experiment known as "The Turing Test."

Early contributions to the field of AI and computer chess, made by Alan Turing, Norbert Wiener, and Claude Shannon demonstrate a conscious desire to engage with complex debates over the nature of intelligence and thought. This constituted a visionary approach to the field and supports the ambition that producing machines which could perform tasks previously resigned only to the realm of human intelligence, such as chess, would

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[16] John McCarthy, Marvin Linsky, Nathaniel Rochester, Claude Shannon, *A proposal for the Dartmouth Summer Research project on AI,* 1955 http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html accessed 12/02/21

[17] *Ibid.*

[18] Stuart Russel, Peter Norvig, *AI: A Modern Approach, Global edition,* (Pearson Education Limited, Harlow 2016)

[19] Rene Descartes *Discourse on the method of rightly conducting the reason, and seeking truth in the sciences,* trans. John Veitch, Sutherland and Knox, 1850 https://www.google.co.uk/books/edition/Discourse_on_the_Method_of_Rightly_Condu/ZqKDkQYxF-cC?hl=en&gbpv=0 accessed 05/01/21

not only prove productive in the development of AI, but might redefine our understandings of what it means to think.

In 1950 Alan M. Turing, widely hailed as the father of modern computing, published a paper proposing a variation of a social experiment known as the 'imitation game.' His adaptation was specifically designed to address the question "can machines think?". However, he would later add the caveat that this question is "too meaningless to deserve discussion."[20] For Turing, whether machines could actually think was not a productive line of questioning and research; he was interested in the ways a machine could be programmed to "imitate a brain, or as we might say more briefly, if less accurately, to think."[21] The imitation game in its original form involved three persons, Person A (female), Person B (Male), and an interrogator. The interrogator would not see the other two participants, nor hear their voices but was able to pose questions designed to aid them determine which player was male or female. In Turing's proposed alteration he poses the question:

"*What will happen when a machine takes the part of A in this game? Will the interrogator decide wrongly as often as when the game is played like this as he does when the game is played between a man and a woman? These questions will replace our original 'Can Machines think?'*"[22]

In this he expresses similar sentiments to Descartes with the crucial distinction being this test is purely concerned with imitating man's intellectual capabilities rather than any attempts to imitate human form or physical movement. Turing even provided an example of an interrogation one might use in the test:

"Q: Please write me a sonnet on the subject of the Forth Bridge.
A: Count me out on this one. I could never write poetry.
Q: Add 34957 to 70764
A: (Pause of 30 seconds and then gives answer) 105621
Q: Do you play Chess
A: Yes.
Q: I have K (king) at my K1, and no other pieces. You have only K at K6 and Rook at R1. It is your move. What do you play?
A: (after a pause of a few seconds) R- R8 mate." [23]

This example is illuminating as chess appears alongside poetry as something which Turing clearly felt would demonstrate a form of intellect or creativity uniquely possessed by humans. This trope which would appear time and again in the history of AI and chess in the 20th century. Much of '*Computing Machinery and*

[20] Alan M. Turing *Computing Machinery and Intelligence* in Mind, Volume LIX, Issue 236, October 1950, pg 433 https://doi.org/10.1093/mind/LIX.236.433 accessed 04/01/21
[21] Alan M. Turing *Can Digital Computers Think* BBC Radio 15th May 1951 recorded in Turing Digital archive http://www.turingarchive.org/viewer/?id=459&title=5 accessed 08/01/21
[22] Turing, 434
[23] Turing, 434-435

Intelligence' deals with the refutations of his proposed theory that if one could programme a machine or computer to answer questions such as this satisfactorily then one could reasonably assert that a machine could think. Geoffrey Jefferson's 1949 Lister Oration is one such argument in which he maintains "Not until a machine can write a sonnet of compose a concerto because of thoughts and emotions felt, and not by the chance fall of symbols, could we agree that machine equals brain"[24] Jefferson's argument, which invokes ideas explored by Descartes, rests on the idea of consciousness and that machines lack emotional responses, opinions, and creativity and that this renders them inferior. Turing's stance is that according to this logic the only way in which you could be sure any machine, or indeed human, thinks is to be the entity itself and feel yourself thinking.[25] In relation to AI and chess, Jefferson's assertion regarding the superiority of human intellect resting on the ability to feel and be creative does not ring true. Kasparov's testimony of how "delight can give way to depression in an instant and reverse again a move later, leaving even the most sanguine player exhausted from adrenaline" will resonate with anyone who has had the good fortune to play a game of chess.[26] A computer on the other hand is invulnerable to such highs and lows, they are neither prone to overreaching in confidence nor becoming nervous when seeing the odds stack up against them. This is what made them such formidable opponents rather than a symptom of inferiority. Alan Turing's approach to AI research was focused on eventual goal of replicating human intelligence. An approach also expressed in the Dartmouth Summer research project's mission to "find how to make machines use language, form abstraction and concepts, solve kinds of problems now reserved for humans, and improve themselves."[27] However computer chess research and AI would increasingly distance itself from such ideas in the late 20th century, becoming more focused on methods which were effective in limited arenas rather than theoretically interesting.

In the earliest known recorded discussion of AI, Turing and Jefferson would engage in the debates surrounding AI directly in conversation alongside mathematician Max Newman and philosopher Richard Braithwaite on radio 4 in 1952.[28] Jefferson questions the Turing test and how well existing machines could perform in it by asking what computers were capable of at the time. Newman's response is that "mathematical computing" is their strongest area but crucially that "They would also do well at some questions that don't look numerical, but can easily be made so, like solving a chess problem."[29] This is revealing of the reasons Newman believed chess to be productive for machine intelligence as something that isn't strictly

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[24] *Professor Geoffrey Jefferson's Lister oration 1949 "The Mind of Mechanical Man"* delivered at the Royal College of Surgeons of England June 9th 1949 published by the British Medical Journal 1949 Vol. 1, No. 4616 1949 https://www.jstor.org/stable/25372573 accessed 07/01/21

[25] Turing, 446

[26] Garry Kasparov, *Deep Thinking: Where AI ends and human creativity begins,* (John Murray Publishers, London 2018) pg. 80

[27] McCarthy et al., *A Proposal for the Dartmouth Summer Research project on AI* 1955

[28] Brian Jack Copeland, *The Essential Turing: Seminal writings in Computing, Logic, Philosophy, AI, and Artificial life plus The Secrets of Enigma* (Oxford University Press inc., New York 2004) pp. 487

[29] Alan Turing, Max Newman, Geoffrey Jefferson, Richard Braithwaite. *Can automatic calculating machines be said to think?* BBC Third programme 14th and 23rd January, 1952, from Turing Digital Archive http://www.turingarchive.org/viewer/?id=460&title=7 accessed 14/01/21

mathematical but could be performed well by a computer. It is also fascinating as he briefly describes a method which could be used to accomplish it saying it could be done "by trying all possibilities, one after another" but conceded it was a "dull plodding method" but one that nonetheless would satisfy the parameters of the Turing test, for as long as correct answers are provided reasonably quickly the methods are of no consequence.[30] It seems likely, due to discussion of such a method, that Newman was aware of the work of another influential mathematician and electrical engineer Claude Shannon.

In 1950 Shannon published what was to become the fundamental paper on computer chess, its ideas would be the foundation for nearly all chess programmes of note throughout the 20th century.[31] Shannon declared that his work, which aimed to create a computing programme which would enable computers to play chess, was "perhaps of no practical importance, the question is of theoretical interest, and it is hoped that a satisfactory solution of this problem will act as a wedge in attacking other problems of a similar nature."[32]

The nature of these problems he mentions are extremely significant both in revealing how conceptions of chess influenced researchers' visions for its application and for its implications for AI research. The problems include language translation machines, machines with the capacity for logical deduction, and "machines for making strategic decisions in simplified military operations" and "machines capable of orchestrating a melody."[33] The reference to computer chess' application to machines capable of strategic thinking in the field of defence reveals the influence of the historical perception of chess as a game with inherent value in strategic training applied to warfare. Many of the fabled stories surrounding chess accounted for in its history feature warfare and strategy; for example, it is said that the Greek warrior Palamedes invented the game to demonstrate the battle positions and art of strategy after returning from the siege of Troy.[34] This indicates that Shannon identified chess' ability to embody human intelligence, similar to music, language translation, and logical thought.

Shannon went beyond making vague claims about the potential of computers to play chess, he provided two possible solutions for how this could be done. He drew on earlier works of Norbert Wiener who had discussed how a computer might play chess and whether chess playing ability constitutes the essential difference between the potential of the machine and the human mind.[35] He argued it was possible to "construct a machine that will play chess in the sense of following the rules of the game irrespective of the merit of

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[30] *Ibid.*
[31] Monroe (Monty) Newborn, *Computer Chess,* (Academic Press, New York, 1975) p. 8
[32] Claude E. Shannon *Programming a Computer for Playing Chess,* The London, Edinburgh and Dublin Philosophical magazine and journal of science, 1950 pg. 256 https://www.tandfonline.com/doi/pdf/10.1080/14786445008521796?needAccess=true accessed 20/01/2021
[33] Shannon, pg 256
[34] David Shenk *The Immortal Game: A History of Chess, or How 32 carved pieces on a board illuminated our understanding of War, Art, Science and the Human Brain*, (Souvenir Press, London, 2011) https://ebookcentral.proquest.com/lib/bristol/reader.action?docID=710405&ppg=1 accessed 12/01/2021 pg. 20
[35] Newborn, pg.7

play."[36] His method to support this hypothesis was one based on the minimax algorithm developed by John Von Neumann, applied in his collaboration with Oskar Morgenstern to the game of chess. They identified chess as a zero-sum game of perfect information with definite ends, win, loss, or draw. This meant it was amenable to the process of Minimaxing, where if one can know the value of a given position in the future, they can work backwards from an optimum outcome selecting the best move available in each instance.[37] They concluded that theirs was not a "practically usable" method of determining the best move.[38]

However, the minimax algorithm alongside an evaluation function, which scored positions according to criteria such as material, pawn structure, mobility, and king safety, was the first method Shannon argued would be capable of overcoming the theoretical difficulty of programming a computer to play chess. A method imaginatively termed Type A.[39] This theoretical difficulty was grounded in the sheer enormity of positional variations, as Shannon's "conservative" estimate from the initial position puts this number at 10^{120}.[40] To put this into perspective, it exceeds the number of atoms in the known universe.[41] The Type A programme which considered all possible variations to a given depth, known as Ply's, and then selected the best move was not Shannon's favoured method as he states "a machine operating according to this type A strategy would be both a slow and weak player."[42] Instead he proposed a second strategy, an amendment of the Type A exhaustive search approach for one in which certain lines of analysis, which were more promising, would be explored at greater depth in terms of moves at the expense of the depth of search for all variations. This strategy, known as Type B, is more akin to the process of elimination in which human practitioners engage when selecting a move. However, Shannon did not provide an exact example of how to accomplish this as he did with Type A. This was due to the complexities involved in developing a programme which could select these more advantageous search pathways according to the 'rules of thumb' or heuristic techniques, which are very situational rather than being a cure for all ills.[43]

The significance of the distinctions between Type A and Type B is how their differences reflect the debates about the ability of machines to possess intelligence and what the nature of it would be if they could, which arose in Turing and Jefferson's discourse. That Shannon believed that Type B would be a more productive method of computer chess programming is a product of the prevailing mentality of the time regarding AI that it should seek to replicate the function of the human brain. However, despite its visions and ambition,

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[36] Norbert Wiener, *Cybernetics or control and communication in the animal and the machine,* (MIT Press, Cambridge Massachusetts, 1948

[37] John Von Neumann, Oskar Morgenstern "Zero-Sum two person Games: Theory" in *Theory of Games and Economic Behaviour,* 1944 60th Anniversary edition (Princeton University Press, 2004)pg.125 https://doi-org.bris.idm.oclc.org/10.1515/9781400829460

[38] Von Neuman, Morgenstern, pg. 125

[39] Shannon, pg 264

[40] Shannon, pg 260

[41] Nathan Ensmenger *Is Chess the Drosophila of AI? A Social History of an algorithm*, Social Studies of Science Vol. 42, No.1 https://www.jstor.org/stable/23210226 accessed 11/02/21

[42] Shannon, pg 268

[43] Herbert Simon, Jonathan Schaeffer *"The Game of Chess"* ch.1 in *Handbook of Game Theory with Economic applications* Volume 1, 1992 https://doi.org/10.1016/S1574-0005(05)80004-9 accessed 26/01/21

Shannon's predictions based on the aforementioned assumption fall short in that the human intellect was not a victim to a Type B programme crafted in its image but to a refined, more efficient form of the minimax algorithm classed as Type A. A strategy he dismissed as being "weak in playing skill."[44] In this seminal paper on computer chess the ambitions of the study are explicit, dominated by the idea that the computer should emulate and replicate the function of the human brain. This idea was one which the development of computer chess would come to dismiss as increasingly Type A programmes coupled with advances in hardware and processing speed became not only viable but formidable. This is not to criticise Shannon's contribution, given the capability of computers during the 1950s, he developed two remarkable models for computer chess which would dominate the next 50 years of research. Shannon set the board for the development of computer chess but the pieces would move in a way he had not foreseen, and the victor would be an unexpected one.

[44] Shannon, 269

Section 2: Out of the Blue: A Brute Force Reality

"Don't make it think, just make it work"[45]

Turing was also applying the computational abilities of digital computers to the automation of chess. Many more programmes followed in the development of computer chess. An analysis of trends in this development will demonstrate how Turing's and particularly Shannon's ideas were gradually superseded by an approach which valued processing speed and depth of search over interring human based chess knowledge and complex heuristics into programmes. This process can be observed over distinct epochs of computer chess development in the 20th century. The first identified by Herbert Simon and Jonathan Schaeffer as the "pioneering era" pre-1975 where researchers, led by the principles set out by Shannon and Turing, developed programmes which showed a distinct tendency towards Type B knowledge-based searches and heuristics.[47] This was followed by a shift in focus from knowledge to depth of search from 1975 onwards, although not true for all programmes as some such as Carnegie Mellon's Hitech would maintain an emphasis on sound knowledge bases. By the late 1980s research institutions had identified a relationship between processing speed, search depth and performance and therefore Type A brute force programmes became the order of the day. Having reached a consensus, the next era from 1985 was characterised by continuing advancements in hardware and refinement of the algorithms incorporated in purpose-built chess computers. This section will be assessing the development of programmes from 1950-1990 to analyse the contribution of computer chess to the development of AI and intelligent systems. Furthermore, this assessment will demonstrate that the advances in processing speed dictated by Moore's Law alone do not account for the changing approaches to computer chess and AI. Chess, its community, culture, and nature as a competitive sport were crucial factors in both the developments in computer chess and its relationship to AI.

A number of notable contributions to computer chess occurred throughout the 1950s following Shannon's work and Turing's hand simulation; the first to put their ideas into practice in a programme, designed for the MANIAC I computer, was the Los Alamos Scientific group in 1957.[48] However this machine was limited to playing chess on a 6x6 board. This was swiftly followed by the Bernstein programme of 1958, the first to run a fully-fledged 8x8 chess game on a computer which employed a Type B strategy through "selective pruning" of the decision tree. However, both programmes drew heavily on Turing's and Shannon's ideas and whilst significant in testing their validity did not expand on the programming techniques which relied on the scoring and evaluation functions discussed by Shannon and demonstrated in Turing's hand simulation.

[45] Kasparov, pg. 95
[47] Simon and Schaeffer, pg. 9
[48] Newborn, pg.19

The work of Alan Newell, John Shaw and Herbert Simon 1955-1958 constitutes a significant development in computer chess. Their 1958 paper outlined their chief concern as being that when a chess player analyses a board "His analysis is qualitative and functional*"* therefore their question was "how can we construct machines that will show similar complexities in their behaviour."[49] Their conviction that a "successful chess programme will approach the complexity of the thought and processes of a human chess player" is characteristic of this period of computer chess research. It demonstrates the influence of the mentality displayed by Turing's conviction of machines being able to imitate the function of the human brain.[50] Furthermore, it also bears the same conviction in Shannon's belief that the best approach to computer chess would be to replicate where possible the way in which humans are able to analyse and play the game. They built on Shannon's ideas of looking ahead using a depth search commonly visualised as a tree which branches outwards from a starting position or *root* towards multiple terminal nodes, indicating potential positions with each *branch* representing a move. This representation of how a computer sees a chess game is important for the explanation of the developments to follow in computer chess. Instead of a fixed evaluation function they used a set of 'goals' which guided the search; these goals were also subject to the conditions of the board which could "be added to the programme or removed without affecting the feasibility of the remaining goals."[52] The reason for this was to provide 'flexibility' throughout the game and allow the machine to be more selective about which branches of the decision tree it explored.[53] This demonstrates their desire to implement heuristic techniques, an approach to problem solving which opts for practical and effective methods to solve problems for which there may only be an approximate or imperfect solution.

Their programme was also the first to boast the Alpha-Beta algorithm, which was an adaptation of the minimax algorithm. It made the minimax algorithm considerably more efficient by 'pruning' the decision tree therefore reducing the demands of conducting a search in depth. It operated by abandoning the search in the instance of a refutation move where the opponent can respond with a move with a higher positional score than a response to a move previously examined. This development was to prove revolutionary for ushering in the next epoch of chess programming. It demonstrated that computers do not need high levels of knowledge or understanding of the principles of the game to narrow down the decision tree and select a move. In their conclusion Newell et. al. stated:

"*There is clearly evident in this succession of efforts a steady development toward the use of more and more complex programmes and more and more selective heuristics; and towards the use of principles of play similar to those used by human players.*"[55]

[49] Alan Newell, John Shaw, Herbert Simon, *Chess playing programmes and the problem of complexity,* IBM Journal of Research and Development Vol. 2, Issue 4 (IBM, October 1958) pg. 320 Chess-Playing Programs and the Problem of Complexity | IBM Journals & Magazine | IEEE Xplore accessed 23/02/2021
[50] Newell *et al.* pg. 321
[52] Newell *et al.* pg 327
[53] *Ibid.*
[55] Newell et. Al. pg.

Ironic given the Alpha-Beta pruning method they pioneered would not only make Type A brute approaches more viable but enable them to play a better game of chess and would pave the way for the second age of computer chess; a turn towards brute force programmes backed up by rapidly developing hardware, which according to Moore's law should double in processing power every two years at half the cost.

This was not an instantly accepted consensus, the strengths of minimax supplemented by the Alpha-Beta algorithm would take a while to be properly recognised. By the late 1960s many programmers were still pursuing Type B programmes, with considerable success. Previously the programmes discussed, although of scientific value, were poor chess players. It was in 1967 that they became "meaningful opponents to players" in the form of the MacHack designed by Richard Greenblatt at MIT.[56] Greenblatt, who was a proficient chess player himself maintained the belief in chess knowledge alongside programming efficiency being the optimal route for success. Therefore, the MacHack was programmed with 50 heuristics 'rules of thumb' which included quite in-depth knowledge of chess strategy as well as an openings guide designed to aid decision making. This was combined with the Alpha-Beta algorithm however, it was still a Shannon Type B programme. Its achievements are as important as its design. It was the first chess programme to compete against humans in tournament play where it was awarded a rating of about 1,400 by the U.S. Chess Federation in spring of 1967.[57] Although this rating is about the level of a decent high school chess player, it not only marks a considerable improvement on earlier programmes but is an insight into how chess culture, namely ratings, competitive matches and tournament play became a crucial driving factor in computer chess research.

By the 1960s a rating system for ranking the relative strength of chess players had been universally adopted – the Elo system. Ensmenger declared that it was the ability of computer chess to demonstrate continual and significant progress which gave it "paradigmatic status as the experimental technology of AI."[58] Ensmenger's comments are prescient, however he misses the opportunity to emphasise that the Elo system encouraged programmers to focus more on performance outcomes over scientific method. This detracted from the original scientific objectives to use computer chess in the development of AI.

Tournament play is a key aspect of chess culture. In 1970 Tony Marsland suggested that the Association for Computing Machinery's Annual Convention should include a demonstration of his chess machine. Monroe Newborn recalls that this served as an inspiration for a nationwide tournament which:

"*would stimulate interest in the field of AI by providing a focal point for individuals to meet and discuss their ideas.*"[59]

In this he expresses the sentiment that computer chess tournaments were to serve the same cultural purpose as human chess tournaments; a place where information could be shared amongst enthusiasts as well as a method

[56] Daniel Crevier, *The Tumultuous History of the Search for AI,* (Harper Collins, New York, 1993) pg. 223
[57] Newborn, pg.43
[58] Ensmenger, pg. 19
[59] Newborn, pg. 49

of settling scores between rivals and determining the superior methods of playing the game. Computer chess programmers did not shy away from the competitive elements inherent in chess, their reputations and those of the institutions they worked for were at stake. It is no coincidence that the early 1970s would not only see the advent of competitive computer chess but also the increasing adoption of brute force approaches to programming. Crevier states that these Type B programmes had a "critical weakness" namely that the chess knowledge and heuristics embedded in the programmes which enabled competent moves also produced flagrant blunders in the face of subtle or obvious ideas which contravened the general principles of chess.[60] Had tournament play and the enticement of higher Elo ratings not held sway over the research community this would have been seen less as a "critical weakness" and more as an interesting problem to be solved through further research and refinement.

By the 1973 United States Chess championship, programmes such as Chess 3.0, modelled on the earlier MacHack but rewritten using a Shannon Type-A approach and renamed Chess 4.0, was able to claim the title with 3 wins and a draw.[61] Simon and Schaeffer define 1975 as the year in which the second era of computer chess and AI began. Type B programmes fell into decline but the spirit of earlier researchers such as Newell, Simon and Shaw lived on in the debates over whether programmes required knowledge of chess strategy or simply a deep enough search.[62]

To ascribe the term 'brute force' to Type A programmes from the 1970s onwards is misleading because they were neither simple nor did they lack finesse; they used pruning and sophisticated selection techniques for making moves. It refers more to the fact that they relied increasingly on calculation in their selection over chess knowledge-based evaluation functions. Nonetheless the post 1975 era saw the dominance of the 'brute-force algorithm' accompanied by steadily rising Elo ratings. Chess 4.7, which could analyse 3,600 positions a second, became the first to be awarded the title of 'expert' having reached the rank of 2000.[63] However, it was soon superseded by Ken Thompson's Belle, a Type A algorithm run on purpose-built hardware rather than using available computers. This machine dominated computer chess in the late 1970s embodying the ascendency of brute force. It won the ACM North American Computer Chess championship five times between 1978 and 1986.[64] It became accepted that an "engineering approach emphasizing hardware speed might be more fruitful" and its approach was replicated in Feng-Hsiung Hsu's ChipTest (1986-87), which evolved into Deep Thought and ultimately into Deep Blue.[65] Again faith in speed and depth paid off in

[60] Crevier, pg. 227
[61] Newborn, pg 141
[62] Simon and Schaeffer, pg 9
[63] Crevier, pg. 230
[64] *Belle,* Chess programming Wiki https://www.chessprogramming.org/Belle#References accessed 25/02/21
[65] Feng-Hsiung Hsu, *IBM's Deep Blue Chess Grandmaster Chips,* 1999 pg.70 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.126.5392&rep=rep1&type=pdf accessed 21/02/21

noticeable results as Belle made a significant jump in ratings earning the title of Master at a U.S Chess federation ranking of 2,200, able to analyse 150,000 positions a second.[66]

Improvements such as this did not go unnoticed amongst researchers. This had unfortunate implications for computer chess. By demonstrating how performance could be enhanced effectively through improvements to hardware and processing speed, it ensured that computers would indeed get better at chess but do so in a way which distanced the discipline from AI. By the mid 1980s Cray Blitz and Hitech had replaced Belle as the dominant programs, however they were both bespoke chess machines using chips modelled on those Belle had pioneered; a consensus had been reached on how to optimise performance.[67] A 1989 article published by the Deep Thought team highlights the prevalence of this trend:

> "*The Ascent of brute-force chess machines back in the late1970s made one thing crystal clear; there is a strong causal relationship between the search speed of a chess machine and its playing strength.*"[68]

This identification of the virtues of the brute force method from the late 1970s onwards provides insight into what drove the research community to adopt this method *en masse* despite Type B showing both promise and improvement. It also demonstrates how success for programmers became intrinsically linked to increasing Elo ratings and tournament performance. The Deep Thought team went as far as to say the presence of this relationship was "the reason the project was started in the first place."[69] This approach, influenced heavily by the competitive element inherent in chess, has given rise to criticisms such as Danny Kopec's observation that "computer chess has appeared to advance primarily as a competitive sport (performance driven) rather than as a science (problem driven)."[70] This is corroborated by the identification of "weaknesses" in Type B programmes such as the MacHack leading to their abandonment rather than further experimentation. We were never able to see the potential of such machines with the improved hardware of the 1980s. This attitude relegated computer chess to having a tenuous connection to AI, a tragedy given its promise as an experimental technology.

The words of Alan Perlis "optimization hinders evolution" ring true in relation to computer chess and AI. The desire to see chess programmes climb the Elo rating board and compete in tournaments outstripped the importance of the scientific questions originally posed by computer chess in the 1950s and 1960s.[71] The primary aim was no longer to find an interesting way of programming a machine to play chess, and in doing so uncover answers to the nature of machine intelligence and human cognition in relation to chess, but to

[66] Crevier, pg.231
[67] Feng-Hsiung Hsu, 1999, pg. 70
[68] Feng- Hsuing Hsu, Thomas Anantharam, Murray Campbell, Andreas Nowatzyk "Deep Thought" in *Computers Chess and Cognition,* T.A Marsland, J. Schaeffer (Springer Verlag, New York, 1990) pg. 59
[69] *Ibid.*
[70] Danny Kopec, "Advances in Machine Play" in *Computers, Chess and Cognition,* T.A Marsland, J. Schaeffer (Springer Verlag, New York, 1990)
[71] Alan Perlis, *Special Feature: Epigrams on Programming,* (ACM SIGPLAN notices, September 1982) https://doi.org/10.1145/947955.1083808 accessed 13/02/21

exploit the existing strengths of computers to win games and tournaments. The most significant advance in computer chess in the alpha-beta algorithm had occurred in the 1950s, it was a solution that proved almost too effective. It was simple, easily programmable and improved in line with hardware improvements. By the 1990s this method had been established and computer chess could now turn its attention to improving processing speed to achieve higher ratings and even defeating the world champion. It was now no longer a question of if, but when computers would be able to "see farther than Kasparov can feel."[72]

[72] Charles Krauthammer, *Kasparov: Deep Blue Funk, Kasparov Wrestles a machine. Civilisation hangs in the balance,* TIME (February 1996) http://content.time.com/time/subscriber/article/0,33009,984175-2,00.html accessed 25/02/21

Section 3: Drosophila

"To the amazement of all, not least Kasparov, in this game drained of tactics, Deep Blue won. Brilliantly. Creatively. Humanly. It played with – forgive me- nuance and subtlety."[73]

By the 1990s computer chess through brute force calculation had achieved its aims of reaching expert human level play, programmes would continue to grow in strength as hardware improved. The result was that competition between 'the Machine' and the finest chess players mankind had to offer was fiercer and more popular than ever. By 1997 computers could add Kasparov to the list of human players to fall prey to their considerable ability on the chess board. This remarkable achievement was a significant moment in the development of computer chess. Invariably when such a milestone is reached the inevitable and important question of 'so what?' arises. What is the significance of the achievements of computer chess, and how they were accomplished? This was a source of contention amongst contemporary commentators and programmers and remains so in the history of AI. This debate serves as a reflection on the field of AI and computer chess' contribution to it in the latter half of the 20th century. Furthermore, the answers to these questions demonstrate how experimental platforms shape the nature of the research for which they are chosen.

A common trope in appraisals and histories of computer chess is to refer to it as the *Drosophila* of AI. This phrase coined by Alexander Kronrod in 1965 was quickly adopted by the research community as the justification of their work.[74] The meaning of the phrase is that chess like the fruit fly *Drosophila*, was a convenient and relatively simple experimental platform which could be used to explore more complex problems. Being both simple enough to be amenable to mathematic formulation but not so simple as to render it theoretically uninteresting.[75] However it also has a broader historical significance in that the adoption of *Drosophila* as the experimental organism of choice for 20th century genetics had significant implications for its research agenda and outcomes.[76] Chess on the other hand held much promise as AI's *Drosophila*, however its influence on the research agenda of computer chess led to a less fruitful contribution to the advancement of AI. The culmination of this research was manifested in Deep Blue, the computer which dethroned humanity as the greatest chess playing entity on earth. I seek to assess the nature of Deep Blue and its relationship to AI. This appraisal will serve as a lens through which to analyse the historical significance of computer chess on the development of AI up to 1997.

[73] Charles Krauthammer, *"Be Afraid" The meaning of Deep Blue's victory,* The Weekly Standard, May 26 1997 https://www.washingtonexaminer.com/weekly-standard/be-afraid-9802 accessed 01/03/21
[74] John McCarthy, *AI as Sport,* review of "Kasparov vs Deep Blue. Computer Chess Comes of Age" Monty Newborn, in *Science,* June 6th 1997 http://jmc.stanford.edu/articles/newborn/newborn.pdf accessed 24/02/21
[75] Newell et. Al.
[76] Ensmenger, pg. 7

In 1996 Deep Blue beat Kasparov in the first game of their match and the manner in which it accomplished this was astounding. Kasparov would later comment he sensed a new kind of intelligence across the board that day. The computer had offered a pawn sacrifice; something Kasparov as well as the chess community at large would consider an "extremely human move."[77] A chess computer is primarily focused on material (piece) advantage leading to their "notoriously materialistic" nature, Deep Blue not only offered up a sacrifice but "played beautiful, flawless chess the rest of the way and won easily."[78] This was not how computers were supposed to behave. It was however a glimpse of what was to come. This new kind of intelligence could perform a search to a depth of ten to fifteen moves. It had not offered up a sacrifice at all as it had already calculated how the material would be won back. Charles Krauthammer in his commentary of the game attributed Deep Blue with having accomplished "alchemy; turning quantity into quality" which although is somewhat sensationalised has a certain truth in it.[79] Using raw calculation alone Deep Blue had produced the sort of creativity and ability on the chess board which takes even the most talented human mind decades to achieve. Kasparov held out for humanity in 1996 but a year later he was facing the improved hardware version nicknamed 'Deeper Blue' able to analyse 200,000,000 positions per second.[80] In 1997 in "swift and brutal fashion" Kasparov and humanity were beaten at our own game by a machine we had created. That Deep Blue was artificial was beyond question but was it intelligent?[81]

Deep Blue's remarkable calculation ability allowed it to conduct a search to a depth of between 16 ply to 40 ply in some circumstances meaning it could up to 20 moves ahead.[82] In contrast Adrian de Groot's study of cognition in chess masters demonstrated the average master will intuitively consider no more than an average of 1.76 moves in each position to rule out the vast majority of moves as undesirable.[83] It is clear that computer chess had not in Deep Blue achieved even a near resemblance of the way the human brain operates when playing chess as researchers in the 1950s and 60s might have hoped. As a result, its contribution to the field of AI is unclear and has been questioned by programmers and associated literature. When asked whether Deep Blue used AI IBM's comment was that:

"*The short answer is no. Earlier computer designs that tried to mimic human thinking weren't very good at it. No formula exists for intuition… Deep Blue relies on more computational power and a simpler search and evaluation function.*"[84]

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[77] Garry Kasparov, *The Day I sensed a New Kind of Intelligence,* TIME 25th March 1996 http://content.time.com/time/subscriber/article/0,33009,984305,00.html accessed 16/03/
[78] *Ibid.*
[79] Krauthammer, 26th February 1996, http://content.time.com/time/subscriber/article/0,33009,984175-2,00.html
[80] Nilson, pg. 483 https://doi-org.bris.idm.oclc.org/10.1017/CBO9780511819346 accessed 17/03/21
[81] Bruce Weber *Swift and Slashing, Computer topples Kasparov,* New York Times, May 12th 1997, Section A, Page 1 https://www.nytimes.com/1997/05/12/nyregion/swift-and-slashing-computer-topples-kasparov.html accessed 21/03/21
[82] Nilson, pg. 483
[83] Crevier, pg. 234
[84] Nilson, pg. 483

This statement reads more as a justification of their approach to computer chess than it does a genuine discussion of whether Deep Blue is in fact intelligent. Furthermore, the original point of computer chess and AI research was to learn about cognitive processes not purely to create a machine that excelled at chess. Nils Nilson argues that this portrays a somewhat limited definition of AI. Deep Blue, whilst predominately utilising computational power, its use of heuristic searches, limited knowledge bases and the alpha-beta minimax algorithm demonstrates the use of some of "AI's foundational techniques."[85] It is unfair to dismiss Deep Blue as unintelligent. Referring back to Alan Turing's writings on the imitation game, the test involves no interrogation of the methods used to produce responses merely an examination of their quality.[86] In this sense, Deep Blue passed the Turing test albeit in the limited setting of a chess board. Grandmaster observers at the time admitted "had they not known who was playing they would have imagined that Kasparov was playing one of the great human players, maybe even himself."[87] There is no easy answer to the question, was Deep Blue or any computer intelligent, as it depends on your definition of intelligence. If, as Edward Fredkin stated, intelligence is "having a problem and solving it" you would be forced to concede that Deep Blue is in fact intelligent.[88] No, Deep Blue did not possess the sort of intelligence the human brain does, nor did it use similar means to accomplish the same ends but it does possess a form of intelligence. Humanity did not achieve mechanised flight by building planes which flap their wings, perhaps it is unrealistic to assume our efforts to create AI would have been any different.

Deep Blue's contribution to AI caused division amongst the research community and has served as a subject of inquiry in the history of AI. Newborn, who was instrumental in the development of computer chess defended Blue's achievements despite its methods being "quite different from than that imagined by prominent scientists of the 1950s and 1960s" stating that this was the result of advances made in computing in that time which had bypassed the theoretical complexity of a brute force approach Shannon had identified.[89] This does not explain the abandonment of theoretically valuable research avenues such as Type B programmes or more thorough knowledge bases such as Hitechs' 'oracle software.'[90] Donskoy and Schaeffer provide an accurate appraisal of Deep Blue's contribution to AI which also happens to highlight the shortcomings of chess as an experimental platform; as AI's *Drosophila.* In it they argue the methods employed to accomplish the impressive accolade of beating the world champion had "relegated the problem of

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[85] Nilson, pg. 484
[86] Turing, pg.435
[87] Krauthammer, May 26th 1997 https://www.washingtonexaminer.com/weekly-standard/be-afraid-9802 accessed 01/03/21
[88] Arthur L. Robinson, *Computer Chess: Belle Sweeps the board,* Science 17th October 1980, Vol. 210, Issue 4467 pg. 294 https://science.sciencemag.org/content/210/4467/293/tab-pdf
[89] Monty Newborn, *Deep Blue's contribution to AI*, Annals of Mathematics and Artificial intelligence 28, 2000 27-30 https://link-springer-com.bris.idm.oclc.org/content/pdf/10.1023/A%3A1018939819265.pdf accessed 14/02/21
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[90] Hans Berliner, Carl Ebeling, *Pattern Knowledge and search: the SUPREM architecture,* Artificial Intelligence Vol.38 Issue. 2, March 1989 pg161-198 https://doi.org/10.1016/0004-3702(89)90056-8 accessed 04/02/21

building chess programmes to only a peripheral relationship with AI." [91] They accurately describe a fall from grace, from early ambitions to computer chess being hailed as the *Drosophila* of AI to an eventual focus on Type A programmes which proved so effective that faster hardware became a viable solution. Combined with the competitive focus of the research community this led to the abandonment of other research avenues. *Drosophila* resulted in a focus on transmission genetics in biology research, but it yielded significant insights into the subject resulting in its elevated status as an experimental organism.

However, with regard to chess there has been criticism such as that put forward by Ensmenger that computer chess yielded little by way of theoretical insights for AI.[92] Computer chess had produced limited insights in the form of alpha-beta pruning and provided researchers with the ability to explore parallel processing, which has been applied to financial modelling, data mining and risk analysis.[93] Criticism of computer chess recognises the squandered potential of it as a *Drosophila* as its considerable accomplishments were achieved using "minimal chess knowledge."[94] When humans assess chess positions they do it mostly through abstract rules and intuition based on large amounts of knowledge; these are fundamentally difficult to translate into quantifiable rules for a programme to follow. Computer chess missed the opportunity to explore how this might be done, and in doing so solve a "fundamental problem of AI".[95]

In this the tragedy of chess as a *Drosophila* is laid bare. It could have produced many more theoretical insights if not for powerful and effective solutions being found early on and a performance driven research community. Deep Blue constitutes an expert system, which is a computer designed to simulate the decision making of a human expert faced with complex problems. The scope of its intelligence is limited and it lacks the ability to learn autonomously from external data. For this reason, expert systems are not considered today to be true AI.[96] Deep Blue is intelligent on the chess board but is effectively useless in all other capacities. This is due to the narrow nature of results driven computer chess and AI research in the period. In recent years, the flaws of computer chess research have been put in stark perspective by the successes of Deep Mind's 2017 project Alpha Zero, which employs machine learning through artificial neural networks, techniques considered the basis of AI applications today.[97] Aristotle's words in Nichomachean Ethics "We deliberate not about ends but about means" appear flawed in the context of computer chess as the inverse can

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[91] Mikhail Donskoy, Jonathan Schaeffer, *Perspectives on falling from grace*, ICGA Journal vol.12, no.3, 1989 https://webdocs.cs.ualberta.ca/~jonathan/publications/ai_publications/grace.pdf accessed 21/01/21
[92] Ensmenger, pg.
[93] IBM Icons of progress "Deep Blue" https://www.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/
[94] Donskoy and Schaeffer, pg. 3
[95] *Ibid.*
[96] Andreas Kaplan and Michael Haenlein, *Siri Siri in my hand: Who's the fairest in the land? On the interpretations, illustrations and implications of Artificial intelligence,* Business Horizons Vol.62 Issue 1, 2019 https://doi.org/10.1016/j.bushor.2018.08.004 accessed 23/03/21
[97] Michael Haenlein, Andreas Kaplan, *A Brief History of AI: On the Past, Present and Future of AI,* California management review 2019, vol. 61 5-14 https://doi.org/10.1177/0008125619864925 accessed 16/03/21

clearly be observed.[98] Deep Blue was the result of deliberation about ends over means, as a result computers got better at chess but AI lost its *Drosophila*.

Conclusion:

John McCarthy, one of AI and computer chess' founding fathers stated computer chess had developed much as genetics would have if:

> *"geneticists concentrated their efforts starting in 1910 on breeding racing* Drosophila*. We would have some science, but mainly we would have very fast fruit flies*."[99]

Whilst an amusing image, it addresses how research purposes and experimental platforms influence outcomes. This study has demonstrated that chess was chosen for research based on perceptions both cultural and practical; the wide range of literature, traditions of competitive play to determine performance, explicit measures of ability and an amenability to calculation. These factors that contributed to a significant shift in research aims of computer chess and consequently its outcomes. It bred an obsession with increasing efficacy through exploiting brute force calculation. The result was the production of systems that were undoubtedly better at chess but increasingly limited in their wider applications and theoretical insights to AI.

However, it demonstrates how much AI could still benefit from chess and other games as an experimental platform with a different approach. Projects such as AlphaZero highlight the potential of chess as a possible *Drosophila* of AI, a title it fell short of in the late 20th century but might yet live up to. The revival of the more cognitive approach favoured by Turing and early luminaries, with the benefit of more advanced technology, to chess is now starting to reveal more about the potential of AI. Research in the field has come full circle. Ideas explored in the 1950s by Turing and others such as machines functioning like brains, dismissed in subsequent research as unrealistic, are now being explored through things such as artificial neural networks. Therefore, the history of AI must be increasingly studied, its importance to the function of our society will only increase as we require AI to perform more complex and significant roles within society, business, governance, and defence. The study of the development of research, and the opportunities missed reveal areas for further scientific and historical enquiry and discovery.

Whilst computer chess' development in the late 20th century rendered it increasingly separate from AI the history of AI cannot exist without discussion of chess-playing automatons. Deep Blue may not have been true

[98] Aristotle, *The Nichomachaen Ethics,* Book III, trans. J.A.K Thompson (Penguin Classics, London, 2004)
[99] John McCarthy, pg. 1

AI. However, the 50-year story of its development remains a worthy chapter in the history of AI and serves as a warning of the pitfalls of performance driven, competition orientated research to scientific endeavour.

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