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Artificial Intelligence: A Comprehensive and Systematic Literature Review of Applications and Comparative Technologies

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Abstract**—**Over the years, the question around Artificial Intelligence has always been one with many answers. Whether by means of use in business and industry or complicated algorithmic programming, management of these technologies has always been the core focus. More recently, technologies have been questioned in industry and society alike as to whether they have improved human-centred design, assisted choices and objectives, and had a hand in systematic processes across the board. With these questions the answer may lie within AI technologies, and the steps needed in removing common human error. Elements such as Machine Learning, Deep Learning, Recommender Systems and Natural Language Processing will all be features to consider moving forward. Our previous intervention with AI applications has resulted in increased productivity, however, raised concerns for the continuation of traditional human-centred occupations. Emerging technologies such as Augmented Reality and Virtual Reality have all played a part in this during AI's prominent rise. As mentioned, AI has been constantly under the microscope; the benefits and drawbacks may seem endless is wide, but AI is something we must take notice of and adapt into our everyday lives. The aim of this paper is to give an overview of the technologies surrounding A.I. and its' related technologies. A comprehensive review has been written as a timeline of the developing events and key points in the history of Artificial Intelligence. This research is gathered entirely from secondary research, academic statements of knowledge and gathered to produce an understanding of the timeline of AI.

Keywords**—**Artificial Intelligence, Deep Learning, Augmented Reality, Reinforcement Learning, Machine Learning, Supervised Learning.

I. Introduction

A comprehensive and thorough review of literature surrounding the whole idea of 'Artificial Intelligence' would be nearly impossible at this stage in its hypothetical life cycle. Terms such as 'reinforcement learning', 'machine learning' and 'natural language processing' to name a few are still today being debated and analysed to determine their true meanings and applications. Nonetheless, to understand the term of artificial intelligence in general, we must first define what the term means. One of our most recent understandings of AI is referred to as "programs, algorithms, systems and machines that demonstrate intelligence" [1], more specifically "manifested by machines that exhibit aspects of human intelligence" [2]. By doing this, different aspects of AI can then be implemented to mimic intelligence human behaviour [3] and, to our current knowledge and research, consists of major components and key technologies in which it relies on. As mentioned, components include machine learning, natural language processing, rule-based expert systems, neural networks, deep learning, physical robots, and robotic process automation [4].

Academics, philosophers, and writers alike have identified and rightly suggested that there are multitudes of works and literature around AI. One fundamental goal is simply to identify and provide an insight into Artificial Intelligence, with a meticulous emphasis on its' development, particularly from 1940 to the present day. Prior to the 1940s, the search and predominant need for a definitive understanding of AI was simply an aspiration, however the notion of a surge and desire for general advancement had always been present. Countless ideas and visions of Artificial Intelligence have risen through the years; AI was either spoken of as the solution for all problems or the superintelligence that will destroy millions of livelihoods, replace medical experts and most forms of manual labour, and end our human dominance in the world as we know it. Elon Musk, a leading magnate, designer, and engineer even declared in 2018 that AI is "dangerous", and that the development of AI would be the greatest existential risk to humanity [5]. In turn, many supported the idea of the risk of something seriously damaging to the exponential unknown within a five-to-ten-year timeframe [6]. It was even stated that AI may not have delivered on its intended capabilities, due to the challenges it introduces related to data privacy, algorithmic biases, and ethics [7].

Numerous sectors have had their ways of labelling AI according to their personal use of the technologies. Several researchers have exclusively stated that AI does not automatically depend on its underlying technology, but rather its' marketing and business application, including automating business processes, gaining insights from masses of data, or the engagement of customers and employees [8]. Many discussions have taken place, particularly the one question that has surrounded us for decades; will AI replace human intelligence and capabilities? The answer can be varied according to who is using the AI, what they are using it for and why, and the long-term objectives of using such technologies. Ultimately, the proposition given out stated by Ginni Rometty, former CEO of IBM was to not lead to a world of man "versus" machine, but

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rather a world of man "plus" machines [9].

It is more important than ever to build a positive relationship with AI, especially if it is the case that it will have a hand in ultimately saving human life. Man has seen drastic development and immense capabilities when it comes to technology and development, robotics, and computer intelligence. The overriding dispute is whether we have the ability and knowledge to employ this effectively for years to come. There are avenues for interpreting the relationships involved, and whether we can ultimately improve our capabilities via machine learning and deep learning once we have grasped and engaged with it. In this case, we can apply these methodologies in areas such as sport, healthcare, and psychology among others.

The following literature will deal with these classifications of AI, highlighting on purely systematic theories, with supportive concepts and clear principal characterisations of the key terminologies around the theme. Ultimately, a clear understanding around the indicated subject will be provided, along with several ways preceding researchers and academics have tried to adapt their assumptions and finding the issues faced by them concerning AI and its' continuous evolution. The foundations of AI must be understood, and expressions and depictions must be understood in detail as technologies advance within society, as well as industry.

It may help us to bridge the gap in our knowledge with how AI can truly aid mankind on both a personal and psychological level if we develop our knowledge. The hardest challenge and decision we will face however is where we stand on AI and whether we should embrace it. The arguments that point to 'Yes' indicate that it is in fact a useful technology; it can provide helpful solutions, from medical healthcare to security systems and maintenance [10]. Contrarily, there are arguments that point to 'No'. AI can manipulate our human choices [11], increase pressure on corporate privacy [12], and even be used for organised cyberconflicts, particularly identity theft [13]. What AI cannot answer for definite is our ethical standpoint on the matter; it is a decision for society to make for the betterment of business, industry, and our well-being. At length, we must consider whether the solutions provided by AI will replace, diversify, or complement and magnify the solutions we had previously. For example, automobiles and electric rechargeable cars have presented to be a positive and effective substitute for traditional horse-drawn carriages. Diversification has presented the development of bicycles with motorbikes. Expansion and enhancement of an everyday device in the form of a simple wristwatch has transitioned from the analogue variant to a digital smartwatch, ever so present in todays' society and technological boom.

However, while reluctance to this change may present an issue, the actual matter of essential skills, databases, infrastructure, and detailed corporate models will still need to be examined to make this notion a reality. Still, many people are hesitant to wear glasses to aid sight purely on aesthetic reasons alone, yet AI may present the feasible solutions to overcome the visual ones. Inevitably as mentioned, opinions will be mixed. Those that delve in prophecies and futurologists may find these questions pointless, however generalisation in this regard could prove detrimental for the greater cause. The case presents the need for philosophy and a broader perspective rather than futurology; the stage is set for to pave the way and think extensively on what we are doing with AI.

II. Pre 1940

Limited research and archetypal assumptions have been made about the idea of artificial intelligence prior to the 1940s. While most of the research and developmental analysis originated after this time, it is difficult to assume we had any solid understanding and basis for AI as we know it today. Nonetheless, the early origins may help towards our understanding of the end goal of achieving total control of AI. Early texts as far back as Aristotle between 384-322 B.C. may have indicated the knowledge that mankind possessed to come. Aristotle initially explained varieties of deductive reasoning called syllogisms and developed the early stages of priori forms named "potential states" or "potentialities" [14]. These early ideas developed into ideas of logic and reasoning, later becoming concepts of perception and cognition [14]. However, the notion of robotics and advanced machine learning were merely make-believe ideologies. Even efforts on automation alone were unrealistic to contemplate at the time.

It was only when prominent mathematician Martin Gardner, considered attributing Gottfried Leibniz (1646-1716) to accomplish the dream of "a universal algebra by which all knowledge, including moral and metaphysical truths, can someday be brought within a single deductive system" [15]. Whilst Leibniz christened his system a '*calculus philosophicus*' or '*ratiocinator*', it was still purely a notion, and progress was only made when propositional logic was devised by George Boole in 1854 [16]. In the closing years of the nineteenth century, Gottlieb Frege established the first system for mechanical reasoning, never seen before on record. Much of the grounds for calculus used now in educational establishments and industry originated from these initial advances. Frege termed the language developed from this '*Begriffsschrift*' in Latin, translated as "concept writing" [17].

As technology was limited at the time, and investigations into emerging technologies were not regarded as an issue to face head-on, it was not until the early 1940s where artificial intelligence would take off as a dominating stimulus. For future problem-solving, design applications, testing and expansion into elements such as machine learning, deep learning and reinforcement learning would now be matters to consider.

III. 1940s – 1960s

A. The Turing Test

A major steppingstone into AI and arguably the most pivotal time for AI technologies was the introduction of the Turing Test, made famous by Alan Turing in the 1950s. The idea that computers would eventually someday begin to think like human beings was one that began over seventy years ago, just towards the brink of the second World War. Scientists alike from multiple disciplines and backgrounds initiated the notion of combining fields such as neuroscience and computing alike. Most notably, mathematician Alan Turing and a neuroscientist Grey Walter combined dynamisms to tackle the challenge of 'intelligent machines' [18].

The Turing Test was devised, a process where a machine is tested and challenges an interrogator that it is human [18]. Many variants of this test were to be further undertaken over the years, notably Joseph Weizenbaum's ELIZA program, in which short actions appeared to the user in order to carry out realistic human dialog [19]. Furthermore, Mauldin's JULIA program would then be designed for a modern approach in 1994, fashioning more high-level and sophisticated dialog and communication methods [20]. It can be argued that Mauldin's eventual program is more relevant to today's standards, as it brought in and evolved the existing ideas and advances from previous developers. Essentially, the Turing Test was clear; if a computer can fool the human user or interrogator into believing it was human, it passed the Turing Test. There is currently however a multitude of robust literature available concerning the Turing Test and arguments testifying the abandonment of achieving human-level intelligence via AI. Neuronlike computational elements have been examined by ethologists, who in turn have also delved into these disputes and compared numerous computational models of animal behaviours. Further notable works include [21] and [22].

While the Turing Test is reflected to be at the forefront of the birth of AI in the early 1950s, the main prediction concerning its' capabilities was to answer a question: 'Can machines think?'. Turing predicted that by the start of the 21st century, high-tech methodologies would produce computing machines with a capacity of 10^9 bits, programs able to fool an average questioner for five minutes roughly 70% of the time [18]. Turing's famous article written in 1950 entitled '*Computer Machinery and Intelligence*' highlighted the question of machine intelligence for the very first time. Described as a 'game of imitation' [18], Turing stated that a human should be able to differentiate human and machine dialogue [18], making the intentions for further research and investigation clear. In terms of offering a definitive answer to intelligence and machine thinking, Moor (1976) broke down the Turing Test, and stated that 'the real value of the imitation game lies not in treating it as the basis for an operational definition but in considering it as a potential source of good inductive evidence for the hypothesis that machines think' [23].

Academics in the field however [24] had previously stated that we have already seen subjective evidence regarding the Turing Test, deeming it to be not sufficiently demanding. Programs such as ELIZA [25] seemed to be deficient in intelligence over a long period of time, yet the test would prove to mark out specific observations and evaluations. However, for Norbert Wiener, a leading innovator in cybernetics at the time, the aim regarding AI was to combine mathematical theory, electronics, and early automation as 'a whole theory of control and communication, both in animals and machines' [26]. Along with Wiener's findings in cybernetics, cognitive psychology and computational linguistics also contributed to the complex and intellectual matrix of AI, predominantly brought in by Chomsky entailing the specific detailing's of the theory of syntax in relation to these concepts [27].

Essentially, it is important to understand that to pass the Turing Test, it is simply 'not enough for the computer program to fool 'ordinary observers' in environments other than those in which the test is believed to take place' [28]. While additional academics and political figures today such as Peter Schweizer claim that a better test than the Turing Test will advert to the evolutionary history of the subjects of the test, also stated by Stanford [29], the test is still feasible and used to this day to determine whether a machine is deemed intelligent in comparison to a human being.

B. Origins of Deep Learning

Since the concept of deep learning came into fruition in the mid-1960s, AI started to develop into something more than just a series of tests for mankind to compete against. Deep learning allowed computers to fundamentally build complex concepts out of much simpler ones [30]. In essence, while deep learning solves central problems in representation learning, the idea of the correct depiction for the data provides one viewpoint on the topic of deep learning. Another factor to consider is that uninterrupted depth will allow a computer to learn a multi-step computer program, suggested by Goodfellow [30]. Separately, the layers of representation can be thought of as the state of the computer's memory (RAM) after achieving another set of commands.

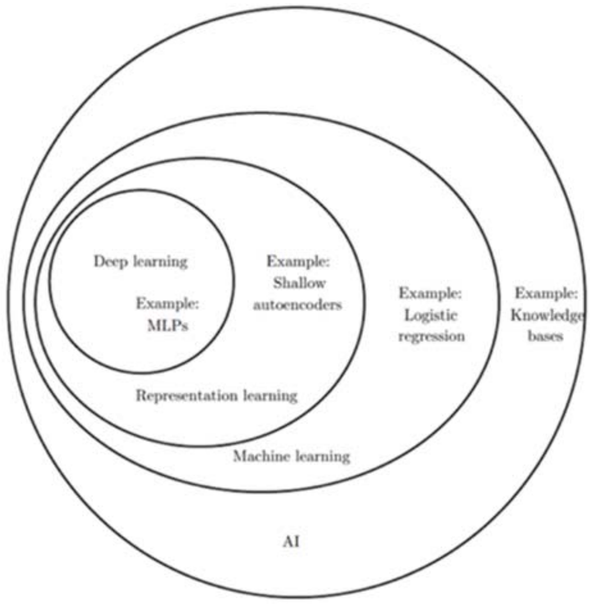

Fig. 1 Venn diagram displaying Deep Learning, used for may approaches to AI; each section includes an example of an AI technology [30]

Deep Learning (DL) is and has been making a major progression in solving problems that have repelled the best attempts of the AI community for many years [31]. Initially, these advances had initially focused on speech and handwriting recognition, but research has streamlined towards new paradigms needed to replace rule-based manipulation of symbolic expressions by operations on large vectors [32]. Traditional methodologies of DL concentrated on small, but entirely functional neural networks, yet its' development and understanding grew exponentially in the 70s and 80s.

There have been many approaches to DL in the past, specifically survey papers that have focused on a certain scope in DL [33], [34]. However, many of the latest DL techniques and algorithms have been presented positively and have thus far demonstrated promising results across different applications. These include Natural Language Processing, Visual Data Processing, Speech and Audio Processing, and many other well-known applications [35]. AI was looked at in heavy detail at this time, and researchers in the field took notice of this. Moreover, attention was paid to a cross-modality structure, which may yield a huge step forward in DL [36].

Further research has shown that various DL algorithms help improve the learning performance, broaden the scope of applications, and simplify the calculation process depending on how they are used [37]. Presented by the majority in a positive light, with use of DL proving successful in most cases, has no doubt enabled consumers to further integrate with business preparation. However, the time-consuming training of DL models remains a major problem. Furthermore, the classification accuracy can be drastically enhanced by increasing the size of training data and model parameters [37]. With Big Data, it would come at a price of physical space in terms of servers/drives, as well as time needed to train users to handle processes.

Moving into the 1960s and 70s, the focus on AI favoured towards a knowledge-based and symbolic approach to intelligence, operationalising models from logic, linguistics and particularly, cognitive psychology [38]. Cognition started playing a huge part in AI, at the time that intelligence was considered to mean displaying and exhibiting interesting behaviour.

IV. 1960s – 1980s

The 1970s and early 1980s saw the development of advanced and increasingly capable programs. These encompassed the comprehension required to impersonate expert human performance, including diagnosis, design, and proficient analysis. Most of the research surrounding AI in the early parts of these decades investigated a multiplicity of representation that displayed many difficulties in search techniques and general problem-solving. A series of influential programs were developed, such as the 'General Problem Solver' (GPS) of Russell and Norvig [39], further explained in their works on AI [40]. Further developments also included components varying from symbolic integration [41], complex algebra problems [42], analogy puzzle solving [43] and most notably, control of a mobile robot [44], explained in detail in Nilsson's work [45]. Feigenbaum and Feldman (1963) composed a series of papers for references in the volume entitled *Computers and Thought*, for a deeper examination into these components [46].

In the late 1960s, research had further inspired filmmakers and impressed the minds behind modern science fiction. A production by Stanley Kubrick that would indisputably make history for eras to come from 1968 was created; '2001: A Space Odyssey' [46]. This production was the first to feature a fully-fledged intelligent computer by the name of HAL 9000 [47]. This proved prolific at the time, and cemented AI's place and acceptance not only in movie production, but in society.

1969 was the year however that many issues started to arise within AI. While believers such as Minsky at the time were firm in their understanding, knowledge began to shake in the form of a robotic invention called 'Shakey the Robot', an adaptable and versatile mobile robot able to make its own decisions and bring about a sense of reasoning behind its actions in accordance with its environments [48]. Major planning and six years of research were spent developing this robot. While seen as a revolution by most, there were few that had their disapprovals. Considered a major breakthrough for the time being with spatial maps in 3D and 4D singly fabricated by Shakey, it was predominantly sluggish in its attempt, with each move requiring an update to its system mapping [49]. At times, it would take an hour to modify and adapt a field of view to move.

A. Reinforcement/Supervised Learning

Early developments of AI focused solely on the engineering process via trial-and-error behind the idea. Reinforcement Learning rose from these demonstrations; a recent definition being the goal of training smart agents that can interact with their environment and solve complex tasks [50]. Real world applications such as robotics [51], driverless cars run by AI [52] and increasingly efficiencies of powerful data centres [53] have all had some form of development derived from RL. Effectively, the idea behind Reinforcement Learning was to implement methods and procedures to a range of problems, often successfully. Algorithms within RL have even been successfully applied to board games such as Backgammon [54], Chess [55] and Go [56].

The introductory consciousness of Reinforcement Learning came about during the computational insights of Minsky and Farley and Clark; in 1954 and 1955 respectively. In Minsky's own dissertation during his prior studies, these computational models were put to the test in the form of analogue component machines entitled SNARCs (Stochastic Neural-Analog Reinforcement Calculators) [57]. Contrariwise, Minsky (1954) labelled another neural-network machine capable of learning by trial-and-error [58]. However, it was not until the 1960s where the terms "Reinforcement" and "Reinforcement Learning" were in literature concerning primarily engineering [59]-[62]. Notably and most influentially, Minsky's paper "Steps Toward Artificial Intelligence" [63] went into excessive detail regarding several key issues significant to reinforcement learning. These comprised of literature such as the '*credit assignment problem'* which focused on distributing credit for success between the decisions involved in producing it in the first place, detailing crucial information for corporate business.

Over time however, the interests Farley and Clark possessed in trial-and-error gradually faded, and an emphasis on generalisation and pattern recognition was born; reinforcement learning revitalised into supervised learning [58], [63], [64].

Arguably, this caused a series of misinterpretations between these two types. Several researchers had their position; Rosenblatt (1961) [65], Widrow and Hoff (1960) [66] were encouraged by reinforcement learning, as opposed to Farley and Clark's ideas on reinforcement. Concepts of reward and punishment were used on systems of supervised learning suited for pattern recognition and perceptual education. It is explored even today for researchers and academics alike often distort the distinctions of comparing networks that learn from training methods as they use resulted error information to update connections. Such processes have clearly become problematic, as it significantly misses out on the fundamental essentials of trial-and-error learning techniques.

What distinguishes Reinforcement and Supervised Learning fundamentally comes down to feedback; only partial feedback is given to the learner about the learner's predictions with Reinforcement Learning [66]. Fundamentally, the goal with Reinforcement Learning is to develop efficient learning algorithms, as well as to understand the merits/limitations of the algorithm in question [66]. Fig. 2 presents a simple diagram displaying the procedures involved with supervised learning.

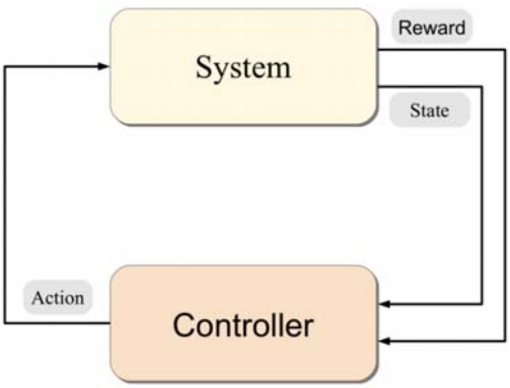

Fig. 2 Basic Reinforcement Learning Scenario [67]

B. Machine Learning and AI Divide

AI's relationship with Machine Learning is one of great prominences; arguably the biggest relationship between the two technologies contains the assemblage of big data to program algorithms for prospective solutions. In layman terms, Machine Learning (ML) essentially involves the designing of algorithms that allow a computer to learn [67]. Furthermore, while learning does not necessarily involve consciousness, it does rely on finding statistical regularities or patterns in data sets. Most ML algorithms may resemble how a human may approach a learning task, but the complexity of the algorithm in question can give a detailed insight into the relative difficulty of learning in various environments [67]. Broussard writes however that ML can improve at its' programmed, routine automated tasks [69]. It is not necessary that the machine would require knowledge or wisdom despite what the term learning may imply [69].

Apart from ML being widely used in scientific applications such as bioinformatics, medicine, and astronomy [69], Ayodele [68] examined the various forms in a recent paper entitled "Types of Machine Learning Algorithms", and a compilation by Shalev-Shwartz and Ben-David highlighted its most common variations [70]:

- Supervised Learning - the algorithm produces a function that maps inputs to outputs.
- Unsupervised Learning - it models a set of inputs, in which labelled examples are not available.
- Semi-Supervised Learning - it combines labelled and unlabelled examples to cause a function.
- Reinforcement Learning - algorithm learns a policy of how to act given a worldly observation
- Transduction – it tries to predict new outputs based on training inputs/outputs and new inputs.
- Learning to Learn - algorithm learns its' own inductive bias based on previous experience.

Moving forward, the late 1970s presented a technological disconnect between ML and AI. Like the "digital divide" between the internet with Information Technology and Digital Media, the algorithmic divide between AI and ML was emerging and ever-present. The division threatened to take away many political, social, economic, cultural, and educational career opportunities provided by ML and AI in the first place [71]. Since the occurrence, the fear has been minimal, and the advances towards collaborative efforts between the two grew. Consumers began to understand how promising a working relationship with ML would prove to be, and the differences were clear. AI could find patterns and predict the future, whereas ML improved as it performed tasks [72]. Within AI, ML has emerged as the method of choice for developing practical software for computer vision, speech recognition, natural language processing, robot control, and other applications [73].

C. Rise of Augmented Reality

Since its' initial introduction, Augmented Reality (AR) has been thoroughly examined and explored since the early 70s. AR has formerly been described as "the technology of adding virtual objects to real scenes through enabling the addition of missing information in real life" [74], creating a link between a digital interface and reality. These technologies became a norm for companies utilising these adapted technologies, with the main devices used for AR including displays, input devices, tracking, and computers [75]. AR's initial mention came about in 1968 and became a reality in the 70s. Deemed futuristic and impractical, requiring us to see through the idea of high-tech spectacles is not so unusual when considering that companies such as Google have recently started applying these ideas in the form of their smart glasses, 'Google Glass' in 2013.

The link between perception and reality has always been a topic for conversation for many years regarding AR and achieving perceptions in a fixed environment have been helped further by Virtual Reality (VR) also. Fundamentally, VR aims to provide an augmentation and perception in close environments followed by definite and bounded set of object registration, whereas the user can perceive in the premises as of both augmentation and registration [76].

Moreover, while AR has combined real and virtual objects and surroundings, interactively working in 3D in real-time [77]-[79], since 1950, it has shown remarkable development in various sectors i.e., medical practice, engineering, and education [80]. AR has presented that it can deal with human problems effectively and efficiency alongside VR and several aspects of AI, particularly later in the emergence of smartphones; earlier forecasted as a potential market for AR applications.

With AR linked to tracking procedures such as GPS, great concern ascended with social acceptance. Mobile devices and PDAs had already been judged as a social barrier in the real world, and with exponentially advanced technologies, the need for having two people in a single room to communicate began to feel outdated within society, with reminders, messages and calls being easily accessible and effortless. A research study has shown that interactions with AR systems implemented in mobile application needed to be subtle, discrete, and unobtrusive due to potential high workloads [81]. Likewise, natural interactions began to fade, and in turn a wider sense of acceptance had taken prominence. Organisations started to focus on wearables, which would become dominant in the early 2000s. AR would also go on to become a leading technology in medical surgeries and procedures, interactive newspapers, gaming in virtual environments, shopping, and interactive learning solutions [80].

D. The AI Winter

The early 1970s brought about AI's predicaments and difficulties and hence 'The AI Winter' was formed. Floridi (2019) best describes the term as a stage where 'technology, business, and the media get out of their warm and comfortable bubble, cool down, temper their sci-fi speculations and unreasonable hypes, and come to terms with what AI can or cannot really do as a technology' [82]. In short, investments in AI would become more selective, and widespread coverage by journalists and academics alike would stop writing about AI completely and set sights on the next developing trend. With regards to this 'winter', the field of AI has experienced many; one of the late 1970s, and a few more in the turn of to the 1980s and 1990s. Some experts in the field state that another predictable AI winter is yet to come [83]-[85].

In 1973, Professor Sir James Lighthill, a leading Mathematician at the time conducted a series of health reports condemning the condition of AI in the UK [86]. Lighthill's views were seen as provocative, summarising in his article that machines would only ever be adept and only reach the level of an 'experienced amateur' level of chess. He further stated that common reasoning and assignments of 'face recognition' would be impossible, and always beyond computer capabilities [86]. After stating such powerful views, his Lighthill's views became widely accepted, causing mass funding for the industry to be slashed dramatically. This was the birth of the term 'The AI Winter' caused by the metaphorical abortion of AI achieved by Lighthill's interpretations. Hereafter, future implications would be studied to avoid potential repeats and develop avoidances to such scenarios; studies that still take place and materialise to the present day.

It cannot be expressed enough how threatening this would be to the development of AI today, and in the current climate and pandemic we face, another AI Winter may prove disastrous in the field. The theory behind a 'winter' of any kind is that while the season may end, it is bound to return at some point, so there must be a level of groundwork to deal with it if/when it will come. Monumental in its presence, experts in the field today warn that another AI Winter could make a return in future. Professor Luciano Floridi, a Professor of Philosophy and Ethics of Information at Oxford University has expressed his concerns as recent as 2016, stating that for some time, 'I have been warning against commentators and experts, who were competing to see who could tell the tallest tale' [87]. Various distinguished literature is available concerning another predictable winter in terms of possible stunted expansions and insights of AI in future; notable works include: Nield [83], Walsh [84], Schuchmann [85].

As mentioned, the chances of another 'AI Winter' have been studied after the initial 'crash' of AI. Today there is growing development of adequate tools to monitor and understand how ML systems reach their outcomes [88]. Without these, a growing uncertainty would take over, particularly as technologies are advancing as well as humans.

V. 1980s – 2000s

A. Symbol-Processing Approaches

Building on the earlier concept of 'Reinforcement Learning' from the 1960s and 70s, an invigoration of the previous trial-and-error methodologies of this within AI began. Klopf [89]-[91] highlighted and acknowledged that specific characteristics of adaptive behaviour were becoming lost as leading research indicated that primary focus was exclusively centred on Supervised Learning (SL), rather than Reinforcement Learning (RL). Klopf recognised that hedonic aspects of behaviour were missing, and thus led the desire for some level of success in terms of controlling the environment to die. This was the fundamental idea of trial-and-error learning, which consequently influenced future academics [92] to appreciate the differences between RL and SL; thus, ultimate focus shifted to the former. Notable works at the time including Barto's work were predominantly in support of the clear and distinct differences between the two types of learning [92]-[95]. Furthermore, other studies and advanced research held the position that RL could address central issues concerning neural networking, particularly learning algorithms for multidimensional networks [96]-[100].

As commercialism started to rise in the early 1980s however, a sense of acceptance and interest resurfaced for AI. Consequently, its' marketable significance was beginning to be widely understood, attracting new and improved sources of investment [101]. Although restructured systems in the 80s were less technologically ambitious than its predecessors, expert systems were designed to focus on much narrower and manageable tasks, particularly in industry. While the need for upgraded systems could have been a root cause for investment, it did mean nonetheless that the determined rise to the top for

AI could not be achieved at the time. In the late 1990s, supporters of 'top-down approaches' become adamantly vocal in their approaches. In 1997, supercomputers such as 'Deep Blue' took on world chess champion at the time, Garry Kasparov [102]. The machine, built and developed by IBM could calculate a phenomenal 200 million positional moves per second [103]. Undoubtably, the thought capacity of the human mind came into scrutiny; the challenges and questions faced were whether these moves were strategic enough in achieving the win. The supercomputer achieved a win so advantageously, that Kasparov was convinced that a human being was in control of the machine [102]. Many academics in the field stated that this was the coming of age for AI. Others however remained sceptical and reserved in their judgment, simply admiring a show of hard work from experts working together to solve a particular problem at hand.

Relating back with McCarthy's 'top-down' knowledge-based approaches [104] in the late 50s, previous symbol-processing approaches were further analysed and systematically laid out in simpler terms. The argument for Top-Down approaches faced fierce scientific competition, with Brooks stating that pre-programming computers with intelligent behaviour was the wrong approach. Thus, the field of neural networks was reviewed accompanying the 'Bottom-Up' approach. Initially inspired by advancements in neuroscience, Brooks begun the transition of human cognition within systems [105]. Motor functions such as human vision principally needed several components in the brain to recognise patterns without a central sense of control.

Concerning AI and the psychological side, a congregation of works observing both the 'Top-Down' and 'Bottom-Up' approaches have been inspired by previous studies of animal and human behaviour respectively [106], [107]. Bottom-Up approaches have traditionally focused on computational elements or logic gates [108]; but research has predominately been fixated on neural-network models, such as networks that learn to pronounce words from written texts [109]. A rise in 'Bottom Up' methodologies from the late 1950s initiated a flourish of encouragement in the early 1990s. AI scientist and leading roboticist Rodney A. Brooks published a thought-provoking paper entitled "Elephants Don't Play Chess' in 1990, detailing situated activity, mobile robots, and subsumption architecture among others, all within the realm of AI. Brooks' detailing of these methodologies laid the foundation for AI moving forward, with primary focus strictly on processing in relation to the workings of the human brain. Most famously, he stated that "over time there's been a realisation that vision, sound-processing, and early language are maybe the keys to how our brain is organised' [105]. In theory, the basis of this statement is simply without original key components, there can be limited development moving forward in terms of mental cognition. The ultimate argument in his paper, was that for robots to achieve human capabilities on a day-to-day basis, higher cognitive abilities such as abstract thought and symbolic reasoning needed to be based on primary sensory-motor action with the environment.

B. Recommender Systems

Recommender systems involve numerous software tools and methods that provide suggestions for items to be of use to the user [110]. Quite simply, these suggestions are offered to the user depending on their personalised needs and wants i.e., what clothes to buy, what music to listen to, or what news articles to read or extract from various sources. Many mobile applications and firms such as Netflix, Google and Amazon are already and have been using these technologies to gather previous data to formulate recommendations for a user depending on their past general purchasing habits and lifestyle behaviours. Furthermore, these technologies grasp the fact that users have differences in health goals, or varied personalities to fulfil and meet a certain objective in what the user wishes to achieve. Many agree that Recommender Systems have proven effective [111], particularly in e-learning environments where students can have their own individual tools, methods, and specific learning goals to work towards; technological advancement has allowed this to occur internationally also [110]. For example, personal Recommender Systems for learners in learning networks would demand the techniques, model and requirements necessary to do so [112], hence designing an effective understanding of specific learners' characteristics and abilities [113], [114].

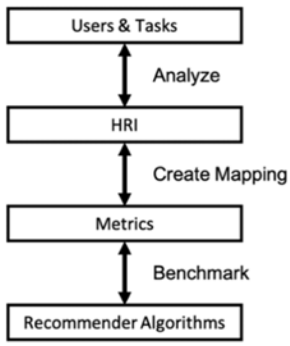

Fig. 3 The HRI Analytic Process Model: Interactions flow both ways to link Recommender Algorithms to users and their information seeking tasks via HRI aspects [115]

Altered systems with a recommendation approach first arose within e-commerce for the goal of product purchase [116], [117]. Facilitated systems assisted and guided consumers towards the products they wanted by creating a digital list of recommended products for each consumer according to their requirements [118], [119]. However, the initial challenge when designing the first Recommender Systems was defining the users and purpose of context or domain in the proper way [115]; the HRI (Human-Recommender Interaction) Analytic Process Model. The Model emphasised in detailing the different points of view with regards to the constructive methodologies of redesigning systems to better meet user requirements.

With Recommender Systems, it has been a central notion to have a level of control over exponentially sizeable information. While knowledge-based systems may not depend on large gatherings of statistics, experience and research has shown however that these systems do in fact help users explore precise areas. This itself conforms to the understanding of an information space. All Recommender/Standardised Systems, however, do require a strong relationship with AI in order to fulfil its' fundamental goal of integrating and bringing together the practices for reference. Progressing into and towards the early 2000s, it is clear to say that this relationship must stay intact moving forward.

Moreover, from an exclusive AI-based perspective, Recommender Systems can be set out as a learning problem that exploits past knowledge about users [120]. Put simply, profiles are widely analysed with user-specific words being highlighted to reflect the long-term behaviours and interests of the user in question. This ties in with the techniques of ML with the primary goal of categorising new data based on previously viewed information that have been labelled according to the user's requirements. The most common varieties of Recommender System are the collaborative or social-filtering types [121], most commonly accumulating data regarding purchasing habits and/or preferences to make future recommendations.

Contrariwise, content-based systems correlate more with ML than the other two, yet stimulate a classifier that can discriminate between various articles that are possibly of importance to the user and those that are likely not, often referenced within academia [121]. Likewise, Knowledge-Based approaches in these systems would be similar but still use previous data and understanding, while others have adapted quantitative decision support tools for this individual task [122]. These systems are particularly useful for advocating a user's likings both for personal and professional use. A classic example would be the restaurant recommender Entree [123], [124], which constructs recommendations according to a customer's requests for food and/or drink at a chosen location. This then allows the user to navigate the system and select their chosen preferences according to their individual searches. Further notable works surrounding this include [125]-[127].

C. The Internet of Things

In a developing world where multitudes of systems, people and machines are connected, the capabilities that technology promises us and offers us today can bring in a new era of the Internet of Things (IoT). In simple words, the term 'IoT' concerns the networked interconnection of everyday objects, often equipped with ubiquitous intelligence [128]. Integration is central to making this idea functional, and further leads to high-tech networks of devices which are distributed and communicated with humans, as well as other systems. The IoT has been of great physical and digital assistance for humankind, combining both the components required to create new products and enable business models to push further and faster than ever before without it. Furthermore, with increasing power management, broadband reliance, advanced memory capacities, communication, and advancements of microprocessor technologies, it has become progressively feasible to digitalise functions and capabilities of industrial products [129]. The fact that we could have video and audio communication seamlessly with friends and family in a different continent was something unheard of previously, but cheaper equipment and advanced technologies have made what we often take for granted possible.

Scopes for applied technologies linked to the IoT are undoubtably diverse, and numerous systems and solutions have become increasingly virtual and practical daily. AI enters the fold in the form of the smart industry, where development of intelligent systems and connected sites are discussed and monitored frequently daily [130]. Applications for these can include transport solutions such as mobile ticketing, smart energy meters i.e., gas and water, and health management, such as patient surveillance and disease administration. A small number of smart city ventures, parking space accessibility and smart lighting systems for roads are currently being explored as options to integrate AI with these multitudes of accessible information and data, made possible with the connection with the IoT. Notable works include [131]-[133].

Business ventures have particularly taken providence of various IoT applications in the case of interaction of people and/ with systems. Software components have managed identity and security features, as well as assisting with integration with business systems i.e., ERP (Enterprise Resource Planning) or CRM (Customer Relationship Management) with external intelligence foundations [134]. The challenges IoT platforms may face are varied, however. Recent issues such as device level energy supplies, identification and addressing, internet scalability, security and personal privacy and standardisation [131] have all come under scrutiny. The key factor to combat these questions will eventually be decided on how these issues are dealt with collectively; ultimately the platform provider's ability to build systems around them with the provision of both professional support and time needed. Implementation is critical, and IT infrastructures will need to follow governance, tools, and processes to manage and connect the necessary resources both within and beyond the reach of individual corporations [129] effectively.

There are numerous challenges such concepts can face. While the IoT constantly raises expectations and demands further information accessibility, there are questions to be answered concerning technology, as well as from a business standpoint into the matter. For example, at the most strategic level of several corporations, a SWOT analysis to require for analysis to determine the opportunities and/or threats the IoT will present to the business. Categorically, business models may need to be adapted to meet long-term corporate objectives based on the positioning of the IoT within corporate functions. In management, hardware and software issues may arise for processes such as product development whereas for areas such as retail, after-sales services may have to be amended to meet requirements of interconnected products sold. The adoption of various design principles to correlate with these inter-connected products nonetheless may be required in the long run, i.e., enabling ongoing product updates and tech or personalisation [134], [135].

AI enabled IoT is an immense concept, spanning across sensors, actuators, data storage and data processing capabilities interconnected by the internet [136]. Hence, this has allowed any IoT-enabled device to sense its' surroundings in addition to transmitting and processing the data it collects. The most common everyday examples we can mention are voice assistants, robots and smart devices that utilise facial recognition, voice recognition, haptics, and speech-to-text technology. The IoT combining with AI could open vast opportunities in future, and the movement to do so will depend on our consistent understanding of developing and improving skills over the years.

VI. 2000s – 2020s

A. Development of Robotics

While the concept of the robot was invented in 1920 [137], the robot (and more importantly the intelligent robot) was a thing of the future and not entirely practical, even so imaginable. However, with the rapid advances in robotics and AI particularly in the turn of the 2000s, human labour is much less stressed as a necessary input and this will be increasingly true once robots are used to produce robots [138]. At present, it can be said that almost everyone has had an interaction with an element or device that has involved some form of robotic component or system. Whether using an automated system to convey a presentation via robotic means or simply vacuuming the modern-day home, robotics has and will continue having a dominant presence within society. Although robots were being utilised widely within manufacturing in the 1980s, service-based industries have generally and often lagged in the use of robots [138].

Almost every business or establishment handle sophisticated data analytics to our everyday household appliances. Moving on from the previous section, Brook's accompanying business 'iRobot', created the first financially successful robot for the home in 2002 dubbed 'Roomba' [139]. The simple task of cleaning floors and carpet was far from the aspiration of AI's expansive minds and ideas, yet 'Roomba' was a colossal triumph in terms of upgraded behaviour-generating systems [140]. Compared to previous models such as 'Shakey', procedures were simplified and optimised for dedicated activities. While sensory functions and processing power were limited, the device still had adequate technologies instilled to complete a simple manual task. Collectively agreed by experts and academics alike, the era of autonomous robots was born, and development continued late into the 2000s to the present day.

Surely, governments worldwide paid attention to developments and wanted participation within the field of robotics. In 2005, the US Military became increasingly involved with AI's advances and began to invest deeply in autonomous robots. American engineering and robotics company Boston Dynamics fashioned 'BigDog', a robotic pack-like animal used in fields of terrain too tough for American soldiers and conventional vehicles [141]. As funding became more frequent, an opening for additional robotics to be implemented became a central focus. A similar robot designed specifically for bomb detection and disposal appointed 'PackBot' performed with intelligent capabilities such as explosives detection in the field [142]. Soldiers in the 82nd and 101st Airborne Divisions and Special Operations have even used PackBot's to search Al Qaeda caves in Afghanistan and hunt for chemical and nuclear weapons in Iraq [143]. Even though investment became consistent in 2005, until 2013 over 2000 PackBots had been implemented and utilised in Iraq and Afghanistan by American military services [144].

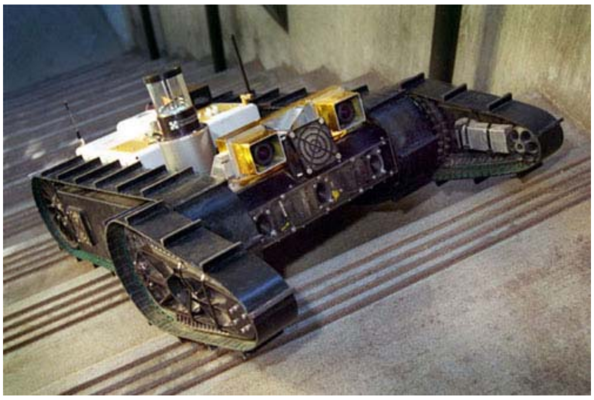

Fig. 4 The 'PackBot' Vehicle [145]

Robotics has conventionally shown to have a positive influence and effect economically as well as within society. It is suggested by Graetz and Michaels that robotics has added an assessed 0.37 percentage points to annual GDP growth for a panel of 17 countries from 1993 and 2007, an effect [146] like the adoption of steam engines on economic growth during the industrial revolution. Of course, with positive results growing economically, this suggests that users are preparing and embracing the idea of interacting more with robotic advances. Evidence has been exhibited recently that the presence of in-house users of robots that have relative access to scientific understanding, will prepare groups to be flexible and acclimatise to novel "smarter" robotics technologies [147].

A common misconception however is that by developing robotics, we are training machines and systems more and more to replace most manual jobs, and in some cases, there have been common misconceptions that robots will replace us indefinitely. It is important to understand that we should ideally collaborate with robotics and AI for the betterment of quality of living within society. However, this idea is conceivably the most argued in the field of AI. A recent study in Bhargava et al. found that participants indicated that while robots cannot make decisions, they do not need regular training, unlike humans, and require human contribution [148]. AI however learns iteratively and becomes capable of making decisions. Fundamentally, robotics can be of great assistance for us in meticulous tasks and may replace necessary manual labour, although individuals are needed to develop these high-tech systems in the first place. The task may be to reaffirm our position and remain, rather than replace completely.

B. Man vs. Machine

Mainframes advanced further in the 2010s, and innovative technologies meant that smaller computers could now function at the same capacities as bigger computers previously in the 1990s. In turn, forward-thinking robots such as 'NAO' robots were developed [149]. The latest 'Humanoid Robots' had encompassed abilities never seen before in former models. One key aptitude in relation to AI was the ability to learn via the developments of ML [150] and in general, neural networks [151]. The battle of man against machine in terms of intelligence had increasingly become close; machines now could learn, and even imitate humans and perform informed and enhanced functions.

Fig. 5 Summary of Artificial Neural Networks [152]

During 'Expo 2010: Shanghai' in China, dubbed 'Better City – Better Life', a new range of robots were presented to the world expressing astonishing competencies, and a display of 20 model robots synced into dance for eight minutes [153]. These new advancements presented at the time highlighted the distance AI closed with human intelligence and design, and many organisations went on to develop robotics within developmental departments. This allowed further work on the innovations made within the world of AI. The question of whether a machine could perform like a human without user intervention picked up attention, and the difference in capability and neural capacity was still on the horizon.

As societies were still unconvinced of AI's power and influence, the argument of 'Man vs Machine' took centre stage, cementing the title for the public to see. Technology took to the stage in America during Jeopardy, a popular US quiz show that is still currently televised [154]. IBM's Watson competed against the human mind with instantaneous complex questions in real time, utilising the improvement of neural networks and over three years development in pattern recognition [155]. AI triumphed in this case, and reigned victorious over two of the show's best contestants at the time. Proving its' doubters wrong once more, the expansive capabilities of Watson went from being a virtual participant in a game show, to being used in medicine today. Data capabilities of Watson are now for example, vital in mining sets of data to identify a patient's medical records as well as making proposals for doctors to provide patients with recommended solutions [156].

C. Developments of AR

Connections within AR became recognised as development continued since its' initial recognition in the late 1950s. Most recently with the understanding of AR today, there are four known central ways of interaction with AR application interfaces; tangible AR, collaborative AR, hybrid AR, and the emerging multimodal interface [157]. With each interface necessitating its own approaches to AR and AI respectively, depending on what outcome is required, the necessary approach with this technology would be taken:

- Tangible AR

These interfaces generally support interaction with reality by exploiting the use of real, physical objects and tools. For example, the VOMAR application [158] allows the user to rearrange furniture in an AR living room design application by using a physical paddle; commonly used now by a wide range of retailers in industry. More recently, the table-top interface TaPuMa [159] utilises physical objects to interact with digital projections of maps using real-life object the user possesses. Gloves and wristbands have also increasingly been used for these purposes in the development of AI and AR technologies.

- Collaborative AR

With these interfaces, the use of multiple displays to support remote and co-located activities are exploited using 3D interfaces to improves physical collaborative workspaces [157]. Such technologies have been widely used within medical applications in hospitals for diagnostics, surgery and maintenance using 3D-windows, hosts, display platforms and various OS' (Operating Systems). Put simply, collaborative AR can integrate multiple devices with multiple locations to enhance teleconferences smoothly via remote sharing [160].

- Hybrid AR

As indicated in the type of AR, hybrid interfaces combine a collection of numerous, but related corresponding interfaces to interact through an expansive range of interaction devices [161]. With flexible platforms for interaction, a provision for interaction is usually given where it may not be known in advance as to which types of displays or devices may be used. Moreover, these AR systems are then implemented to support end users in assigning physical interaction devices to operations as well as virtual objects. In turn, these reconfigure the mappings between devices and object sand operations between the user and system in question. Notable works include [162].

- Multimodal AR

Comparable to a hybrid AR, multimodal interfaces combine real objects as inputs with naturally occurring forms of language and behaviours such as speech, touch, and natural hand gestures [157]. Mostly connected to ML techniques, multimodal interfaces are the most recent technologies, with organisations such as MIT utilising wearable gesture interfaces with their sixth sense product, WUW (Wear Ur World) [163]. WUW allows the user to project information onto surfaces and walls via natural hand gestures, arm movement and/or direct interaction. Multimodal interfaces have increasingly been used to support future AR for efficiency purposes, as well as a flagship interface for UX and UI design. In essence, they possess the ability to combines modalities compliantly from one input mode to another.

Notably, developments in AR glasses have been used recently in paediatric surgery, and a report in the International Journal of Surgery (IJS) devised a study entailing the use of Google Glass over a period of four consecutive weeks within a University Children's Hospital [164]. Results presented an argument for both scenarios; while drawbacks listed poor battery endurance, data protection issues and reduced audio performance, the progressive reactions were generally welcomed. Hands-free photo and video documentation were achieved successfully to examine post-surgical results, as well as real-time internet searches for medical terminology and syndromes. In summary, the study concluded that Google's Glass had clear benefits and pragmatisms in a clinical situation. While issues such as data protection needed to be solved combining dedicated medical applications, it was universally recommended at the children's hospital in Westchester, New York, USA for use by physicians and surgeons respectively. It was encouraged moreover that a new edition of Glass 2.0 would be replaced with the then current Explorer version. Further outcomes and conclusions can be examined in the full Journal at ScienceDirect. However, a CNN Business Report in 2019 stated that Google Glass was withdrawn in 2015 after beta versions failed to gain traction due to its excessive retail price of $1,500, clunky design and concerns about privacy, as stated in [165]. Since these developments, Google have since shifted attention to more business-related objectives and corporate focus. The first edition of Google's 'Enterprise' glasses has been used in manufacturing and logistics by many firms including Deutsche Post DHL Group and Sutter Health. In turn, this has brought competition from rival corporation Microsoft, who have developed the HoloLens and HoloLens 2 AR headsets respectively [165], [166].

Despite its initial retail value of $3,500 in the US, Microsoft's attractive USP for their AR headset was the projection of augmented visuals over both eyes of the user, rather than a projection over one eye of the user of the rival Google Glass model [166]. Microsoft's addition in the AR market has had numerous questions. While the HoloLens 2 were equipped with powerful sensors and integrated computing capabilities, the headset also allowed users to see and manipulate holograms embedded in their environment [167] which arguably cemented the idea of AR becoming an actuality of technologies soon. Projections of images are produced so that visible holograms are perceived by the user to coexist with physical elements in a shared environment. Furthermore, distance reduction is also in effect, and coincides with the distance between the user and interface. With monumental success since its' introduction in January 2015, developers, engineers, and architects alike have used the technologies in their own fields, reinforcing the demand for these technologies.

VII. The Future of A.I.

In the space of approximately eighty years since our foundational understanding and knowledge of AI, it has become clear to see the development, need and uses of the technologies and elements presented. It has become difficult to forecast the future opportunities, but what is clear to see is the infinite and boundless possibilities and exploitations we have the capacity to probe into. Widely discussed in the academic field by experts alike, it has been articulated that we are in a constantly changing and shifting landscape with regards to AI. More research is required in AI and its' core elements in terms of application outside an engineering or information technology field, producing vast development across the board.

A. AI in Health Maintenance

Artificial Intelligence has taken dominance in several fields, none more critical with human interaction and interference than with psychology and healthcare. Artificial neural networks are some of the examples that require specific DL, which has marked the biggest trend in AI over the last decade [168]. With consistent progress in healthcare, AI has proved to be an aid for mankind in seeking out solutions to diseases and psychological cases. In modern times, researchers have also started to utilise elements and applications such as social media to study public awareness about certain illnesses, such as lung cancer [169] and cardiovascular disease [170].

Particularly, intelligent cameras have been more recently used with cancer research and advancements in clinical trials. Imaging data for example has been used to train AI models for skin cancer classification [171] and lymph node metastasis detection [172]. Data have also been used for various functional impact assessments [173] and more importantly, patient survival prediction [174]. National organisations such as Cancer Research UK have utilised these technologies in forms of small cameras being used to film tumours in the gut, as well as within genome-scale experimental studies and imaging data; in terms of AI interaction, DL algorithms have been integrated and largely been applied to cancer data integration and digital health care. This has often been the case for combining the process of EHR's (Electronic Health Records) within systems supporting physician-computer interactions [175].

At present, the accessible data in cancer research in general may not always provide the level of granularity required for effective decision-making. Healthcare resources have demonstrated a shortage of patient information regarding cancer subtypes, minority groups and rare cancers such as the case of paediatric oncology [176]. The main areas of application and data types of AI within this research however are predominately based for training and assessment. For instance, imaging data have been used to train AI models for skin cancer classification [171], while sequencing data have been used for functional impact assessment [173] and patient survival prediction [174]. All these functions and procedures adopt primarily artificial neural networks, specifically DL methodologies which mentioned previously, has marked the biggest trend in AI over the last decade [168].

There have been several organisations that work with AI in several fields to form solutions to otherwise manual problems. In 2018, Group 42, an AI and cloud computing company founded in Abu Dhabi, UAE became readily available to collaborate with SMEs and individuals within industry. Initially based as a start-up company, the organisation currently works towards the evolution of AI and industry in the government sectors, particularly healthcare, finance, oil and gas, aviation, and hospitality [177]. Using data scientists, G42 encompasses experienced data technologists, researchers, and engineers based in Abu Dhabi through their Inception Institute of Artificial Intelligence (IIAI); involving AI, big data and ML [177]. By exploiting cloud computing, they have been able to apply solutions worldwide which allows the company unlimited reach with their clients working around the clock. Mental health has also been increasingly a topic for discussion in society in which AI seeks to bridge the gap between our knowledge of poor mental health and its' potential solutions. Yet, there is little research surrounding this, but organisations such as Group42 help to bridge the gap between mental health and solutions within AI rather than a conventional human interpreter or psychologist.

B. AI Applications in Sport

Regarding sports and team management, AI has undoubtably taken a huge part in these technologies, even if it is heavily controversial in recent times. Players, managers, and technology companies alike have worked on AI's involvement in football in the hope of developing the game and predicting the best-case scenarios in-game.

Former professional footballer Esteban Granero has already combined his expertise in football with advanced technologies, particularly in team management heavily concentrated in AI. Working with the CEO of Olocip, a Madrid-based consultancy specialising in the development and application of AI in sport [178], Granero joined forces in the hope of pioneering an AI revolution in football. The focus has been on club transfers, tactical decisions, and injury prevention, all fixated on the vast quantities of data available from various clubs around Europe. Predominantly, football statistics have been the principal attention, with applied use of ML and Recommender Systems to predict future decisions and predictions to make better decisions. Olicip now work as an AI department for clubs, working with sport scientists to create complex algorithms to provide predictive support, primarily in player recruitment, injury preventions and tactical advantage [178]. Determining football statistics has evolved in recent years due to automatic or semi-automatic detection technologies that provide high-fidelity data streams for each match solely based on recordings or observations made using sensors [179].

Likewise, the technology GAMEFACE.AI has also used AI to analyse match footage and manage insight and optimise gameplay without the use of tedious splicing, tagging, and coding of games. GAMEFACE simply performs instant video footage analysis to highlight key events and decisions from a standard football match. In turn, statistics for tracking goals, assists, players, passing patterns and ball possession have become clearer and can then be used for post-match examination. Companies such as GAMEFACE have adopted these technologies on match statistics to analyse strategies and players' performance [180]. Such undertakings have proved to be quite tedious and time-consuming; the CEO of the professional football platform Wyscout claims his company employs 400 people on soccer data, each of whom takes over 8 hours to provide up to 2000 annotations per game [181].

Moreover, the technology system Veocamera feature includes soccer recording, coaching and analysis to make the recording process uncomplicated and to be able to mark the key highlight(s) of the match [182]. Without the aid of a physical camera, the AI used always detects the position of the football in-game which in turn produces the data to analyse play styles and tactical awareness. Essentially, Veocamera currently picks up statistical data to effectively analyse player performance after matches. The advantage in this of course is that no physical human cameraman is needed, and the technology implemented detects every possible movement of the ball for management at higher levels. In summary, this determines the best plan of attack. Similarly, Kickoff.AI uses ML to predict the most realistic result and outcome from matches; Bayesian interfaces are used to predict the percentual possibilities of each possible results of soccer matches [183]. After analysing the last 100 matches predicted pending March 2019, Kickoff.AI had a 56% success rate in match, yet no draw was predicted by the AI [183]. With further research and big data being used now, the potential success rate of a game's future outcomes predicted may improve. These technologies can be applied to other sports such as basketball and cricket correspondingly, if the right approach is continuously taken.

C. AI Applications in Gaming

Artificial Intelligence has been linked with computer gaming since the first program was originally designed to play chess [184]. Challenges have always been present with increasingly development since the 1950s however, in turn have made significant breakthroughs in computational intelligence, algorithms, ML, and combinatorial game theory [185]. Inevitably, AI has developed vastly since, and new technologies and technologies have been applied to gaming for future. New AI techniques have been used in computer games, for example to enhance graphical realism, to generate game levels, storylines, and to establish player profiles to balance complexity or to add intelligent behaviours to non-playing characters [186], [187]. Essentially, video games have become smarter. By progressively playing a tactical, sport or shooter genre themed game, the AI within the in-game program best determines and predicts the user's next step, theoretically enhancing the game to be harder to play against as the user progresses.

As hardware capabilities improve, new types of interaction will emerge that would need better AI. In recent years, AI in games has improved appreciably [188]. There have been many examples of these interaction techniques with more recent generations of gaming systems and games. Notably, the Forza Motorsport series and its successors gather data about how players drive, that is then processed using ML techniques. This permits for the creation of "drivatars" that mimic a specific player driving style and can then be used to play against. Likewise, a similar goal was attained in the 'Killer Instinct' game using case-based reasoning. Notable works regarding ML techniques in games can be found in [189].

Many elements of AI can be investigated further, such as ruling systems, BML (Behaviour Mark-Up Language) and NLP (Natural Language Processing). There are two main approaches for modelling non-verbal behaviours and animations: rule-based (procedural) and ML [190], [191]. BML has been commonly used for tactical gaming; an XML-based language that is used to model and coordinate speech, gesture, gaze, and body movements. Advances in NLP have also opened new opportunities to support natural dialogues with NPCs, either companions or enemies, and to support interactive storytelling [187]. Most commonly, these have been associated with online multiplayer games such as 'Fortnite' and the 'Call of Duty' series. Real-time synchronisation of many agents acting autonomously can easily produce performance problems and delays.

In theory, these AI approaches can be used in other fields such as sports and psychology. The illusion of intelligence has grown into reality, and game developers themselves are happy to use ad hoc cheats that offer players the illusion of intelligence, instead of any deep intelligence [192].

D. AI Applications in Social Media

Social Media involves the collaboration of websites and applications that enable the user to create and/or share content online as a means of social networking. These networks and collective media allow us to share all daily activities with a group of people online who essentially live in a virtual world [193]. Most commonly Facebook, Twitter and Instagram carry the largest followings. Effectively, evolving media such as television and radio have advanced to be social networks in themselves because of the ability to connect people and share diverse information [194]. The use of AI in these applications is exponentially mounting, however there are challenges to be faced along the way. While AI is growing, computers cannot simply react on their own without human intervention. AI is not capable of being aware of human emotion for example, so a machine will not know what we interpret as something funny, even if we introduce these aspects into its ruling systems [195].

Social Media and networks have no doubt been overtaken by AI in terms of search optimisation, generic content browsing and particularly user recommendations. Widely used with increasingly popularity and most predominantly, chatbots are AI software's that can maintain a conversation or a discussion with a user using NLP on different platforms such as email platforms, websites, or mobile applications. These have become increasingly popular, and psychologically have helped users interact with a product or service more effortlessly and user friendly, particularly in times of the COVID-19 pandemic in 2019. However, to fully achieve positive results, the chatbot must be able to perform two tasks simultaneously. One being human support and the other being intervention in the form of development, monitoring, and optimisation of the chatbot's technology system [196]. On the technical side furthermore, chatbots are only a basic evolution of a question-and-answer system based on NLP [197]. Ultimately, social media has a mass of tools that allow users to express themselves, have fun, build new knowledge, create a new community, and share opinions [194].

Algorithms have generally worked well within social media, particularly with the reasoning of machines on top of structural problems such as visibility, redlining, targeting, favouring, and normalising some users over others [198]-[203]. While these developments have proved useful, there have been concerns over privacy and data collection; consequently, the Data Protection Act came into full effect in 1988, with GDPR (General Data Protection Regulation) coming into force in 2018 [204].

A digital revolution has been shaping the marketing world, making it highly entrenched in social media platforms and dependant on the online social relationship between consumers and a given brand [205], [206]. In recent times, image has become central for a social media user. In some ways, to expand and gain wider outreach for business purposes, others as an attempt to present a high value representation of a particular individual or brand. Luxury brands especially tend to show a degree of hesitance with regards to their adoption of social media [205], [207], as they are seen to be unique, exclusive, precious [208]. In most cases, they are expected to offer consumers emotional and symbolic advantages, such as status, prestige, and affluence [209]. Most recently however, these brands have had to turn to social media and its' technological advantages for competitive advantage. Using applications that are embedded within AI is key, predominantly as the growing importance of social media has shifted the power and value production processes from companies to consumers [210]. Social media has not only enabled brands to communicate with customers, but also encouraged a higher level of consumer engagement, learning, and expressions of loyalty and promise [211].

It is argued that AI has made its biggest impact within social media applications, and the rate of which it is being used and implemented has grown astronomically. AI, and in particular ML concepts are often used to describe widely used, yet controversial computational models are employed to cluster and make sense of data to predict actions in within Big Data [212]. Most certainly, this has been the case for social media's relationship with AI; making it possible to make a strategic watch on social networks and other digital platforms [213].

E. AI in Research

Within academia and literature, AI is being used exponentially to save time, detect specific phases or articles, translate language, and recognising authentic sources from false information. For students, academics, and researchers alike, these applications are immensely widespread and used daily in industry. Microsoft's Azure program incorporates ML, DL and AI to study language, visions, and search APIs (Application Programming Interfaces). The free to use service on an open platform expresses its ease of access to all, with over 25 free services available to all users. Additionally, the Azure cloud computing environment enables scaling for cost control and provides product offerings to address aspects from raw infrastructures for DL, to fully managed services with pretraining models [214]. There have been questions regarding ethical approaches to this however as data are open sourced, but codes of practices have been put in place to prevent any misuse of these data, which scales throughout the organisation from engineering to marketing [215]. By building on the Azure platform, developers and data scientists can leverage infrastructure that scales virtually infinitely, with security, availability, compliance, and manageability [214]. For example, the Azure Search feature enables the user to define and select intelligent filtering, search proposals, word decompounding and geo-search [214].

Google Scholar is arguably the most popular tool now for searching and examining literature and articles. Allocated by Google, the service covers a range of academic disciplines and even searches content behind paywalls [216]. Released in November 2004, Scholar attracted the attention of libraries and information professionals due to its potential as a free online search engine for scholarly literature in a wide range of subject areas [217]-[221]. A vast amount of big data is used, and several multifaceted algorithms are put in place to collate and distribute accurate results to a particular search query. As Scholar is a branch of Google itself, data are shared within its already complex systems, and interpreted to raise articles and academic texts. With Scholar, a single search can lead the user to full digital PDF versions of articles and academic journals [222].

Subscription-based services have become increasingly accessible within research. Genei.io is an AI-powered research and note-taking tool that analyses webpages, documents, and PDF files [223]. Offering both a student and standard service respectively, the fundamental purpose of the tool is to extract keywords from articles, cross reference query-based searches, and summarising and compiling entire documents. Their main USP to attract users is time management; while the average journal on PubMed takes 25 minutes to read, with Genei the same article would take only 3 [223]. Similarly, currently one of the largest academic AI-based search engines, Semantic Scholar, also provides an academic service designed for scientific literature. Like Google Scholar, Semantic Scholar skims the web for citations via algorithms, which favour precision and full-text access over recall [224]. Up to 2017, Semantic Scholar currently boasted ten million articles readily available prior to branching out into biomedical literature [225], [226]. These applications utilise AI for time management and setups that would otherwise be more strenuous if approached manually.

VIII. Conclusions and Summaries

In summary of this literature, it is clear to see the opportunities and prospects AI, ML and DL have allowed mankind to study and integrate in both societal use and business use. The overall provision of existing information and ongoing research is dominant; there is unlimited room to manoeuvre moving forward with the tools in question. The implications are also clear. As well as using AI for business purpose, we must in turn look at how these changes have affected us individually and in society. The psychological aspect and cognition parts a huge part looking forward, and core and detailed understanding of AI's competences must be examined, particularly with the constant evolution and expansion technologies and capabilities. The key developments have been highlighted of AI and its elements throughout the years since its known inception. While the room to grow and expand our understanding is forever prevalent and visible, it is important to comprehend the growing role it has taken on mankind. Furthermore, the current state of literature is generally derived from secondary sources, particularly within the past ten to twenty years, as AI has become exponentially more and more researched and studied during these times.

There have been respective occasions where academics and researchers alike have found disagreements and differences within their research respectively and have had contrasting views on topics such as ML and RL. The prominence of these differences ranges further in their work, yet in some cases result in the same outcomes indicating that the understanding of the foundations of AI were understood universally at the time of scrutiny. The research will undoubtably result in a difference of opinion or methodologies used to come to a resulted outcome. This could have stemmed from a misquotation of figure within a particular experiment or even conducting research within an erroneous pattern. Identification of gaps within research and lapses of time between certain sections are crucial for moving forward. The space is there to explore AI within other disciplines and create a physical network between them to address numerous issues across the entire board.

Most of the current research on AI bases itself on its past findings and research, yet not necessarily the human interaction and connection psychologically with its technologies. Rapid advancement means that time has become limited in some regard to stop and think about the decisions and steps AI takes in various activities and scenarios. We need to understand how these technologies make us feel, whether it can help us as humans, and consider how future developments will interact with mankind on a personal level. Research has shown glimpses of this being the case for most, but as mentioned previously, the space is there to expand, and investigate whether AI has its other uses. With sport, AI has been involved in VAR technologies, team management and even training preparation pre- and post-game involvement. With psychology, heavy funding has gone into healthcare and wellbeing, allowing tasks from patient check-ups to open-heart surgeries more seamless, while extracting thorough data for future use.

The key is to understand that AI is not there to replace us; but rather there to advance us as research has established. Mankind will always be in ultimate control as we the ones that program and implement these technologies into our daily lives. The aim is to utilise it to the best of its abilities, and really push capabilities for us on a subjective level.

We have seen AI move at an exponential rate in our lifetimes, even more so within the start of the millennium. The real investigation is whether we can build on it rapidly. Limitations simply cannot be placed on such technologies in terms of advancement; a classic example being the ability to live and see in virtual environments on a day-to-day basis. Our trust in AI will undeniably be questioned, and our ethical approach will be key moving forward. Questions will continuously be asked of AI to advance our understanding, and the answers may lie in the fact that ultimately, by figuring out how AI can help us on an individual basis, we may in turn help mankind sooner rather than later.

It is clear to see how Artificial Intelligence has produced and developed into useful systems and technology since its birth. However, it is generally acknowledged that the fundamental goal of achieving human-level intelligence is still a distant thought. With much discussion and argument considering what the best approaches for AI are, laying the core foundations for achieving these long-term ambitions is as imperative as ever, indicating particularly the importance of the past forty years of research. There are still many challenges and obstacles we face; it is inevitable with such a significant theme such as AI. Nevertheless, the research we do undertake in its many aspects will no doubt bring us one step closer to achieving a closer link and deeper understanding of Artificial Intelligence.

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