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The Intelligence Spectrum: Unraveling the Path from ANI to ASI

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Abstract: The transformation of natural intelligence into artificial intelligence (AI) has generated significant excitement regarding its current and future impact. AI's integration into various domains has established its presence in nearly all aspects of life, leading to high expectations from narrow AI to general AI and even super AI. This paper provides a comprehensive analysis of AI's current achievements and future prospects by examining the journey from natural intelligence to AI. It explores the foundational principles of natural intelligence, focusing on human information processing, reasoning, and learning. The paper then traces the development of AI models i.e. machine learning models, neural networks, and advanced algorithms, that emulate and enhance human cognitive abilities. Looking ahead, it speculates on the future of intelligence, particularly the potential emergence of Artificial General Intelligence (AGI) with human-like cognitive capabilities across diverse domains. The synthesis of natural and artificial intelligence presents both opportunities and challenges, necessitating careful consideration, ethical deliberation, and collaborative efforts to ensure intelligent systems benefit humanity responsibly. The author also proposes hypotheses based on philosophical and religious beliefs to enhance AI performance. Ultimately, the paper envisions a limited but expanding role for AI within a defined scope.

Keywords: Artificial Intelligence, Artificial Narrow Intelligence, Artificial Super Intelligence, Human Heart, Future Artificial Intelligence, Heart Cognition.

1. Introduction

Artificial Intelligence has revolutionized the present world and according to famous AI scientist, Andrew Ng. "*AI is new electricity*" [116]. Just like electricity, which transformed almost everything around 100 years ago, AI will also bring the same revolution. This huge impact on human society creates the research interest to know its current and future impact and implications.

Intelligence is a multidimensional and complex phenomenon which has been the focus of curiosity of thinkers, scientists, and philosophers throughout history. Intelligence is usually identified through its features like learning, adapting, reasoning, and solve problems. Roughly it could be stated that this is a cognitive process that humans and other living beings use to solve various problems.

Similar to the understanding of intelligence, measuring intelligence is also a complex process. Scientists and social scientists have developed various tests and models to measure intelligence like psychometric tests and IQ tests. These tests attempt to qualify and quantify intelligence as maximum as possible however intelligence is a broad concept which is difficult to capture through these tests. The researchers are trying to identify the basics of intelligence in terms of quantitative and measurable factors [85].

Artificial intelligence (performing intelligent tasks through artificial means i.e. computation) can perform the tasks in faster and more efficient way. It can enhance the natural intelligence in multiple ways: Complementing the human capabilities to the extent beyond human perception and expectation [43]. Augmenting Cognitive Abilities where AI tools can assist with tasks that require significant mental effort i.e. faster calculations, complex pattern recognition and extraction, automating routine tasks and supporting natural intelligence to work more creatively.

Today we can find lot of AI based services and products which can either perform single task or group of tasks. An application performing single task is said to possess narrow intelligence whereas an application/service performing multiple tasks is known to possess (limited) general intelligence. It is estimated that AI based global economy will rise to $15 trillion by 2030 [44]. It is a hot debate in research community that whether advancements in AI can compete natural intelligence and go beyond it. A number of researchers believe that level of super intelligence is achievable whereas others believe that it is impossible. In this work our main motivation is to explore through different aspects to understand and predict the future of artificial intelligence. This work presents the types and emergence of AI with its potential roles in human society. In this context, we will focus on:

- Prominent features which define natural intelligence and define the criteria for computer systems to be intelligent.
- Explore different types of computational methods being used for constructing artificial intelligence in machines.
- Overview of different intelligence levels that are expected to be achieved by the software systems.
- Provide a detailed discussion on the achievability of these levels with author own opinion.
- Understand and evaluate the heart cognition with brain cognition.
- Explore the religious perspective about heart-brain cognition.

The rest of the paper is organized as follows. The section-2 "Research Methodology" presents the procedure of this study. Section-3 discusses about the concepts of natural and artificial intelligence which provide the basis for analysis of AI progress. Section-4 reviews the existing related research, intelligence types and methods used for materialization of those AI types. This section also discusses how natural intelligence is mapped to artificial intelligence through different artifacts. For validation of a system posing AI, field experts have developed a set of tests which are discussed in this section too. Section-5 provides a comprehensive discussion on achievability of different levels of AI from scientific and religious perspectives. Finally, section-6 provides a discussion on AI future and concludes the work.

2. Research Methodology

As first step of this study, I formulated the scope by listening the points to cover, in order to understand this journey of intelligence. Here is the list of research questions for this research:

- What are different methods being used and explored to achieve the highest level of AI?
- Is it scientifically possible to advance Artificial Intelligence to AGI and ASI level?
- How do religious perspectives fit into this context, and do they offer any insights?

Next, research sources are identified, mainly these are research search engines like Google Scholar and IEEE explore. The search strings used on different research publication platforms include:

"Natural intelligence", "evolution of artificial intelligence", "natural to artificial intelligence", "artificial super intelligence", "artificial general intelligence", "intelligence in religion", "point of intelligence in human body"," Intelligence In heart or brain", "computational modeling *of human brain", "cognitive modeling", "heart modeling", "heart intuition", "heart intelligence", "neuroradiology"*

Considering the nature of articles, sources like websites, books and blogs are also considered, as shown in the reference section. In first round more than 200 articles are collected. The articles clearly supporting or opposing the author point of view are filtered and used in further knowledge building. During review process, based on type of a point under discussion, articles specific to the point are searched and reviewed which helped the author to have solid evidence in favor of his point of view. In addition to these, religious sculptures and relevant research artifacts are also consulted.

3. Research Background

Before exploring more about AI, we look at the important aspects of intelligence.

a. Intention

Intentionality can be defined in multiple ways:

"*The fact or* quality *of being done on purpose or with intent*" (dictionary.com)

"The quality of mental states (e.g. thoughts, beliefs, desires, hopes) which consists in their being directed towards some object or state of affairs" (oxfordreference.com)

It is the mental state and capabilities of mind that can represent and reasons about the decision it has taken. The state of mind and affairs can be described by a complete sentence, by complete concept or thought. As an example, when we think of something i.e. chair, our mind refers to some particular things based on its observations and previous knowledge, or when someone names "cooking", our mind has a concept about it, the mind understands that to which it is referring and why. If one believes that she is beautiful lady, this belief represents the intentionality. You wish to get your business established, this desire shows your intention, and similarly the perceptions are directed to some way i.e. people believe that Saudi Arabia is a rich country. In short, intentionality refers to aboutness of things [8]. It is important to point that any intentional concept or decision has solid logical reasoning and understanding which provide the base of the decision. There are some important questions that need to be understood in context of intension such as how a representation is reached, how a complex representation is derived from its constituent representations, how one's mental state and meaning of external symbols used to represent the mental state are correlated and finally all decisions made by mind are really intentional? [9].

b. Cognition & Metacognition

The concept of cognition can be defined as

"*the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses.*" (oxfordreference.com).

Although this definition covers many aspects of cognition, however the term "cognition" does not have single, stable and well-behaved meaning [17]. It covers all aspects of intellectual functions. We use cognition throughout our life and almost in all activities. Recent cognitive theory [18] is divided into two branches 1) mental representation: how mental states and thoughts are represented internally in mind such that they can be mapped to symbols in computational system. This aspect considers the mental states similar to data structures (symbols) which are processed by the brain. 2) Computation: it attempts to understand human thoughts and reasoning process based on acquired information. The CRTT assumes thinking as a process of computation leading to formulate mind as symbol processing machine. Scientists are attempting to develop a unified theory of cognition through software which can learn automatically and based on that learning can solve the problems [18]. Another theory of cognition is based on assimilation and accommodation. Assimilation refers to interpretation of world according to human internal model of understanding whereas adjusting that model based on experience is known as accommodation [19]. Cognition leads to rationality and rational behavior. Rationality is the quality or process which is based on logic and reasoning. In other words, rationality is based on cognition.

Metacognition is an important property which allows the intelligent agents (i.e. human being) to reason about their own decisions and awareness about their thought process. It could be summarized as "thinking about thinking". It consists of two things: knowledge and regulation. Considering the case of an intelligent agent, the knowledge about itself like its capabilities, available resources and the "rule base(s)" form the Knowledge component. The formulation of process which decides about the application of rules taken from the "rule base" to apply on current situation is called the regulation. Regulation is basically a planning and performance monitoring process [20]. A good discussion of cognition and consciousness can be found in [132].

c. Natural Intelligence (NI)

Understanding the concept of natural intelligence is crucial before we delve deeper into our discussion. Making rational decisions and showing rationality about actions is the depiction of intelligence. According to website ec.europa.edu, natural intelligence can be defined as

"the intelligence created by nature, natural evolutionary mechanisms, as biological intelligence embodied as the brain, animal and human and any hypothetical alien intelligence (ec.europa.eu)".

Few other interesting definitions of NI are given below:

"Natural Intelligence refers to an intellectual quest to understand nature's survival strategies accumulated over 3+ billion years and etched into the DNA of circa 8.7 million species alive today in order to tool ourselves with strategies for adapting to global change"(https://naturalintelligence.com/)

Intelligence is an ultimate power of human brains aggregated from sensory (data), neural pathways (information), neural representations (knowledge), as well as real-time inference and problem-solving capabilities (intelligence), where the corresponding terms in parentheses are counterparts in AI and computational science [128].

From Muslim religious point of view, the intellect is the property of understanding, creating and comprehending speech, vision and visualization, feeling and thinking, created by Allah in human beings, Jinns and angles.

"And Allah brought you out of the wombs of your mothers while you knew nothing, and gave you hearing, sight, and intellect so perhaps you would be thankful. (16:78)"

Researchers and Psychologists characterize the natural intelligence through a set of diverse traits (logical and physical) which may consists of learning, reasoning, problem solving, language use and perceptions (britannica.com/science/psychology). Although a lot of research is done in computational and mathematical modelling of human brain to understand the "mind", still there is no reliable and comprehensive model for brain functions [12]. Neuroscience is still searching and researching to understand the relationship between different brain components. According to [13]:

"a fundamental challenge remains to understand how the brain's structural wiring supports cognitive process".

With this incomplete and partially known knowledge, the researchers in the field of computation attempt to imitate the working of brain through algorithms and computational hardware. Attempts in this direction have created a new field of knowledge called Artificial Intelligence (AI). If we consider brain as physical biological device and mind as an abstract concept, AI attempt to incorporate "mind" (smart algorithm) into brain (processors).

d. Artificial Intelligence (AI)

According to oxford dictionary, Artificial Intelligence is defined as:

"the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages (languages.oxford.com)"

AI intends to develop computer systems that can perform the tasks which require usually human intelligence. Artificial Intelligence (AI) intends the creation of software or complete computer systems which can mimic human intelligence and can perform the tasks in human like way. The list of tasks that require human cognition can include observing, learning, reasoning, language understanding, language creation and logical decision making.

The main objective of AI is to develop systems that can autonomously collect, understand and analyze data. Such systems can adapt to changing environments and improve their performance through data analysis and previous decision making without explicit reprogramming. There are lot of hypes about AI and its impact on society, however the dependance of current AI on data, makes it weak and limited in its nature which characterizes the AI models as loose thinking of human cognition process [65].

4. Literature Review

Comparative analysis of natural and artificial intelligence is not a new topic. Since the emergence of the term "Artificial Intelligence", it remains a continued discussion. Both types of intelligence are analyzed through various aspects. Research community have published a number of studies comparing natural and artificial intelligence, analyzing the journey of artificial intelligence, understanding the human brain operations and translating them into algorithms. In order to discuss the materialization of natural intelligence into artificial intelligence, it is very necessary to understand the human brain, its cognitive functions and its mechanism to generate intelligence.

4.1. Cognitive Modeling

Human brain is considered to have quantum nature with lot of thoughts at a time and we cannot chose what to think, on the other hand in present computational machines, we always have control on processing and execution. The biological structures microtubules are considered to form the quantum nature of brain.

The journey of AI starts with human mind understanding and attempting to replicate its functionality in machines. Cognitive modeling is the process of understanding and mapping the human brain functioning and underlying mechanisms in the context of computation and then represented in the form of theoretical constructs known as cognitive models. By creating a simplified and abstract representation of these processes, cognitive models allow us to study the natural intelligence. A number of cognitive models have been proposed in literature that may include symbolic models (ACT-R & SOAR), connectionist models

(neural networks), production systems, and agent-based modeling and hybrid models. In following text, we review few cognitive models to understand the mapping of NI algorithms to AI domain.

Authors in [140] have proposed a cognitive computational model named "four component architecture for production systems (4CAPS) to simulate cognition and predict brain functions. This model is built on some previous cognitive models i.e. SOAR, ACT-R, EPIC. This computational model is described as a theoretical framework that simulates cognitive processes by using computer algorithms to replicate the way the brain functions for specific tasks. The model aims to predict evident variables such as human response, error patterns, and brain activation levels. This research highlights the model's potential for advancing our understanding of cognitive computation and brain functions.

G Vitiello in [121] discuss the intelligence as electrical signal-based computation like Spontaneous Symmetry Breaking (SSB) model. The author considers veracious natural intelligence modeling like MEE [memory states + electrical signal processing + energy exchange between brain and environment]. He argues that past of one could be considered as mirror of self in time and interacting with that one use for learning i.e. learn from past. The author further argues that chaotic classical trajectories caused by the change in memory states provide the basis for unpredictable behavior. Machines operate in well-defined and ordered chain of steps whereas human mind does follow these restrictions. The author considers humans as machines that exhibit unpredictable or irregular behavior not influenced by external observers due to "novelness" nature of intelligence (human brain). Finaly, he states that it is difficult to model brain functional activities in current AI research framework. G. Vitiello concludes his discussion with the comment

"Unfortunately, AI projects today are still limited to the design of "stupid stars (G Vitiello)"

According to Ferud. S [133], in his theory of personality, the human mind consists of three components: 1) id, 2) ego and 3) super ego. Ego is the sense of selfness where one understands itself as an entity. Physically a part of brain called tectum (colliculi) in connection with other components and processes like hormone levels and breeding forms, the concept/relationship known as selfness. It is also known as rational and decision-making part of mind. The super ego also known as "moral compass" or "conscience" is considered to be responsible for moral standards, idealized self-image which is a judgmental part of image. Physically, it is located in the prefrontal cortex. Finally, the "id" (unconscious) is the impulsive and pleasure-seeking part of mind. The generation of thoughts, their processing and finalization is shown below:

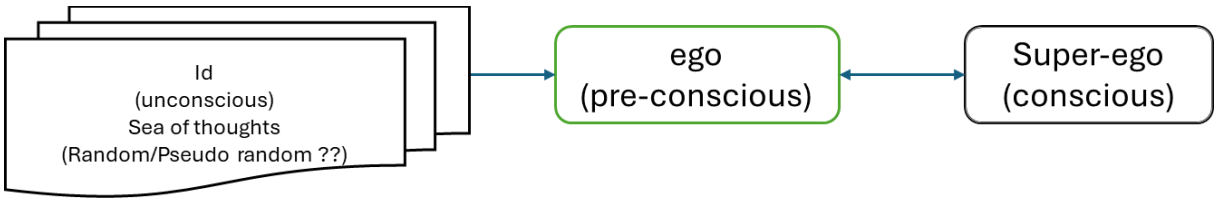

Figure 1. The process of idea generation to Decision Making

In figure-1, it can be seen that there is a large set of thoughts which float in unconsciousness all the time. Few of them move to ego part which are finalized in super-ego part. Now here is an important question that how the "list of thoughts" is prepared with dynamic updating? Although scientists have presented different theories in this context, however more research is required. If we can understand this mechanism, we would better be able to build vital part of intelligence in machines.

Authors in [142] present a cognitive framework for developing theory of mind (ToM) for AI to create computational models that can deduce goals, beliefs and intentions of others like humans. In this work the authors have studied the existing computational methods like Bayesian (probabilistic) ToM and machine (deep learning based) ToM and have proposed a new approach called CogToM which is based on instance-based learning theory to simulates how humans learn and predict others' behavior through experience and observational skills.

Recently we have observed huge success of large language models which are an advancement toward AGI and can perform multiple tasks however for many tasks, these models perform with unhuman like characteristics. Researchers [141] are attempting to transform such computational model into high performing cognitive models which can work even better than human.

4.1.1. Discussion

A number of human brain models have been proposed in literature however all computational models are still incomplete, even the most successful "attention" based models are incomplete where they fail to consider the hierarchical and multi-feedback mechanism [125]. Through literature review, it is observed that instead of understanding the human brain and replicating its function to silicon chips, now researchers are attempting to incorporate computational models to build/improve cognitive models. There are number of directions which are being explored for development of better cognitive models leading to more intelligent algorithms and machines. Few of these directions include the neuro-science informed models (brain-computer interfaces), inter-disciplinary collaboration and human-AI teamwork.

4.2. Types of Artificial Intelligence

Based on the scope of the algorithm (no. of tasks to be addressed) and AI based problem solving model, AI can be classified as follows:

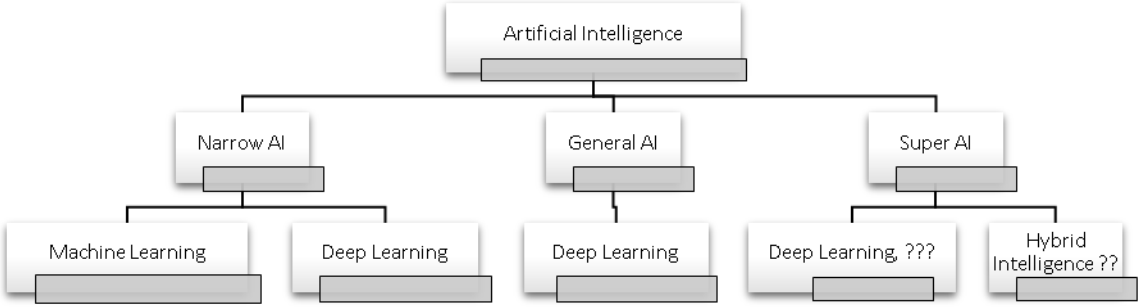

Figure 2. Hierarchy of Artificial Intelligence

Based on scope of type of AI, it can also be visualized as:

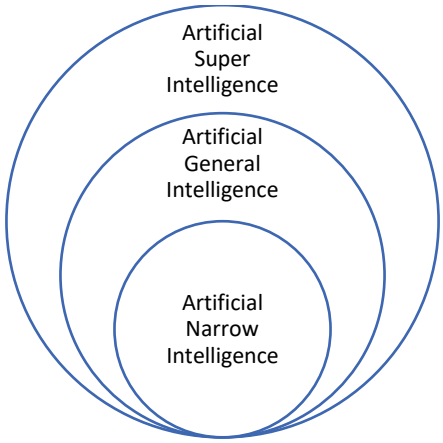

Figure 3. Scope of different types of Artificial Intelligence

Considering figure 3, as we move from inner circle to outer circle, our discussion will also travel from experimental to philosophical direction.

4.2.1. Artificial Narrow Intelligence (ANI)

Artificial Narrow Intelligence (ANI), also known as Narrow Artificial Intelligence (NAI) or weak artificial intelligence, refers to the ability of a software or computer system to solve a specific and difficult problem [21]. It is a type of artificial intelligence (AI) that considers solving particular tasks or challenges, such as self-driving cars, image classifiers, and language translators [22]. Almost all AI solutions that we observe today can be categorized as NAI solutions. While NAI has shown impressive advancements in recent years, the development of general intelligence remains elusive [23]. NAI applications are organized by the type of problem they address, such as text comprehension, speech recognition, and computer vision. Weak AI considers the computer as a powerful machine to understand the working of human mind where the hypothesis (in the form of programs) are written to test psychological explanations of phenomena.

Pros: Generally, AI uses mathematical or statistical models (formulas or algorithms) to solve the tasks intelligently. If the algorithm is focused on only one or partial task, it requires less computation and algorithm design can focus only on solving that problem. This makes the problem easier for the researchers and developers. NAI models have outperformed the human capabilities in those domains for which they are designed and trained. The models requiring less computational resources and time are cost-effective

and can easily be deployed. Traditional machine learning methods take very less time as compared to neural networks which require large amounts of time when they are trained. For example, if we consider the network in [32], its training time is 36 minutes. This training time is directly proportional to dataset size and training cycles (epochs). The time complexity of neural networks is given as $O(E * W)$, where E is the number of training epochs and W is the set of weights [30, 31]. A good discussion of time and space complexity can be found in [32].

Cons: Despite good performance, there are number of issues associated with NAI models whether they are neural networks or traditional machine learning methods like SVM. As the NAI models are designed and trained only for specific tasks and using available data, they usually fail to generalize for unseen data, or their performance deteriorates. There are many such failure examples like 2010 flash crash [33] and Tesla Model S crashes into a van [34]. Narrow AI models, in their current state, lack human level intelligence, even for specific tasks like common sense reasoning, empathy, and feelings. The NAI models learn from available data where quantity and quality of data can affect the performance of NAI model. If data is biased, the output of the system will also show bias. It is a general rule that more the data is used in training, the more model generalizability is achieved. NAI models present various other challenges like they can malfunction, malicious attacks can be made on them, and mismatched objectives can lead them to unwanted and unexpected outputs. For example, Tay Chatbot [35] by Microsoft Crop. That after its deployment, started to post inflammatory and offensive tweets resulting in its shutdown after 16 hours of its launch. As reported by Microsoft, the bot was trolls who attacked, and bot replied to them following their style [36] which is an example of model biasness. Currently NAI also lacks a generally accepted theory of intelligence [35]. Considering the current deep learning models, if they are not retrained on new data, they become biased and lead to declining performance with the passage of time. On the other hand, continual training of models require significant amount of time and energy.

In short, although NAI has shown good performance and solving a big number of tasks, there is need to address its limitations to safeguard against unexpected and unwanted results.

4.2.2. Artificial General Intelligence (AGI)

Smart machines that can execute the functions at or beyond the natural intelligence (human intelligence) level are said to possess artificial general intelligence (AGI) or strong AI i.e. it possesses the intelligence characteristics as described in section 3 (and those characteristics are not well defined yet). A human can solve a problem using multiple intelligent approaches, building such intelligence in machines is a hard task, and the problems that require multidimensional intelligence for their solution are known as "AI complete" or "AI hard" [58]. According to [15]

"An artificial intelligence system can have a mind and consciousness."

Marcus Hutter et. al. in [68] proposed the mathematical formulation of AGI in the form of AIXI (hypothetical) agent that attempts to maximize:

"the ability to satisfy goals in a wide range of environments [68]"

However, this model is not computable and subjective [72]. The type of AGI mathematically formulated is known as universal artificial intelligence. At present, we cannot find any system that can meet the AGI agreed upon criteria and therefore AGI, at present, is a hypothetical type of artificial intelligence (AI) that can match the human intelligence [47]. It would have the ability to learn from any domain of knowledge, reason logically, and understand natural language. In strong AI, the computer is not considered just as a tool but a machine that is programmed and represents a mind with right level of intelligence with intentions. In other words, the programs are themselves explanations. Strong AI systems have "mental" states where the hypothesis (programs) are not mere tools to find psychological descriptions rather the programs are explanations themselves. Scholars and researchers have proposed various cognitive architectures for the development of strong artificial intelligence, incorporating hybrid approaches and psychophysiological foundations [40] as discussed above. However, there is no consensus on how to define or measure intelligence, or whether AGI is possible or desirable [38] therefore Artificial General Intelligence remains theoretical. Researchers and tech-based organizations are continuously working toward the development of AGI based applications. Following few examples to show the progress towards AGI:

OpenAI: It is a research organization that intend to create useful and safe AGI applications. Latest GPT models like GPT-4 which can generate natural language text on various topics in the form of question answers or prompts and their responses. (https://openai.com/).

DeepMind: This organization, a subsidiary of Google, also intends to create general purpose AI systems. Some of its AGI directed applications include AlphaGo, AlphaFold, Gemini, Palm-2 and Imagen-2. (https://deepmind.google/)

Anthropic: A research institute that seeks to understand and line up the goals of AGI with those of humans. Anthropic is working on building interpretable and scalable AI systems that can be trusted and controlled. Claude is its main product that is an AI assistant for different tasks. (https://www.anthropic.com/)

Above cited examples are the AI models that can perform multiple tasks at a time however researchers argue that these do not represent the true AGI [46, 47]. Artificial Intelligence is still in its evolving form where we observe new and innovative methods being developed continuously. There are different theoretical approaches being developed and investigated for the materialization of AGI in different AI research directions that include symbolic AI, emergentist approaches, hybrid intelligence methods and Universalists methods [47]. Considering the success rate of AI models, it is expected that neurobiological inspired computational methods will lead to the high performing methods [48]. Deep learning methods like neural networks and simulations of the human brain are recent potential candidates in this context [45, 52]. Researchers are even working on establishing frameworks for the materialization of AGI [49, 50, 51, 102]. However, various researchers also consider AGI as science fiction and a topic in future studies [52].

Pros: Considering above discussion, AGI has wide variety of applications and can help in solving many social and scientific problems. It can result in the production of self-aware, conscious, and sustainable machines that can create electromechanical duplicates of living intelligent organisms. On the positive side, humans will get workers and assistants that can handle multiple intelligent tasks relieving them and making their lives more comfortable and enjoyable. Current uses of question answering chatbots like Open AI ChatGPT, Google Gemini and Microsoft Co-pilot present a small picture of future AGI systems. Researchers believe that AI will only be beneficial for human society. An interesting communication about the effects of growing artificial intelligence can be found in [60].

Cons: On the negative side, creation of AGI systems and machines will produce human competitors resulting in serious threat to humanity. The potential of strong artificial intelligence to reach human-level or even surpass it will challenge our understanding of the world and the concept of being a creation by God [41]. First and foremost danger is the mass level unemployment. Pawel Gmyrek et. al. [62] analysed the unemployment caused by generative AI, one of the pre-AGI applications, and found that 24% percent of clerical tasks are highly affected whereas other professions show 1-4% affect. Other major danger is that machines trained on biased data will result in biased decisions based on (artificially generated) liking and disliking of developers and creators [59] or biasness generated through training data. Creating self-governing machines will lose the control of human and machines may create their own ways to operate which could be un-understandable or even harmful for the human community [35] and will create sever concerns about validity and reliability of AGI systems.. A detailed article [63], about unemployment caused by AGI, presents more specific statistics. Conflicts ranging from personal to national level can lead to use of AGI machines for military purposes resulting in destruction and extinction of human being [61]. Other threats posed include autonomous weapons, social manipulation, social grading, invasion of privacy, conflicting goals of humans and machines and discrimination by machines about humans. Finally, with the increase in AGI applications, social dependency on algorithms and machines will increase at a rapid pace resulting in sever decrease of human expertise?

Development of AGI applications raise ethical dilemmas and existential questions about the impact of AI on human uniqueness and its society [39]. The interaction between artificial intelligence and humans in various domains, such as transportation and legal proceedings, highlights the need for legal regulation and ethical principles in the development and use of strong artificial intelligence [42].

4.2.3. Artificial Super Intelligence

ASI is the intelligence that exceeds the natural intelligence i.e. intelligence of human being. It is considered the branch of intelligence that can perform smartest tasks which are virtually impossible for humans to do. A software, hardware or an integrated system that possesses intelligence is called intelligent agent. Like many other terms, the term "artificial super intelligence" is also not well defined. According to Merriam-webster dictionary:

"an entity that surpasses humans in overall intelligence or in some particular measure of intelligence [73]"

Based on our previous discussion, we have observed that it is still far to achieve general intelligence therefore ASI is considered as hypothetical type of intelligence which we can perceive only at present and are not sure when to achieve it or whether we can achieve it or not. It is to mention that an artificial super intelligence surpasses human intelligence not only in one ability but across all cognitive abilities like learning, creativity, problem solving, understanding and expressing.

The development of ASI poses significant challenges and raises ethical, societal, and safety concerns that researchers and policymakers are actively addressing as AI technology continues to advance. Considering the advantages of super intelligence, we can hypothesize that ASI will be able to solve complex and even unknown problems. Researchers and philosophers have varying views about super intelligence. Some of them believe that ASI if created sometime would be almost impossible to control and it would take over this world resulting in deterioration of human society [64]. Superintelligence urges vigilance and thoughtful planning to navigate the evolving landscape of AI and superintelligence. Following table provides a comparative view of three types of AI.

Table 1. Comparative view of different Artificial Intelligence Types

Feature	**Artificial Narrow Intelligence (ANI)**	**Artificial General Intelligence (AGI)**	**Artificial Superintelligence (ASI)**
Definition	Specialized AI that can only solve specific tasks $ANI < NI$	AI that possesses general cognitive abilities across a wide range of tasks $AGI = NI$	AI that beats natural intelligence in all aspects $ASI > NI$
Scope of Functionality	Limited to predefined tasks	AGI can perform any cognitive tasks which human can do.	Capable of outperforming the best human minds in every field
Current Status	Presently in widespread use (e.g., Siri, Alexa, self-driving cars).	Still theoretical. Research is ongoing, but no true AGI systems currently exist.	Purely speculative and hypothetical at this stage. No ASI systems exist.
Learning Capability	Limited learning capability	Advanced learning capability much like humans	Possesses superior learning abilities Potentially capable of self-improvement and recursive learning.
Cognitive Ability	Mimics human intelligence in specific areas, without general understanding.	Exhibits human-like cognitive abilities.	Exceeds human cognitive abilities, potentially developing new forms of reasoning and intelligence.
Autonomy	Operates within the specified limits. Lacks true autonomy.	Would have autonomy similar to humans. Independent decision making.	High level of autonomy that may be incomprehensible to humans.
Examples	Image recognition systems, virtual assistants (e.g., Siri, Google Assistant)	A robot capable of performing any task a human can do.	Speculative entities like an AI that can design new technologies and solve unsolvable problems

Potential Risks	Risks (e.g. bias) are generally limited to the task it performs	Potential loss of human control, ethical dilemmas, and unforeseen consequences of autonomous decision-making.	Existential risks: The possibility of AI developing goals that are misaligned with human interests.
Ethical Concerns	Primarily focused on bias, fairness, privacy, and transparency in narrow applications.	Raises significant ethical concerns regarding consciousness, rights, and moral responsibility.	Entails profound ethical challenges, including issues of power, control, and the long-term survival of humanity.
Development Timeline	Actively being developed and used in society	Estimated to be decades away, if achievable.	The timeline is speculative and unknown Could be far in the future or never realized.
Impact on Society	Already transforming society in almost all aspects.	Will revolutionizing every aspect of life, including work, education, and governance.	Could fundamentally change the nature of human existence, with unknown consequences for society.

4.3. Directions of AI Advancements

The advancement in AI can be categorized as:

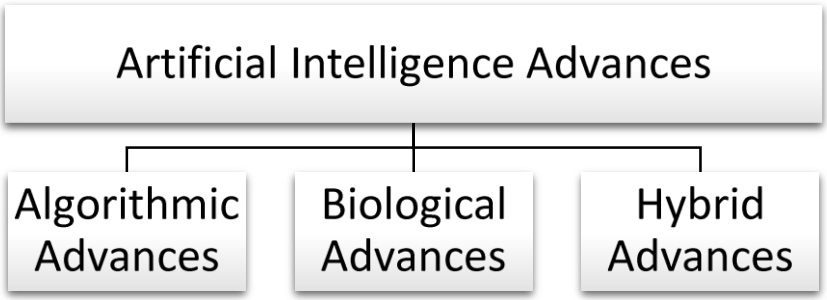

Figure 4. Directions of advancements in Artificial Intelligence

4.3.1. Algorithmic Advancements

Researchers argue that advancements in AI will result in a general system with limited cognition at the start and later on these limitations will also be addressed. Researchers are developing new algorithms on a regular basis for the use of Artificial Intelligence in each domain of application. As an example, use of AI in IoT is being explored and even smart sensors are being developed for cost-effective and intelligent monitoring approaches. The sensors being developed possess multiple capabilities like computer vision, voice recognition, gesture recognition, measuring the presence and intensity of different gases and water [77].

Different algorithm development directions are under research community focus that include brain inspired algorithms i.e. neural networks, nature inspired methods like evolutionary algorithms and swarm intelligence, optimization methods. Brain informatics, an interdisciplinary field, focuses on studying and understanding the information processing mechanisms of the brain and applying that knowledge to the development of computational models and technologies [83]. New domains are being discovered for the application of AI which also guide the development of improved algorithms as domain knowledge plays a good role in algorithm development [79, 80].

Use of Deep Neural Networks (DNNs) in AI algorithms has shown high performance almost in all tasks and researchers are continuously focusing to improve them to achieve AGI and even can go beyond. Recent Deep Learning methods are too deep and large in parameter count (i.e. GPT4 has around 1 trillion parameters [82]) that they have become unexplainable and uninterpretable. The algorithms with these capabilities are not trustworthy and they can misbehave with changing of few parameters creating hindrance in real-time and crucial applications. To understand the behavior of these algorithms, scientists have recently shifted their focus towards building trustworthy AI [81]. Other emerging AI algorithms evolution directions include AI for social good, Quantum Computing and neuro Symbolic AI. Different research journals are publishing special issues about the advances in artificial intelligence [76] whereas there are specific journals only to report the progress in algorithmic developments in this field [77]. Both algorithm developers and computer hardware manufacturers are building AI focused artifacts and products [78].

4.3.2. Biological Advancements

The biological modifications in humans like DNA modification can result in a product possessing super intelligence [66]. Some other researchers have different believes that humans will evolve mentally, physically, and emotionally to reach the level of ASI. Scientists are experimenting to improve natural (human) intelligence through various means like use of nutrients [82]. There are multiple conventional and modern methods being used to improve human intelligence which include education, cognitive training, physical exercises, brain boosting foods, mindfulness and meditation, genetic interventions, pharmacological interventions, neurofeedback, cognitive prosthetics and brain computer interface. There are number of studies about human enhancement through genome editing to produce transhumanism [86] and improve genetic traits [87]. Gene editing related current progress can be seen in number of recent researches [88-92]. While there have been notable advancements in various fields of biology and neuroscience. The idea of achieving superintelligence through biological means faces numerous ethical, technical, and conceptual challenges.

4.3.3. *Hybrid Advancement*

Once the biological advancements were out of scope of artificial intelligence, however with new interdisciplinary and collaborative research biological advancements have found their role in AI. Even the recent advances have shown that silicon-biology integration is new wave in AI research. There are number of studies which are focusing on direct communication of natural and artificial intelligence. Human brain interface based applications can provide the basis for creating super intelligence using best of both. Human brains are likely to interface with AI systems for problem solving or can upload their minds to computers to augment and enhance the intelligence. Human intelligence augmentation (IA) can be achieved in two ways 1) using AI models and tools to enhance natural intelligence and 2) deploying both intelligences to solve routine and difficult tasks. IA aims to create a symbiotic relationship between humans and machines, where machines augment human abilities rather than replace them [95]. This augmentation is both ways: from AI to natural intelligence (NI) and vice versa [93, 94, 96]. Here we will only discuss the second technique.

Brain-Computer Interface (BCI) technology involves direct interaction between the brain and an external device, i.e. computer. While BCIs are primarily developed to assist individuals with neurological conditions, they also hold potential for augmenting human intelligence and facilitating direct interaction between the brain and computational systems.

Motor memory (muscle memory or motor learning) is the ability of the brain to acquire, store, and retrieve information related to motor skills and movements. There are number of characteristics associated with motor memory which AI can explore and benefit. These characteristics include skill acquisition, practice, neural plasticity, consolidation, transfer learning and self-error correction. Scientists consider human memories are realizable [98] and investors are putting large funds for human brain and memory communication with computers. Interesting applications of memory augmentation can be found in literature [97]. Recently, scientists have published the largest human brain map [99] to understand the operation, cognition and decision making.

4.4. Artificial Intelligence Materialization Pathways

Scientific community is exploring multiple ways to achieve highest level of machine intelligence. Generally, Artificial Intelligence (AI) is considered as the application of mathematical methods to mimic human intelligence. These methods can be grouped majorly as mathematical and statistical (applied side of mathematics) methods. Whereas hybrid intelligence is also emerging as a new dimension. These approaches can be further divided into different categories based on the method used to solve the problem as shown in figure-1.

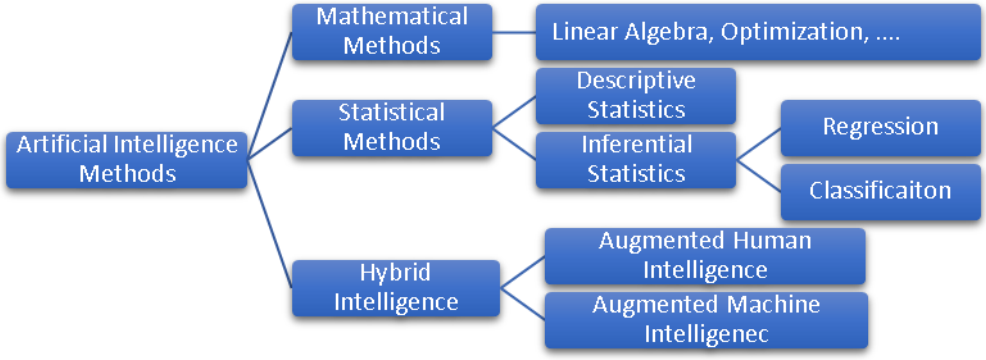

Figure 5. Classification of AI methods

4.4.1. Mathematical Methods

Mathematical methods are generally used to perform the "accurate" or "exact" AI. Data for such methods is also precise and certain, leading to exact results [24]. These methods use well defined rules and their manipulation mechanisms. Mathematical methods also encompass areas like logic, predicate calculus, propositional calculus, modal logic, theorem proving, non-monotonic and temporal reasoning. Commonly, these focus on numerical methods for expressing concepts and relevant details. Mathematical methods provide the foundations for algorithms and models in AI including those used in machine learning and neural networks. Examples of mathematical methods may include linear algebra, calculus, optimization, graph theory, and information theory. One of their major applications is rule based expert systems where domain expert coined rules are used to decide about given problem. There are number of characteristics associated with mathematical methods like formal and precise results, modeling of complex relationships and efficiency in computation. Several researchers have analyzed the application of traditional mathematical methods in AI [25, 26, 27] and in early applications of AI, these methods shown good performance.

4.4.2. Statistical Methods

Statistical methods are based on data and mathematical methods to create methods that can provide insights and predictions about the future data. These methods have certain properties like developing experience from historical data, handling uncertainty and variability in data, use of probabilistic aspects to understand the data and then mine the data to find patterns and phenomena explanations. For example, machine learning uses data mining techniques (statistical) and learning algorithms (mathematical) to build models. AI then uses these models to reason about the world and achieve intelligent behavior. The statistical methods are usually categorized as descriptive and predictive statistical methods. Most of the recent applications of AI methods are predictive statistics that include the regression and classification. Examples of these methods include machine learning methods, artificial neural networks, ensemble methods, univariate and multi-variate statistical analysis methods.

4.4.3. Hybrid Intelligence (HI)

HI is an emerging concept that combines the natural and artificial intelligence with the purpose of augmenting human intelligence instead of its replacement. In other words, HI aims to bridge the gap between natural intelligence and artificial intelligence. Hybrid intelligence helps the humans to solve complex and time-consuming tasks by combining the strengths of both type of intelligences. Natural intelligence brings the creativity, emotions, domain expertise and critical thinking whereas artificial intelligence provides fast process, identifying complex and hidden patterns and automating routine and repetitive tasks. Various researchers [129,131] are arguing that the objective and focus of AI developments should be Intelligent Augmentation of complex tasks through integration of human skills and self-learning

AI. This type of intelligence is being named as "Collaborative Intelligence". Examples include medical diagnosis and digital trading. Hybrid intelligence can be categorized as 1) Augmented Human Intelligence and 2) Augmented Machine Intelligence [134]. These formulations of HI include human-in-loop HI and cognitive computing based HI. Recent HI research directions include human-brain interfaces, human-machine collaboration, advanced perceptions and smart environments [135].

Although AI has been derived through NI approaches, AI and brain science can benefit each other. Brain science aims to understand natural laws, while AI focuses on inventing technologies. The collaboration between these fields could lead to significant advancements.

Augmented Human Intelligence (AHI): The process of enhancing the cognitive capabilities of humans through technology, tools and systems to improve the decision making, creativity and problem solving is known as augmented human intelligence. Various ANI applications in common use are examples of AHI i.e. use of speech recognition and auto translation systems. Current deep learning based computational models work like black box where the designer, developer and user do not know about the parameters involved in decision making. According to Open AI, chaptGPT 4.0 has almost 1.8 trillion parameters and even if we can find a way to determine the role of these parameters, it is impossible to understand their collective effect, effect of subset of parameters and their weight adjustment. In this context, to augment human intelligence, the exploration of explainability and interpretability in black box AI models like neural networks is one direction of collaboration. The research community has developed a number of means to achieve interpretability and explainability of AI black box models like intrinsic vs post hoc explainability, model agnostic (Local Interpretable Mode-agnostic Explanations – LIME, SHapley Additive exPlanations - SHAP) and model specific methods (Saliency Maps in Neural Networks). Use of generative AI like large language models with human intelligence is recent AHI materialization direction [136]. We can observe the applications of AHI in many fields like healthcare, technical writing, education and research.

Augmented Machine Intelligence (AMI): AMI is the opposite of AHI where machines' computational and intelligence capabilities are enhanced through the use of human mind. AMI aims to develop mechanisms that can mimic human brain functionality. Use of human brain to augment the computational machines is an interesting and evolving area of research. There are different research directions to understand and materialize of collaboration that include Computational Neuroscience and Neuromorphic computing. Both are closely related disciplines however with different goals, methodologies and applications.

- Computational neuroscience: This branch uses mathematical models, theoretical analysis and computer simulations to understand the brain functionality.
- Neuromorphic computing: This branch of research intends to mimic the neural architecture and processing in silicon chip. It is concerned with design of hardware and software to replicate human mind functions.

The interaction of two branches can be represented as follows:

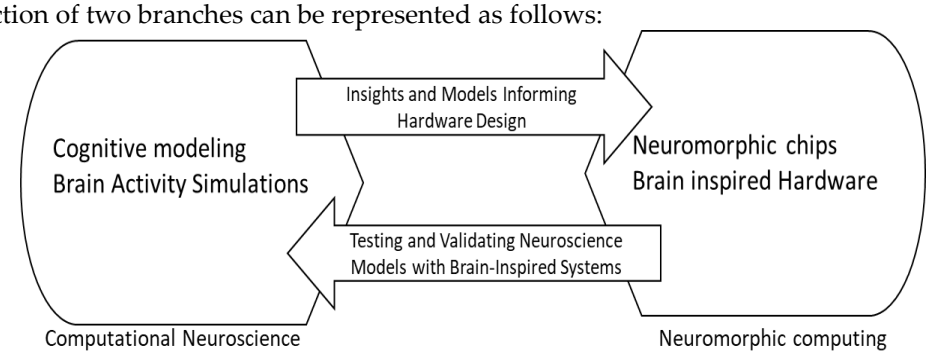

Figure 6. Interaction of Computational Neuroscience and Neuromorphic Computing

Both branches of research are playing vital role in advancing the level of AI. Although Computational neuroscience is providing the basis for developing algorithms functioning similar to human brain however this mainly focuses on theoretical aspect. On the other hand Neuromorphic computing intends to create related products for human being. It has helped to create innovative medical products as described below:

Bio processors: These are type of devices that use biological material for computations such as DNA or proteins. Instead of using electronic circuits these use biological molecules to process data. However, these

are still in experimental phase and are found to be useful for complex and highly parallelizable tasks with low power consumption. Final spark neuro platform is an example of this [137]. According to authors:

"The Neuroplatform enables researchers to run experiments on neural organoids with a lifetime of even more than 100 days [137]".

Organ-on-a-chip (OoC): A cutting-edge technology to mimic the functions of human organs on micro scale. It is a microfluidic, multi-channel 3D cell culture chip with capabilities to simulate the activities, mechanics and physiological responses of complete human organ or part of that. The natural tissues are grown within the microfluidic chip. The examples include the lung on a chip, liver on a chip and heart on a chip [143]. The OoC and AI technologies are being merged to create more intelligent, innovative and biological products. This technology is playing an emerging role in AI advancement. It can create realistic biological environments that can be used to train, validate and improve AI models.

Brain on a chip (BoC): Instead of understanding the working on human brain and then mapping it to computational models, scientists are attempting to use human brain directly in computational machines. It is real time interaction between electrical processor and biological brain where the brain activity signals are translated into output. BoC, a new cutting-edge technology, aims to reproduce brain functions using microfluidic devices [138]. The technologies like Organ on a chip (OoC), Multi-organ on a chip (MoC) and Brain on a chip (BoC) are expanding the boundaries on artificial intelligence. Recently, researchers at Tianjin University, China, has announced the development of an open-source on-chip brain-computer interface intelligent interaction system (MetaBoC). In this system they have deployed the "human brain" in a robot and performed successful intelligent experiments with it.

Table 2. Comparison of different AI methods

Aspect	Mathematical Methods	Statistical Methods	Biological Computational Methods
Purpose	Solving equations, modeling systems, optimization	Analyzing data, making inferences, predictions	Simulating biological processes, modeling organ functions
Basis	Pure mathematics, algebra, calculus	Probability theory, data analysis	Biology, biochemistry, bioinformatics
Key Techniques	Differential equations, linear algebra, calculus	Regression, hypothesis testing, Bayesian methods	DNA computing, neural networks, organ-on-a-chip, brain-on-a-chip
Data Requirements	Can work with abstract models or numerical data	Requires empirical data for analysis	Requires biological samples or simulated environments
Handling Complexity	Can model complex systems with precise equations	Often simplifies complex relationships	Mimics biological complexity through simulations
Interpretability	Typically, high if models are simple	Interpretation can vary; statistical significance	Can be complex; interpretability may vary
Computational Demand	Depends on model complexity; can be high	Generally moderate; higher with complex models	Can be very high, especially for large-scale simulations
Scalability	Scalable with efficient algorithms	Scalable with appropriate data handling	Scaling can be challenging; high computational cost
Flexibility	Highly flexible; adaptable to various problems	Moderate flexibility; constrained by assumptions	Highly flexible; can model dynamic and complex systems
Examples	Optimization algorithms, mathematical modeling	Linear regression, ANOVA, machine learning algorithms	Brain-on-a-chip, DNA computing, synthetic biology

Limitations	May require simplifying assumptions; not always practical	Assumptions may not fit real-world data; can be biased	Can be costly and complex; may not fully replicate biological processes
Applications	Engineering, physics, economics, operations research	Social sciences, economics, medical research	Drug testing, disease modeling, personalized medicine

4.5. Discussion

While mathematical methods are very powerful and can produce exact results, these methods are very limited and fail in many cases to handle the problems where large number of variables (features) are present. These methods also face the issue of limited generalization capability and high biasness. Generally speaking, mathematical methods are not capable of handling big data. On the other hand, statistical methods are good to cover the down sides of mathematical methods and can provide better results. However, mathematics provides the basis for many statistical methods and similar shortcoming could be observed with statistical methods like data dependance, assumptions and simplifications, scalability issues, explainability and interpretability. Both type of methods can be combined for better results and could be considered as complementary. Many researchers have studied the application of one type of method as supportive for other type of method [28, 29]. Computational methods being used in hybrid intelligence have opened up new ways of achieving AGI and beyond. Specifically, use of human brain with digital circuits has advanced the AGI to a larger extent.

4.6. Natural Intelligence-Artificial Intelligence Mapping

Intelligence is a complex and multi-faceted trait that involves various cognitive abilities and skills. Researchers and psychologists often use different models to describe intelligence. Intelligence traits are the characteristics that help to identify its presence. In this section, we will see how different input/output and processing capabilities associated with humans are being incorporated into artificially intelligent computational systems.

4.7. Logical traits

Howard Gardner in his book [104] "Frames of Mind: The Theory of Multiple Intelligences" attempted to classify different intelligences and proposed the theory of multiple intelligences. He designed the different criteria for identification of each feature as physical or logical intelligence that is also referred as analytical or mathematical intelligence. All these types of intelligences can be implemented in the form of algorithms and learning methods in computers except thoughts and consciousness which seem to be external factors in human biological machines.

Mathematical Thinking (MT) is a cognitive process that involves reasoning, problem-solving, and making connections within the context of mathematics. It goes beyond mere computation and encompasses understanding the underlying principles, recognizing patterns, and applying logical reasoning to solve mathematical problems. When this is implemented through AI, is known as Artificial Thinking (AT) [123] that is one of the essential characteristics of AGI. The process of AT involves the acquisition of information and development of "thought" in humans with the capabilities of autonomous information systems. Research community is attempting to explore different directions to incorporate artificial thinking into latest AI applications.

Authors in [120] have proposed an environment for evaluating the thinking capabilities in AI systems. AI agents, using Reinforcement Learning (RL), are evaluated on symbolic and visual versions of the task and found that agents are clearly failed to reach the human intelligence level. This failure in incorporating scientific thinking requires more future research to bring human level cognitive capabilities in machines. Associative reasoning is considered part of human thinking. Jelínek, J. in [122] attempted associative reasoning to simulate the thinking process. In another work [124], Gopych shows that artificial thinking cannot be implemented using inorganic computational hardware.

Creating machines that can "think" is a fantasy, a fiction and future world. This can take machines higher than our imagination. The processing of "think" involves philosophical discussion and experimental scientists do not know, at present, how the thought process starts. I believe that religion can provide its better explanations i.e. the role of heart and brain in decision making.

4.8. Physical Traits

Physical traits refer to observable characteristics or features of an organism or object that can be described, measured, or identified through visual inspection or other sensory means. In this section we describe how the most prominent physical traits of natural intelligence are implemented in artificial intelligence. Following table-1 lists these physical traits and their corresponding artificially intelligent mappings:

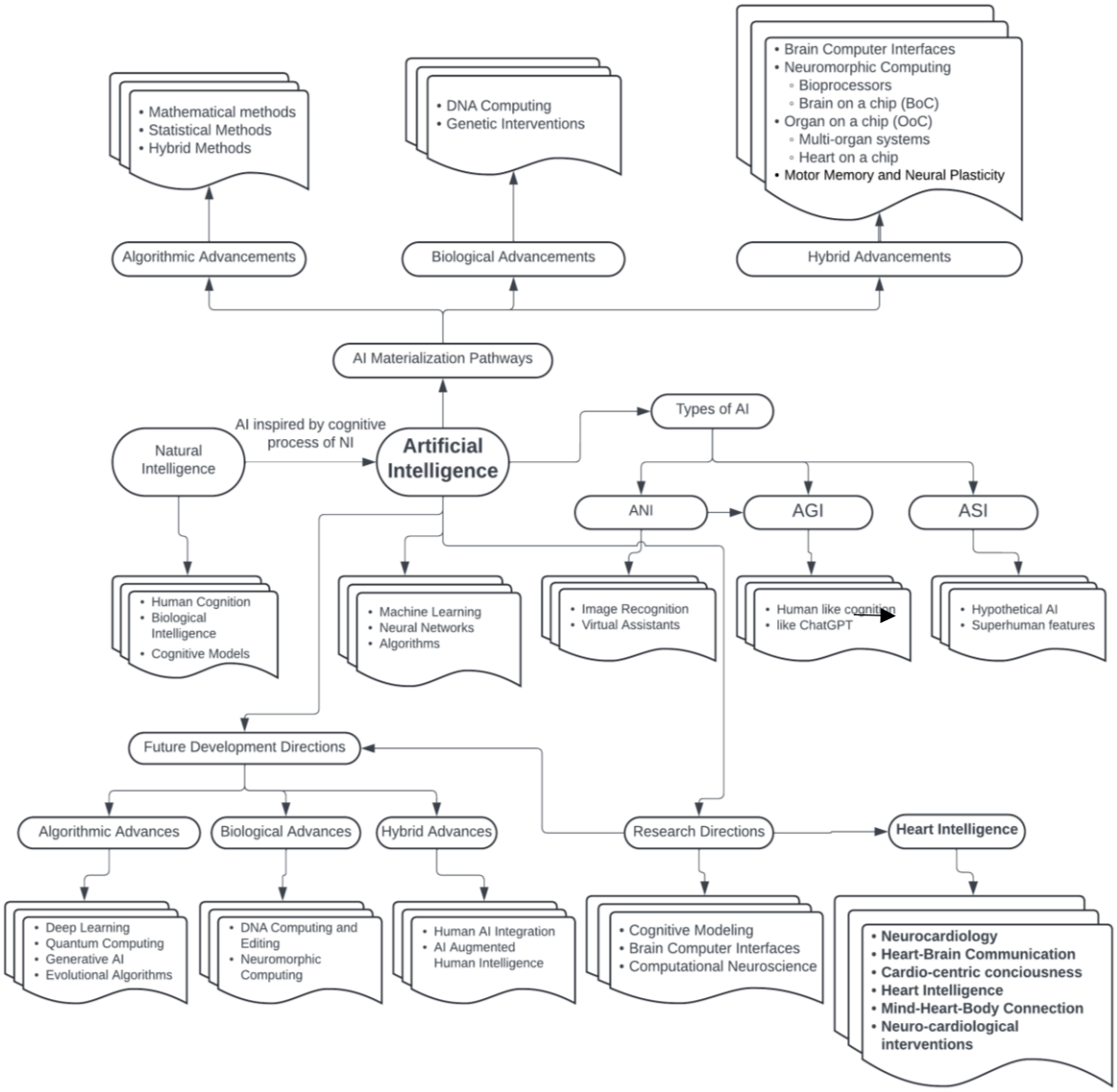

Figure 7. This research AI landscape

Table 3. Physical and Logical Intelligence traits mapping

Type of Trait	Natural Intelligence	Artificial Intelligence
Input	Eyes	Computer Vision (Cameras)
	Ears	Audio synthesis (mic)
	Nose	Artificial Nose [145]
	Skin	Sensors and IoT
	Tongue	Artificial Taste Sensors [146]
Output	Speaking	Speakers
	Gestures and Expressions	Output Screen
		2D and 3D printers
	Physical Interactions	Robotics, organ-on-a chip [144]
	Smell Generation	Sensors [112]
Processing	Brain	CPU – (Electrical circuit/Bio processors)

Cognitive Skills	Algorithms
Types of skills	Algorithm types
Thinking	Algorithms/Brain-on-a-chip [138]

Now we briefly describe the mapping of artificial and natural physical traits. First, we look at input traits:

Seeing: Human eyes are used to get visual input and feedback from the environment. AI based systems can use cameras for this purpose.

Listening: These voice capturing devices have their alternate known as microphones.

Smelling: This biological device assists the biological organisms to smell. To provide the characteristics of smelling in computing machines for detection and analysis of odors, researchers have developed artificial sensing devices called photonic nose [105, 106]

Sensing: Artificial sensing refers to the use of technology to mimic or replicate the sensing capabilities of living organisms. It involves the development of sensors and systems that can detect and interpret various stimuli from the environment. Several research have been published that worked on different aspects of artificial sensing. AI-enabled wireless sensing technology for medical diagnosis is discussed in [107]. Various types of sensors have been developed to sense different types of things like heat, air humidity and presence of nearby objects.

Tasting: Artificial tasting systems aim to detect and analyze taste-related information, such as pH value, alcoholicity, or flavor, without relying on human sensory evaluation. Several approaches have been explored in this field. For example, the authors in [108] worked on the development of a self-powered biosensing electronic skin that can detect the pH value and alcoholicity of beverages. It can be used as an artificial gustation system for tasting beverages without the need for an external power source. As another example, the development of an artificial tongue that can amplify and sense analytes, allowing for the identification of specific tastes and substances in [109].

Thinking and Decision Making: Scientists are attempting to embed real human brain cells (i.e. human brain) in machines to provide them with high level of intelligence. Achieving AGI and ASI has become debatable now from impossibility [139].

Now we look at output trait materialization for AI where most of mappings are familiar to common computer users like for speaking, speakers are available, for producing something materially, 2D and 3D printers are available, for movement of things, and robotics is there. For artificial smell generation, various methods such as weak electric pulses or digital scent synthesizers have been proposed [110]. Smell Engine is proposed in [111] with a framework to install odor sources in virtual space. An olfactometer is used to manage an approximation of odor mix for the system user. In a recent study, the development of a Smell Engine that can synthesize artificial odors in virtual environments, allowing users to experience real-time odor sensations is discussed [112].

Finally, the processing of information and input received through different input devices can be carried out through different types of algorithms and processors that range from general to AI specific. These include different types of Central Processing Units (CPUs), Graphical Processing Units (GPUs), Tensor Processing Units (TPUs), Field Programable Gate Arrays (FPGAs), Neuromorphic Processors and AI optimized CPUs.

4.9. Intelligence Tests

There are two main arguments presented to establish whether a software is intelligent or not. These are Turing Test (TT) and Chinese Room Argument (CRA). Turing test states that if you ask a question to a system and by looking at received answer you are not able to identify whether that response is generated by a software/machine or human being, the software generating that response is said to pass the Turing test [14]. This argument is very strong in establishing the intelligent behavior of machines however how a machine is depicting intelligence is overlooked which is considered in Chinese room argument [15]. This argument differentiates between memorizing and learning. The argument states that if a man who knows nothing about Chinese language is placed in a closed room and he is taught the mapping rules (of words and sentences) from English to Chinese and vice versa, he would be able to translate one language to another when some input text is given to him to translate. Such a person is never considered to be intelligent as he fails to deal with the text which is not given in mapping rules (unfortunately larger part of our educational system is working in same way i.e. rotting). An intelligent person would be able to do the

job when he is given with partial set of rules. For example, a large number of expatriates move to Saudi Arabia each year and most of them do not know the Arabic language and yet they remain successful in communication and learning about the culture. Any system performing mapping for translation will learn to some extent through its experience.

Researchers are continuously designing new tests to measure AI and its artifacts (products, algorithms, and services) are struggling to pass them [52-55] [68] - [70], even there are efforts to establish methods and benchmarks for intelligence measurement [56, 57].

Like natural intelligence, there could be multiple definitions of artificial intelligence which may present the same fact from different aspects. Based on its problem-solving capabilities AI is further divided between Narrow, General and Super AI.

4.10. Is AGI or ASI achievable?

Literature review shows that there is no consensus on what AGI means or whether it is even a coherent concept. The definition of AGI was coined in early 2000 and since then has been updated and limited to only cognitive tasks. Cognitive scientists emphasize that intelligence is not a single measurable quantity but a complex integration of various capabilities and it is very difficult to separate the concepts from each other. AGI intends to optimize the task in hand whereas human intelligence involves complex integration of innate needs. The history of AI has repeatedly challenged our intuitions about intelligence, and it remains to be seen whether current speculations will prove similarly misguided. The development of a more rigorous and general science of intelligence is needed to answer these questions [130].

Achieving general or super intelligence is a fiction at present and there is very hot discussion in research and philosophical community that whether we will be able to achieve it or not. In this section, first we present the arguments of those who believe in the achievement of AGI and ASI then we will discuss the arguments of the opposite side and at the end I will present my own views.

Proponents: In literature, researchers use the term materialization of AI as creating robots or physical artificial intelligence (PAI) agents [65] however in this discussion materialization of AI refers to achieving the desired level of AI in some particular form. Considering the path to ASI, AGI is the first step, and many authors are hopeful that this is achievable. A number of authors are also predicting its expected time [67]. In 1965, AI pioneer Herbert A. Simon predicted that:

"… Machines will be capable, within twenty years of doing any work that a man can do [69]".

However, this prediction failed. In another research [71], the participants expected the AGI achievement around 2080. Still researchers believe that, in future, we will observe Technological Singularity (TS) soon. TS is a hypothetical achievement in future where AI will become uncontrollable, irreversible, and unpredictable for human society. Major characteristics of technological singularity include exponential technological growth and super-intelligent systems.

Opponents: A large number of researchers and thinkers also believe that humans will never be able to build AGI machines. The fear of machines taking over is founded on a wrong basis [75]. According to research [74, 100], machines will never rule the world because artificial intelligence (AI) is mathematically impossible to achieve at a level that surpasses human intelligence [103]. Authors in [125] conclude that current AI often lacks robustness i.e. in image data, a panda can easily be recognized as gibbon if the pixel values are little changed. A renowned AI investigator, Calum Chace [101], in his article on forbes.com concludes that developing AGI is like to achieve the level of God which is impossible. According to research [118]:

"we are no closer to the goal of producing a truly sentient being than when it started"

4.11. Cognition and Emotion: The Brain vs. The Heart in Decision Making

The generation of thoughts in humans is a complex and multifaceted process involving various aspects of the brain and cognitive functions? Scientists believe that generation of thoughts is the result of various human brain part activities, consciousness and unconsciousness. As the concept is not clear in science, we look into social sciences especially different religions and their views about thoughts and emotions.

Islam focuses on heart instead of brain for "thoughts and emotions" and it is interesting to know that there is little scientific research done on the role of heart in "information and inputs generation" for human information processor (brain). The heart is not merely seen as a physical organ pumping blood but is also considered the center of consciousness, emotion, and spirituality.

"Have they not travelled through the land, and have they hearts by which to reason and ears by which to hear? Verily, it is not the eyes that grow blind, but it is the hearts which are in the breasts that grow blind." (Quran 22:46)

Prophet of Islam, Muhammad (peace be upon him) said:

"Beware! There is a piece of flesh in the body, and if it becomes good (reformed), the whole body becomes good; but if it becomes corrupt, the whole body becomes corrupt. That piece of flesh is the heart." (Sahih al-Bukhari)

A wonderful discussion on the role of heart in human intelligence from Islamic perspective is presented by Dr. Gohar Mushtaq in [151]. This book consists of seven chapters. In first chapter the author challenges the concept of "heart" from merely a blood pumping organ to the center of intellect, wisdom, and understanding and supports his argument through scientific publications and claims the existence of intelligence within heart that interacts with brain. In chapter 3, the author focuses on relationship between mother's heart and her child before and after birth. Scientifically it is proved that early development of the fetal heart and its sensitivity to the mother's heartbeat. The unconscious memory of mother's heartbeat can cast positive or negative effects on the child. The author formulates four communication ways of heart with brain i.e. neurological, biochemical, biophysical and energetic. He discusses the heart's significant role in emotional experiences and decision-making is highlighted.

In Christianity, the concept of the heart similar significance as that of Islam, encompassing physical, emotional, and spiritual dimensions. The Bible, the central religious text in Christianity, frequently refers to the heart in various contexts. For example:

"I will give you a new heart and put a new spirit in you; I will remove from you your heart of stone and give you a heart of flesh." (Ezekiel 36:26, New International Version)

"Create in me a pure heart, O God, and renew a steadfast spirit within me." (Psalm 51:10, New International Version)

Exactly same role of heart is defined in Judaism. For example:

"Rend your heart and not your garments. Return to the Lord your God, for he is gracious and compassionate, slow to anger and abounding in love, and he relents from sending calamity." (Joel 2:13, New International Version)

"May these words of my mouth and this meditation of my heart be pleasing in your sight, Lord, my Rock and my Redeemer?" (Psalm 19:14, New International Version)

Similarly in Hinduism, heart has major role in intention and understanding.

"The heart is the only sacred vessel. Anything and everything can be brought into the heart." - Swami Kripalu

For example, in Bhagavad Gita, Chapter 10, Verse 20, Lord Krishna says:

"I am the Self, O Gudakesha, seated in the hearts of all creatures. I am the beginning, the middle, and the end of all beings."

A relevant work in Chinese philosophy by Wong, David in [149] has worked on the relationship of heart and mind. The author explores the ontological relationship between heart and mind whether they work in collaboration or in separate. The authors present the views of different philosophers like Confucius, Mohists and Xunzi. There are different philosophies which either consider heart or mind as single entity or two separate entities. This work shows that there is substantial effect of heart on human information processing mechanism.

Present AI only focuses on brain models and associated characteristics. The heart could be next possible organ of interest from computations perspective.

The research [126] provides an in-depth examination of the current state of artificial intelligence (AI) and its future potential. The authors argue that while AI is a buzzword at present, all advances are mainly progress in machine learning and recently in bio-processors. The true revolutionary impact of AI has yet to be realized. The author Stian Antonsen in [127] presents three paradoxes which need to be addressed before materialization of NI into AI. These include Intelligence Paradox (role of data quality and human contribution), transparency and verification paradoxes.

4.12. Heart Intelligence

At present, science has no clue about cognition in heart however, considering the above discussion about religion, it seems that there is some type of computational mechanism present in heart and this hypothesis can open a new research direction. Various computational models have been developed to understand the working of heart. Hunter, P. in [147] have made a study on how the heart's tissue structure relates to its function, using computational models. These models intend to explore that how the heart responds to different physiological conditions.

Scientifically the relationship between heart-mind-body is proved. Levine et. al. [150] have worked on the concept of "mind-heart-body" connection. They argue that these body parts are interconnected and can influence each other. Understanding these relationships at physical and information interchange level, can lead to various explanatory and predictive analytics. For example, using machine learning, disease classification based on heart murmurs is performed in [148].

A new and emerging field of medicine known as neurocardiology [152] aims to focus on the connection between heart's nervous system and the brain. Science has discovered that heart has its own complex network of neurons called "little brain on the heart (LBH)". The LBH allows heart to process and communicate information with brain. This shows that how heart has well established role in information processing which can influence emotions and thoughts.

In another research, Mukhopadhyay et. al. [153], have named the heart intelligence as "cardio-centric consciousness." They argue that the way of human heart information processing is superior to brain. They base their claim on the fact that brain is only information processing machine which do not have intuition, feelings and thoughts. They argue that the collaboration and synchronization between heart and brain is at much deeper level in the realm of consciousness. Finaly authors conclude that the heart intelligence is more valuable than brain intelligence.

A recent publication by Lusk, Jay B. et. al [154] emphases the increased interdisciplinary collaboration between neurology and cardiology to come up with more insights in neurocardiology. The authors also outline the challenges and opportunities to work in neurocardiology.

5. Technical and Ethical Limitations, Challenges for AI Evolution

In this section, I present limitations and challenges associated with AI and its evolution. This section also presents the author's understanding about transformation of ANI to AGI.

5.1. Technical Challenges

How are thoughts generated in mind? We need to understand this mechanism in more detail. There is an open question whether brain is only computing device or it can be creative. Science has an incomplete view in this context whereas religion answer this question with confidence that heart is the root of emotions, feeling and initiating information processing in brain.

Is the concept of mind is only associated with brain? Science is still working and trying to find the answer of this question. However, considering the religious sculptures, I believe that the concept of "mind" is associated with heart than brain.

Can basic intelligence (skills) by incorporated in machines? Humans have two types of factors that constitute intelligence: Problem solving and mechanical skills. I name both features as skill and it can be easily observed from literature of science and arts that skill can be quantified, qualified and reproduced. This allows us to build skills in machines both in soft and hard form. Examples include fast and efficient computational methods and robotics.

Is prevalent AI capable of advancing to AGI? All present AI is based on existing knowledge i.e. machine learning based on training data which is a major limitation in achieving even the basic level of intelligence.

Is brain modelling alone enough to provide a complete view of "intelligence"? Consciousness and intensions are the features which are specifically associated with human beings. I do believe that building these features in machines is impossible. Here I would like to quote from Holy book of Muslims "Quran":

We have certainly created man in the best of stature (95:4)

The only reason of this superiority is the intellect and consciousness. If human can recreate consciousness, they will be able to produce better machines than God which is not possible.

Is thought a controllable process? The generation of thoughts is natural and autonomous process. It is not fully controllable whereas the computational models are usually controllable and traceable. AI with controllable and traceable algorithms will not be able to advance to AGI except reaching to Artificial Multi-Narrow Intelligence level (AMNI).

Can a machine create better machine? Humans are intelligent creatures, and no creature can create a more intelligent creature than itself. If a machine can invent a more intelligent machine, then through recursive process, an infinitely intelligent machine can be constructed which is against the physical and mathematical laws. If theoretically, it is possible then one day it will cross the intelligence of God. Here are few paradoxes that provide a view about the impossibility of this idea.

The Ouroboros Paradox: An ancient symbol of a dragon eating its own tail, representing cyclical nature and self-consumption. This paradox suggest that a machine endlessly recreating itself will be unable to surpass its own limitations.

The Promethean Ceiling: A Greek mythology character, Prometheus, stole fire from the gods and gave it to humanity, but was eternally punished for his act. This name implies a machine reaching a point where further advancement is impossible, despite its initial potential.

The Bootstrap Bottleneck: Bootstrapping refers to the process of self-improvement or self-creation. It highlights the inherent challenge of a machine trying to surpass its own capabilities, suggesting a point where progress becomes stagnant.

Will we understand the brain completely? If humans become successful in understanding the brain, then multiple research dimensions can be opened to use human cognition and understanding process either through electrical or biological processors to realize the Artificial Super Intelligence. At present, we are in the process of understanding functions and have covered to larger extent however, as discussed above, human heart is more "intelligent" than brain. Mere understanding of brain will not advance the ANI to AGI or ASI.

Can we use human brains directly in machines? Yes, as we have seen in literature review that human brains are being used in computing machines i.e. neuromorphic computing. However, there are multiple problems with this approach which need to be addressed.

Blackbox Modeling: Present deep learning models which now possess few hundred to billions of parameters and understanding the role of each parameter is almost impossible. Human brain consists of trillions of neurons and even higher number of connections. At present, it seems impossible to understand the internal processing of brain. Using "living brain" in machines will produce higher level of black box models leading to compromised explainability and interpretability.

Brain Intent Detection: There are number of studies [155, 156] published to detect the intention of brain however these are all ANI based applications. How brain intention can be determined in the realm of AGI? This is far away and may not even be achievable.

Limitation of Brain Thinking: We observe that human brains are prone to many biological limitations like tiredness, confusion and biasness. It is still not clear that how these things will be handled. I believe that "mind" is very powerful thing whereas the physical brain is not capable to cope up with full potential of mind.

Can BCI lead to AGI? The answer of this question was most likely "No" a decade back. However, with advancement in neuromorphic computation, this seems to be a gray area. There are many ways, machines having "living brain" can depict AGI like expert remote brain embedding in problem solving, use of ensemble of human brains, crowd intelligence-based solution development and use of electrical (machines) and biological (machines with living brains) communities in algorithm design. It is common in human society to have biased and conflicting concepts, incorporating such limited and conflicting rules in machines will transform them into infinite looping machines or machine with conflicting and ambiguous behavior.

Do we have enough power to run AGI systems? Recent advances like ChaptGPT report huge energy requirement for training and running of such systems. For example, ChaptGPT report that:

"Training a single large language model like ChatGPT-3 can consume up to 10 gigawatt-hours (GWh) of power".

"The daily energy consumption for handling hundreds of millions of queries on ChatGPT can be around 1 GWh"

"As models become more sophisticated and larger, the data center energy for training and using these models can become unsustainable"

Considering the energy requirements, it can be observed that such systems will be difficult to handle.

Have we explored all aspects of "mind"? Research has been conducted on working of brain however the role, information generation, thought generation, intent generation, as discussed in various religions is not studied scientifically and I do believe that research in this direction may open new vistas for science.

Are science and religion different? Science and religions are studied separately without understanding their natural bond. Many religions (i.e. Abrahamic religions) claim various facts which have been proved too which argue the science community to consider both in parallel.

5.2. Ethical Challenges

The human community considers the current ANI as friend in hand. This AI provides wonderful solutions of daily life and is beautiful due to proper human control over it. The transformation of ANI to AGI (if achieved) casts a number of fears and challenges. In addition to this several ethical challenges associated with this transformation:

Will humans keep control of AGI? The first and foremost challenge is human control over technology. It is perceived that AGI will become self-aware with no human control. Since the evolution of human society, they have devised the society policing to keep society in control. This fact predicts that humans will not allow uncontrolled technology to exist.

Will present legal frameworks suffice for evolving technology? Different human societies have started to devise cyber laws. Similarly we will observe the laws in future to keep AI in control.

Will AGI increase social disruptions? Various researchers and thinkers are predicting various disruptions caused by AGI like job displacement, bias and discrimination and existential disruptions. It is observed that although AI is removing old jobs, however it is creating new jobs too like AI and Machine Learning specialists, data analysts, prompt engineers, AI Ethicists and AI trainers and operators.

Will privacy and security be compromised? Data about humans are being collected at various places through different means. Social media sites and personal smart phones are the major sources. It can be predicted that ubiquitous presence of personal data will affect the privacy and security to a larger extent.

How much humans will depend upon automated systems? Recent and historical use of technology shows that humans use technology with caution. Technological misuses and frauds have warned society to be careful and control dependance on technology.

Will human attempt to create the AGI be blind? Yes, financial and commercial competitiveness will enforce the technical companies to advance AI to AGI level however its achievement is still in gray area. Even the developers of AGI will not intend to have uncontrollable technology.

Will governments favor AGI: A government is meant to be a controlling authority? So from my point of view, governing bodies will never tolerate the uncontrolled AGI.

Will society accept the AGI: First of all, achievement of AGI is almost impossible however if ever achieved, society will not accept it due to uncontrolled and "fair or biased" decision making.

6. Conclusion and Future of Artificial Intelligence

The future of artificial intelligence (AI) holds immense potential and is expected to bring about transformative changes across various domains. As we have observed, in last few decades, that AI has found its various applications in different domains of human as well as non-human activities [113-115]. The use of AI will continue to grow, and it is expected that almost all areas of human and human related tasks will see AI applications. However, considering the ANI, following few facts could be identified with more certainty where AI will progress: advanced and high-performance machine learning methods, exponential growth in data both structured and non-structured, text and multi-modal conversational agents, robotics, explainable and responsible AI, Human-AI increased and improved collaboration like Brain Computer Interface and human memory manipulation. It is challenging to predict the future applications of AI and their impact on human society. Some of the known effects include the improved lifestyle with compromise of privacy, security and employment.

Predicting the timeline for achieving AGI is difficult, however the research community offers many insights about it. As discussed above, a group of scientists is optimistic about the AGI timeline, however we can see the failed claims in this context too. Some researchers believe that the level of AGI could be achieved in few decades whereas others believe that it will take centuries. There is another group of philosophers and thinkers who claim that AGI would never be achievable. AGI is an interdisciplinary type of science which involves almost all areas of science, arts and humanities. As stated above, human machines are complex combination of logical and physical traits and programming all these lead to singularity which is mostly believed to be unachievable.

The case of ASI is more unclear and needs to be explored more. ASI will be based on AGI and it is impossible to comment on its achievability. At present, we can consider ASI as science fiction, a thing not seen and observed by anyone. In short, I conclude that AI will grow to a limited extent and will not be able to mimic the human intelligence in general.

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