On Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI)*

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Abstract

The analog VLSI design of neural networks was introduced by C. Mead [7] showing that the solution of some basic early computer vision tasks could be posed as using related analog VLSI components [8], in analogy to human intelligence at those basic levels of vision processing prior to cognition, as originally assumed. Learning, part of cognition, requires the generation of learning models and in practice, due to performance requirements, hardware is indispensable. Those models can be run with increasing levels of sophistication on CPUs, GPUs and NPUs (Neural Processing Units). Neurocomputers [9] could also be conceived as part of an integral solution in industrial environments and applications, e.g., using supervised learning, but not only [10], as well as acceleration special boards to speed up model training, processing the provided data (training, validation, and test sets), and inference to process data in unseen situations like already in the late 1980's with the commercial SAIC Delta neurocomputer processor board [11], an early form of an NPU, and programming languages to develop general complex learning models [12] and applications with much broader levels of abstraction than with today's CUDA (Compute Unified Device Architecture) [13], used to program NVIDIA's GPUs [14] including the H200 tensor core GPU [15], which hosts tensor cores and thus hosts an NPU. Higher levels of abstraction can be programmed using libraries and frameworks like PyTorch and TensorFlow. Current trends such as technical advancements in AI, public perceptions of the technology, and the geopolitical dynamics surrounding its development can be consulted, e.g., in [16]. References are exemplaries, by no means exhaustive.

Bounds on the generalization error compound as bounds of approximation plus estimation error and their relationship to hypothesis- (or model-), sample- (number of provided examples), and time- (speed of training and inference) complexity have been elaborated and powerful learning methods with innumerable applications have been developed, e.g., in [17]. The areas of neural network architectures and associated learning methods for Machine Leaning (ML) [18], Deep Learning (DL) [19], and Generative Artificial Intelligence (GenAI) [20] have been very active and provided significant improvements in research and technology development (R&TD) [21] for building intelligent machines and their operational incorporation into real world applications [22]. Applications of learning methods and machines have penetrated in the meantime almost every aspect of human life. To showcase it in the area of consumer electronics, Figure 1 shows one of the Apple's current, 16th generation

*This abstract has been granted permission for public release. The author is the youngest individual worldwide in history to be awarded the IEEE Fellow Prize ("Nobel" Prize in Engineering) [1] with mention "for leadership in neural and parallel computation, and pioneering contributions to autonomous space robots". He launched and led as Chief Scientist, EiC a scientific journal on AI/ML for 15 yrs. published by Elsevier Science [2]. As a decade civil servant at the German Aerospace Center DLR he launched with the Office of the German Federal Minister of Research and Technology in 1988 the First Federal Program for AI/ML Research and Technology Development in Germany [3], focused with his consortium including DLR and Siemens Corporate R&D in Munich, Germany on Learning Robotics and Automation. He led a highly classified DoD development of flying objects hosting neurochips [4] with subcontractors including Lockheed Martin and SAIC. Most recently, he helped NASA JPL design the next gen Mars autonomous helicopters [5] and the U.S. Space Force (USSF) design the next gen space defense systems against incoming hypersonic and ballistic missiles [6].

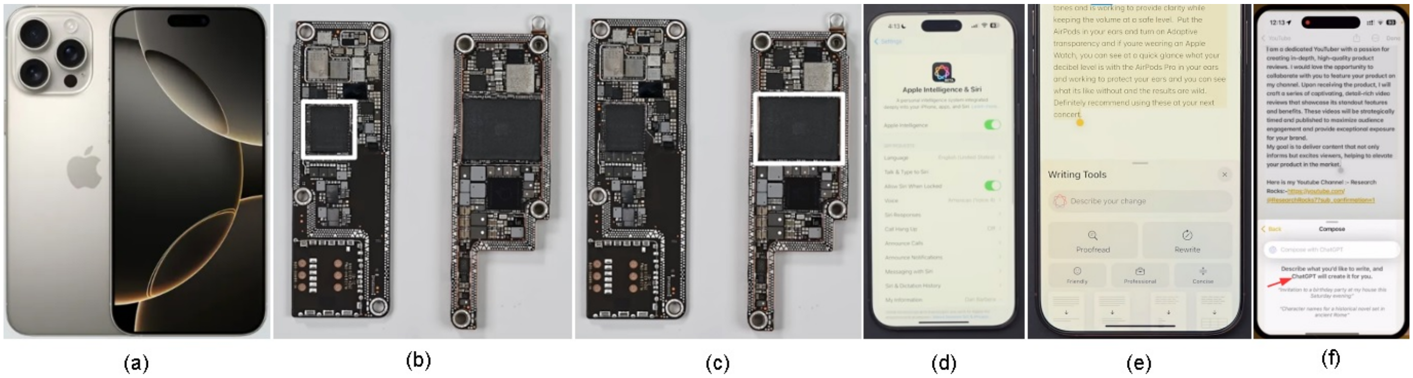

Figure 1: Apple iPhone 16 Pro Max with the Neural Processing Unit (NPU) inside the A18 chip and Apple Intelligence software [APPLE] (a) the frame (b) the logic board's Qualcomm SDX71M modem (c) the logic board's A18 Pro System on Chip (SoC) (d) Apple Intelligence and Siri settings (e) Writing Tools (f) built-in OpenAI ChatGPT to enhance functionality

smartphone products, the iPhone 16 Pro Max with multiple state-of-the-art technology items built-in including the A18 Pro System on Chip (SoC), which hosts a new 6-core CPU with 2 performance and 4 efficiency cores, a new 6-core GPU, and a new 16-core neural engine, also called a Neural Processing Unit (NPU), among multiple others [23]. It comes with an easy to use, privacy-protective personal intelligence software that uses artificial intelligence (AI) called Apple Intelligence [24] that runs on the A18 SoC under the Apple's iOS 18.1 operating system. Apple Intelligence includes several tools like Writing Tools to summarize, proofread, and rewrite text. The Notes and Phone apps support recording, transcribing, and summarizing audio. The OpenAI AI-powered chatbot ChatGPT is built-in to enhance functionallity. Transformer architectures, Foundation Models (FMs), and Large Language Models (LLMs) provide solutions for multiple Natural Language Processing (NLP) tasks as is the case with ChatGPT and others. Over the years, the area of automation and robotics has also shown heavy interest [25] in incorporating learning machines to enhance productivity. In that area, I also launched early R&TD in Germany, initiating the first German Federal AI/ML Program [3] and with my winning consortium including the German Aerospace Center DLR and Siemens Corporate R&D focused on learning machines for automation [26] and robotics [27], considering supervised and unsupervised learning methods [28], which later were complemented with reinforcement learning [29]. From a more recent perspective, when we go beyond language to behavior, we need Large Behavior Models (LBMs) or the equivalent which learn from expert demonstrations diverse tasks including action patterns and contextual interactions. We can then design more capable intelligent, autonomous, learning robots [30].

On the ambitious end of current efforts and developments to achieve global AI hegemony, Figure 2 shows an outline of the recently announced Stargate project at the White House [31]. The goal is to build a new AI infrastructure, since in particular, GenAI typically requires massive computational power. Its initial equity funders are OpenAI (operational lead), SoftBank (financial lead), Oracle, and MGX, with participation of Arm, Microsoft, and NVIDIA as initial technology partners. One disclosed, salient area of applications is healthcare, to introduce the automated disease diagnosis and prognosis as well as the robotic production of personalized medicine and vaccination. Issues regarding government regulatory measures will need to be addressed properly [32]. Apart from current Generative Artificial Intelligence (GenAI) efforts and advances, expectations have been recently raised through Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI), types of AI that perform any human intellectual task and surpass human intelligence, respectively. Their definition is easy enough to precisely formulate. Both not yet realized and very challenging to achieve. From [16, chapter 2]: "AI beats humans on some tasks, but not on all. AI has surpassed human performance on several benchmarks, including some in image classification, visual reasoning, and English understanding.". Here again, it is a question of definition, e.g., what that referred benchmark for English understanding entails, which should in the best case retain the common sense

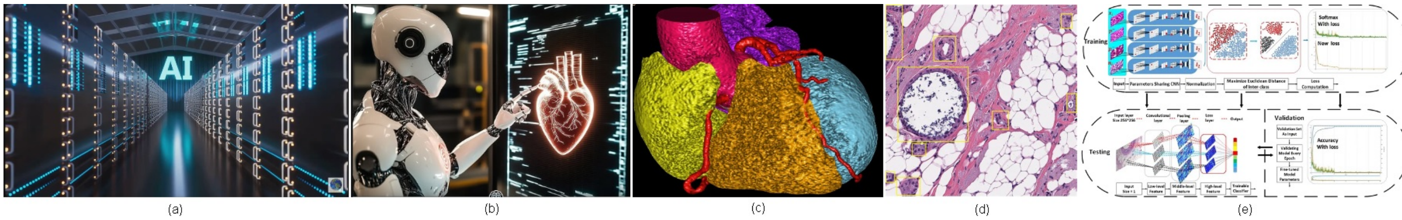

Figure 2: Project Stargate [WH] [31] (a) AI data center infrastructure [33] (b) Healthcare applications – AI-based automated disease diagnosis and prognosis (c) AI-based CT scan segmentation and cardiovascular risk prediction [CWRU] (d) breast cancer histopathological image labeled by pathologists (e) breast cancer diagnosis and prognosis – integrated workflow of automated breast cancer multi-classification based on transfer structured DL

understanding of the denomination. One could for example imply that in order to translate between two languages, one should understand, even master both languages. Some results analysis in this context will follow. At this point, nobody has doubts of the rapid development of AI capabilities, the factual relevance and productiviy increase to use AI in multiple applications and create lots of jobs and profit from huge earnings, though not yet in a wide range of applications, too hard for AI at this moment in time. The level of cognition capability of GenAI is way too low if at all really existent. On the other hand, that does not mean, that AI/ML including GenAI cannot and is not extremely useful. An airline plane is the opposite of intelligent, literally cannot do anything autonomously, but is extremely useful. Those are two different subjects and we rather keep them separate, related loosely for sure. At this stage of the game, it is not wise to incur in almost infantil definitions of intelligence related terms. In reference to the Turing test or Minsky's prediction about how fast AI would achieve general intelligence, from [21]: "For all understanding of the early beginning's efforts, those formal definitions of intelligence were/are fully insufficient even compared to any layman's understanding of the word intelligence. Basic understanding could even lead immediately to the clear answer to long-standing questions whether at least some animals are intelligent since computers cannot see "so well" (even in the meantime) while those animals can". Let us turn our attention to language translation for a second, specifically from German to the Germanic language English. Despite advances w.r.t. the "widely recognized" benchmark for German-English translation, i.e., the WMT 2014 German-English dataset, if you use google to translate and enter "Er versteht nur Bahnhof", google translates it to "He only understands train stations" whereas the real meaning is "He does not understand a thing", so much to cognition capabilities of GenAI and LLMs at the moment. On the other hand, there is no question that GenAI and LLMs can and are very useful.

There are specific areas of technology and applications for which I have and we can already now design intelligent machines with required human-like behavior or even superhuman capabilities, resembling loosely some basic capabilities of AGI and ASI, respectively, but human cognition as a whole has not been achieved and is beyond reach at this point. While the artificial reproduction of human cognition based on our increasingly better understanding of it, is undoubtedly a remarkable goal, one could more realistically speak of IHC=Intelligence Human Capability (a particular one or a set) and then extend this concept to AG-IHC and AS-IHC, instead of AGI and ASI, respectively to reflect current and more immediate developments. The era of AG-IHC and AS-IHC we are already in and moving forward pretty quickly. From [30]: "The integration of advanced AI/ML methods into real robotic systems is enabling them to become more human and obtain superhuman capabilities for terrestrial and space applications [34] and establishing a sophisticated automation and robotic infrastucture past AIOps for new manufacturing factories, but not only [22]". In this report, all types of artificial intelligence including AGI and ASI are explored in depth and determined why particular forms of AG-IHC and AS-IHC and their associated applications should be pursued with priority identifying challenges if any still to be overcome for successful technology and systems development and deployment.

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