APPENDIX F
Toward Artificial General Intelligence

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1. Introduction

Herbert Simon received the Nobel Prize in Economics related to AI in 1978 [NobelPrize 1978]. In 2024, four received the Nobel Prizes; Demis Hassabis and John Jumper, along with David Baker, received the Nobel Prizes in Chemistry for protein structure prediction based on the AI model [NobelPrize 2024]. Jeffrey Hinton was awarded the 2024 Nobel Prize in Physics with John Hopfield for their work on artificial neural networks. His comments include "Industrial Revolution exceeding in physical ability, and AI (Revolution) possibly exceeding in intellectual ability. We don't have any experience and must worry about it" [NovelPrizeinPhysics 2024]. Demis Hassabis described AGI as "AGI – the ultimate general-purpose tool to help us understand the universe" in his recent talk, "Accelerating science discovery" [Hassabis 2024b]. He talked about "Technology as transformative as AGI requires explicit care and foresight" during his Nobel Prize talk. Max Tegmark warned on "Tool AI vs Uncontrollable AGI" in the recent newsletter of Future of Life Institute [Tegmark 2024]. He also recently gave a talk, "Why we should build Tool AI, not AGI" at Web Summit [Tegmark 2024b].

There is an interesting YouTube video from Digital Engine in 2024 [DigitalEngine 2024]. It shows many major players, organizations, and projects on Artificial General Intelligence (AGI) in 2024.

The following AI experts and podcasters are covered in this video.

Sam Altman
Ilya Sutskever
Geoffrey Hinton
Dario Amodei
Demis Hassabis
Eliezer Yudkowsky
Yuval Noah Harari
Yoshua Bengio
Yann LeCun

Dwarfish Patel, Podcaster
Lex Fridman, Podcaster
Craig Smith, Podcaster

Artificial General Intelligence and Artificial Super Intelligence are defined in Wikipedia as follows;
"Artificial general intelligence (AGI) is an artificial intelligence that matches or surpasses human cognitive capability across a wide range of cognitive tasks. Artificial superintelligence (ASI), on the other hand, refers to AGI that greatly exceeds human

cognitive capabilities" [Wikipedia 2024].

Human-Centered AI of Stanford University publishes the AI Index Report every year, and covers selective AI index technical performance benchmarks vs human performance. In some areas, AI exceeds human performance from the 2020s [HAI 2025].

Stuart Russell gave the talk, "Provably beneficial AI" at the Institute for Ethics and AI, Oxford, recently [Russell 2025]. In this talk, he covers on AGI elaborately including possible "AI Mega-Winter."

2. History

2.1 Turing Test

"*The Turing test, originally called the imitation game, was proposed by Alan Turing in 1950 to test a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human*," [Turin 2014]. The recent YouTube shows several cases where the latest AI systems, such as GPT-4 passed the Turing Test [YouTube 2024].

2.2 The 1956 Dartmouth Workshop

"The Dartmouth Summer Research Project on Artificial Intelligence was a 1956 summer workshop widely considered to be the founding event of artificial intelligence as a field" [Dartmouth 1956]. The project proposal covers computers, natural language processing, neural networks, theory of computation, abstraction, and creativity.

2.3 Strong AI (AGI) vs Narrow AI (Weak AI or AI)

Artificial intelligence was initially classified as Strong AI and Narrow AI (or Weak AI). Later, the Strong AI was also called Artificial General Intelligence (AGI), which implies human-level or higher intelligence on a wide range of cognitive tasks. Narrow AI is a term used to describe artificial intelligence systems that handle a specific task. In the 21st century, we generally use the terms AGI and AI. The latter is a generic term. We no longer use terms such as the Strong AI, the Narrow AI, or the weak AI.

In the 20th century, most AI developments focused on Narrow AI, such as natural language processing and image recognition. In the 21st century, we started having companies focusing on artificial general intelligence, such as DeepMind, OpenAI, and Anthropic, in addition to many companies focusing on Narrow AI, in particular on its applications [AGI 2024; OpenAI 2024; DeepMind 2024].

Auto driving may be a special case; super intelligent beyond the narrow AI, but not the artificial general intelligence. Research and development on the autonomous driving system started in the 20th century [DARPA 2004; SelfDriving 2024]. Many kinds of autonomous driving systems are now installed in passenger cars. These automatic driving systems may be classified as narrow AI. However, it focuses on a single task, automatic driving, and may not be appropriate to classify as artificial general intelligence. But the driving systems may be superintelligent since many of the latest driving systems are better than human drivers and have fewer accidents.

3. Current Status and Definition

Future of Life Institute

"AI systems will only get more capable. Corporations are actively pursuing 'artificial general intelligence' (AGI), which can perform as well as or better than humans at a wide range of tasks. These companies promise this will bring unprecedented benefits, from curing cancer to ending global poverty. On the flip side, more than half of AI experts believe there is a one in ten chance this technology will cause our extinction," [FLI 2024].

Wikipedia

"*Artificial general intelligence* (*AGI*) *is a type of artificial intelligence (AI) that can perform as well or better than humans on a wide range of cognitive tasks,[1] as opposed to narrow AI, which is designed for specific tasks.[2] It is one of various definitions of strong AI.*

Creating AGI is a primary goal of AI research and of companies such as OpenAI,[3] DeepMind, and Anthropic. A 2020 survey identified 72 active AGI R&D projects spread across 37 countries.[4]

The timeline for AGI development remains a subject of ongoing debate among researchers and experts. As of 2023, some argue that it may be possible in years or decades; others maintain it might take a century or longer; and a minority believe it may never be achieved.[5] There is debate on the exact definition of AGI, and regarding whether modern large language models (LLMs) such as GPT-4 are early, incomplete forms of AGI.[6] AGI is a common topic in science fiction and futures studies.

Contention exists over the potential for AGI to pose a threat to humanity;[7] for example, OpenAI claims to treat it as an existential risk, while others find the development of AGI to be too remote to present a risk.[8][5][9]"

OpenAI defined AGI as "highly autonomous systems that outperform humans at most economically valuable work," and also defined levels of AGI as follows [AIsafety 2025b; AIrevolution 2024; OpenAI 2024c];

Level 1 Chatbots: AI with Conversational Language
Level 2 Reasoners: Human-level problem solving
Level 3 Agents: Systems that can take actions
Level 4 Innovators, AI that can aid in invention
Level 5 Organizations, AI that can do the work of an organization

DeepMind also defined AGI in five levels [AGI 2024];

Emerging
Competent
Expert
Virtuous (Circle)
Superhuman

4. Issues

Common sense

"In artificial intelligence, common sense reasoning is a human-like ability to make presumptions about the type and essence of ordinary situations humans encounter every day" [CommonSense 2024]. *Ernest Davis characterizes common sense knowledge as "what a typical seven-year-old knows about the world", including physical objects, substances, plants, animals, and human society.*

Consciousness

Lex Feldman recently interviewed many AI specialists on consciousness, including artificial consciousness. They include Joshua Back [Fridman #392], Sam Harris [Fridman #365], Christopher Koch [Fridman #2], Philip Goff [Fridman #261], and David Chalmers [Fridman #69].

There are several YouTube videos on consciousness.
"This AI system is conscious, and experts are starting to agree," Digital Engine [DigitalEngine 2023].
"How does AI attain consciousness?" DW, 2023 [DW 2023].
"Did Google AI just become sentient?" Cold Fusion, 2023 [ColdFusion 2023].
"Is consciousness an illusion?" [BigThink 2024].

Wikipedia has the articles on consciousness and artificial consciousness [Consciousness 2024; ArtificialConsciousness 2024].

First "creativity" symptom

AlphaGo made the unusual move "Move 37" during its second match against Lee Sedol in 2016, which was unthinkable by Go experts [Hassabis 2023; Hassabis 2024]. This move may be considered one of the first creative moves by the AI systems. Bubeck noted an initial AGI during his experience on ChatGPT in 2023 as described in his article and video [Bubeck 2023b].

Artificial Super Intelligence

Artificial Superintelligence (ASI) and Artificial General Intelligence (AGI) are the major topics in AI. There have been many articles and talks on these topics lately. Ray Kurzweil published The Age of Spiritual Machines in 1999, which discussed artificial superintelligence. Nick Bostrom also wrote the books Superintelligence: Paths, Dangers, Strategies in 2014 and Deep Utopia in 2024.

We may consider two cases of Artificial Super Intelligence (ASI);

Artificial General Super Intelligence (AGSI), and
Artificial Narrow Super Intelligence (ANSI)

Many argue that we may reach ASI fairly quickly once we reach AGI. On the other hand, we may also consider ANSI. We have had several cases of ANSI lately. One is Level 4 autonomous driving, which substantially reduces traffic accidents, including fatalities, as described in the following paragraph.

Another interesting case is AlphaFold by DeepMind. Demi Hassabis and his colleague received the Nobel Prize in 2024 for discovering numerous protein structures with AlphaFold. While each protein structure may take years to discover, AlphaFold discovered numerous proteins quickly. In his Nobel Prize speech [Hassabis 2024], Hassabis predicts that AlphaFold could be applied to many other scientific fields. This may be halfway between ANSI and AGSI by covering many areas of natural science. DeepMind also came up with AlphaEvolve as an AI agent [Wired 2025].

We may expect many more cases of ANSI in the coming years before we realize the ultimate goal of AGSI, similar to Artificial Narrow Intelligence and Artificial General (Strong) Intelligence.

Future of Life Institute organized the "SuperIntelligence Imagined" contest in 2024, with over 100 submissions and five winners [FLI 2024c]. Hendrycks, Schimidt and Wang wrote the article, Superintelligence Strategy with the following coverage recently; Deterrence, Nonproliferation, and Competitiveness [Hendrycks 2025]. They also authored "Super Intelligent Expert Version" recently.

Many scholars, through the following and other articles, are warning about the superintelligence, including the following in addition to the above articles;

A. Aquire, Keepthefuturehuman.ai
Digital Engine, Experts show why WW3 over AI is inevitable, 2025
Elon University, Being human in 2035, Imagining the digital future center, 2025.
Yuval Harari, How do we share the planet with this new superintelligence?, 2025.
D. Kokotaljo & S. Alexander, AI 2027, ai-2027.com, 2025.

All of a sudden, in 2025, we are having many new YouTube interviews on the superintelligence [CNN 2025; Tegmark 2025; AICopium 2025; Hinton 2025].

Autonomous Driving

DARPA sponsored autonomous driving technology demonstrations in the 2000s [DARPA 2024], such as driving from Las Vegas to Los Angeles. Then, many automobile companies, including Tesla, as well as universities, put much effort into autonomous driving. We now classify autonomous driving from Level 1 to 4 [SelfDriving 2024]. Many automobile companies are reaching Level 4 now. Waymo in the USA started autonomous driving in cities from 2010, and now offers commercial taxi services in San Francisco, Los Angeles, Austin, and Phoenix [Waymo 2024; CNBC 2025b], and plans to expand to many more cities in the

coming years. Waymo even started testing in Tokyo recently. Tesla has been developing autonomous driving software, and will start "robo-taxi" in 2025. China is operating commercial autonomous driving services in various cities. All commercial autonomous driving cars in China and Waymo in the USA, except Tesla, are equipped with LiDAR. WeRide and Baidu, among others, offer commercial autonomous driving services, including buses in China. Collectively, the eleven cities in China now provide commercial autonomous driving taxis. Additionally, there are many "Little Yellow EVs" for the delivery of goods.

Autonomous driving at Level 4 may be considered one of the first artificial superintelligences, as Level 4 substantially reduces the fatality rate due to automobile accidents compared to human driving, with more than one million fatalities now [Waymo 2024; SelfDriving 2024]. Bloomberg Intelligence compiled the crash rates per million miles of Waymo and Tesla [Bloomberg 2025];

Tesla	0.15 (through 2024Q4)
Waymo	1.16 (in 2025Q1)
US Average	3.90

Waymo comes with 29 cameras, five LiDAR sensors, and six radars, whereas Tela comes with nine cameras only. Amazon's Zoox is similar to Waymo with LiDARs [Amazon 2025; Zoox 2024]. Waymo started commercial service more than 10 years ago, and Tela began to the commercial service in June 2025. Zoox has not started the commercial service yet.

Robots

Robots have been under development for many decades, starting with the robot arms for manufacturing. Robots are one of the intensive developments, including humanoid development and other AI technology developments, recently.

Jensen Huang, the NVIDIA founder, gave a talk at the 2025 CES [CES 2025], and classified intelligence to

- Cognitive Intelligence, including perception AI, generative AI, and agentic AI
- Physical Intelligence

He further classified the physical (artificial) intelligence into robots, automobiles, and drones.

Marc Raibert, the founder of Boston Dynamics, described his efforts at Boston Dynamics, one of the robotics engineering leaders. In his talk with Lex Fridman #412, He described the development at Boston Dynamics. He also commented on AGI [Fridman 2024]. Humanoid robots are being demonstrated in the Race for AI Robot, Cold Fusion, 2024 [ColdFusion 2024]. The following seven robot companies are developing humanoid robots now: Boston Dynamics, Unitree, 1X Technology, Figure, NVIDIA, and Meta [AImarketing 2025]. China is also working on humanoid robots, including Unitree now [AGIrobot 2024].

There are three leading humanoid robots [TeslaSpace 2025]: Boston Dynamics, Atlas, Tesla, Bot, and Unitree G1.

AI Data Center, AI Supercomputer, and AI Personal Computer

Data centers for AI are significant, but could be very expensive and consume a lot of electricity [situational-awareness.ai 2025; Epoch 2025]. Only huge companies can afford large-scale AI data centers. Processors for the AI data centers are costly, costing tens of thousands of dollars or more per processor, and we need up to a million processors. The GPU is used for the AI data center. NVIDIA dominates the Graphics Processing Unit (GPU) market for AI data centers [NVIDIA 2024]. Google uses Tensor Processing Unit (TPU) instead of a GPU. Additionally, the GPU processor consumes a substantial amount of electricity. [Science 2023] AI data centers globally consume 2% of the electricity generated in the world in this decade. Additionally, AI data centers require appropriate backup electric power, which could be problematic.

With OpenAI, Microsoft proposed that the AI data center, especially for AGI, be ready at $100 billion by 2028 [Reuter 2024]. This would be a part of the Stargate Project now. xAI developed the AI data center with 100,000 GPUs in 2024, doubling GPUs in 2025. Meta, Amazon, Open AI, and Google are also expanding the AI data centers [TopFives 2025]. Google uses its own processor, TPU. As Macron announced at the AI (Safety) Action Summit in Paris 2025, Europe joined the large-scale AI data center.

Microsoft and Intel announced an AI personal computer in 2024, and NVIDIA also announced Digits, a "Personal AI supercomputer," at the 2025 CES [Wired 2025].

AI Safety

AI safety has been one of the important issues. Future of Life Institute raised this issue in the last decade and carried out AI safety projects [FLI 2024; AIsafety 2024]. The UK and US governments recently organized an AI Safety Summit [UK 2023]. The next summit was held in Seoul in 2024, followed by France in 2025. There were International Dialogues on AI Safety (IDAIS) focusing on AGI in London (2023) and Beijing (2024). Many national AI safety institutes have been founded recently, including the UK, USA, France, South Korea, and Canada [Chon 2024]. Several AI safety institutes in China are collaborating internationally [Zeng 2024; IAPS 2024]. China AI Safety and Development Association (CNAISDA) was founded to represent all AI safety institutes in China recently [CNAISDA 2025; Stanford 2025].

AI safety and AI development may have conflicts. This is particularly true among the leading AI development companies such as OpenAI. The recent YouTube video describes the OpenAI case [AIsearch 2024]. In the meantime, Ilya Suskever quit OpenAI and founded Safe Superintelligence (SSI) in 2024 [Suskever 2024]. Jan Leike also quit OpenAI and joined Anthropic. Hassabis also commented on safe and responsible AGI development [Hassabis 2024]. Stewart Russel also gave talks on AI safety, including "Make safe AI, not make AI safe" [Russell 2024b]

Military Artificial Intelligence Applications

Military AI applications need particular attention. Many countries are putting much effort into military AI [Autonomous 2024; Economist 2024; FLI 2024]. Weapons with AGI could be devastating. Much effort is being put into coordinating military AI applications globally.

AI Agents

ChatGPT is a typical passive AI that reacts to its users' input. On the other hand, AI agents actively process with/without human inputs [IntelligentAgent 2024; Sapkota 2025].
The intelligent agents were commented on by Yann LeCun and Andrew Ng, among others [LeCun 2022; Ng 2024; Sutskever 2024; Oriol Vinyals 2024; IBM 2025]. June Park and his colleagues are working on a generative AI Agent as recorded on YouTube lately [June Park 2024]. Google recently announced its AI agent software, Gemini [Gemini 2024]. D. Hadi and Liam Othley commented on AI agents in their recent YouTube talks [Hadi 2024; Othley 2025]. Hadi stated that generative AI is just beginning. AI agents are what comes next. He said, "*AI agents plan tasks to execute, reflect on outcomes, and use tools to accomplish goals*". Jason Huang also talked about the agent as the last step of the cognitive AI as follows [CES 2025];

Perception AI
Generative AI
Agentic AI

Agents may be classified into the following [Kim 2025];

Single-Agent System;
- Simpler architecture
- Lower latency
- Easier deployment

Multi-Agent System;
- Distributed processing across specialized AI agents
- Scalable architecture
- Parallel execution

IBM Technology posted the YouTube video on generative AI and agentic AI [IBM 2025]. In this talk, Large Language Model (LLM) is the common root. The difference is that the generative AI is reactive, whereas the agentic AI is proactive—both cover text, image, sounds, and code.

Amazon is considering offering agentic AI for shopping at Amazon [Wired 2025b].

As Ilya Sutskever of Safe Superintelligence points out, we are facing the end of pre-training due to a lack of data worldwide [Sutskever 2024]. One of the natural choices is the agentic approach, followed by reasoning and understanding.

The panel discussion at Davos addressed the AI agents, AI safety, and AGI [Davos 2025]. Please refer to the Remarks for further comments on this panel discussion.

Manus in China is developing an AI agent system like Deep Seek based on generative AI [Information 2025].

Globis showed AI agents to innovate cooperative operations in its YouTube posting [Globis 2025]. On the other hand, AI Frontiers showed *"the best performing model only completed 24 percent of its assigned tasks…" at a simulated software company experiment* [AIfrontiers 2025].

UC Berkeley offers the course, Introduction to AI; Rational Agents [UCBerkeley 2024], along with Machine Learning and Deep Learning. In the class, the followings are shown as "What cannot AI do?";

Unload any dishwasher in any home.
Perform a surgical operation.
Construct a building

He also shows the following as questionable;

Discover and prove a new mathematical theorem.
Write an intentionally funny story.

Deep Seek

Deep Seek, a Chinese venture that developed AI software, including the Deep Seek-R agent, announced it as open-source software in February 2025 [Berman 2025; CNBC 2005; Mint 2025; Wired 2025b]. The performance of Deep Seek-R exceeds all major AI companies in the USA, including OpenAI, Google, and Meta. This shocked the world, including stock prices, which dove down, the NASDAQ by 3%, and NVIDIA by 17% over the weekend of January 25-26. Deep Seek does not use high-end GPUs to perform these tasks.

Deep Seek's AI data center comprises 10,000 A100 GPUs, including approximately 1,250 GPU compute nodes, 200 storage servers, 122 200G Infiniband switches, and optical interconnect products [Kim 2025]. Some of Deep Seek's models use distillation.

Ben Norton's recent YouTube video, "Tech CEOs admit they want AI monopoly: US plans to block China, Geopolitical Economy Report" [Norton 2025], provided an interesting review of articles related to Deep Seek and related issues. France 24 also posted the video, "The debate panic in Silicon Valley; China's Deep Seek challenges US supremacy", 2025.1.27 [France24 2025].

5. Remarks

1. Alan Turing stated, "*It seems probable that once the machine thinking method had started, it would not take long to outstrip our feeble power. At some stage, therefore, we should have to expect the machines to take control"* [Turing 1951].

2. Ilya Sutskver elaborated on AGI on various occasions [Sutskever 2021; Sutskever 2023; Sutskever 2024b]. Stuart Russell elaborated on AGI in his talk in 2024 [Russell 2024b]. Sam Altman also elaborated on AGI during his recent conversation with Lex Fridman [Altman 2024].

3. Yoshua Bengio also elaborated on AGI, including safe AGI, in his talk during the AI Safety (Seoul) Summit in May 2025 [Bengio 2024b]. His explanation of "Uncertain timeline of AI Capabilities" during his talk was interesting, particularly concerning AI capabilities in the 2000s: agentic AI, Generative AI, Narrow AI/ML, and Early Systems. The report,

International Scientific Report on Safety of Advanced AI [Bengio 2024], is available.

4. Eric Schmidt elaborated on AGI at the 2024 Future Investment Initiative Conference [Schmidt 2024b]. He stated that AGI is based on 90% of AI performance in various science disciplines, such as physics, chemistry, and biology. The overall intelligence on the natural science of AI exceeds human beings [IIF 2024]. The recent YouTube. "What happens when AI knows too much?" [Beeyond 2024]. This may also be considered at AGI.

5. Ben Goertzel of Singularity Net stated that artificial superintelligence (ASI) could be accomplished relatively quickly once artificial general intelligence (AGI) could be developed. AGI could iterate itself many times to move up to ASI [Goertze 2024].

6. The Future of Life Institute recently organized many talks to warn about AGI [Tegmark 2024]. Max Tegmark tries to focus on Tool AI, not AGI. Similarly, Connor Leahy recently published Compendia and gave a talk, "Why humanity risks extinction?" at FLI [Leahy 2024].

7. The panel discussion, "Do we need international collaboration for safe AGI?" The panelists include Max Tegmark (chair), Yoshua Bengio, Demis Hassabis, Yan-Qin Zhang of Tsinghua University, and a professor at UC Berkeley. Hassabis defined AI, AGI, and Super AGI. Bengio, the chief editor of the AI Safety Summit, reports in 2023, 2024, and 2025, explained the importance of AI safety for AGI agents. He Zhang explained the international collaboration among governments, business, and academia with examples [Davos 2025].

8. Lex Fridman also recently posted an extensive podcast and over 5-hour video on YouTube [Fridman 2025].

9. Another interesting YouTube is "Ethical Hacker: This is how deep seeker will destroy the entire AI industry as Ryan Montgomery forecasted [TopMaster 2025].

10. AI Safety Newsletter #47 Reasoning Models has an interesting analysis of computing resources. V3 to R1 in the case of Deep Seeks or o1 to the later model in the case of Open AI do not require much computing resource since the reasoning in V3 and o1 already consumed much computing resource [AIsafety 2025].

11. There is a fascinating and informative interview with Deep Seek founder Liang Wen Feng [Liang 2025].

12. There is an interesting video, New AI, Open Thinker, just beat Deep Seek by Open Thoughts, AI Revolution, 2025.2 [OpenThinker 2025].

13. Mistral AI in France and Cohere in Canada offer generative AI, like Open AI and others in the USA, and Deep Seek in China [Mistral 2025].

14. There are three interesting interviews related to AGI by Hassabis, Hinton, and Bengio [Hassabis 2025; Hinton 2025; Bengio 2025]. They predicted AGI within a decade or so. This would be a good contribution to the world if we do it right, or a danger if we don't do it right.

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