AI Opportunities, Challenges, and Possibilities, Part 1

SMT Perspectives and Prospects

by Dr. Jennie S. Hwang, CEO, H-TECHNOLOGIES GROUP

In this installment of my artificial intelligence (AI) series, I will touch on the key foundational technologies that propel and drive the development and deployment of AI, with special consideration of electronics packaging and assembly.

The objectives of the series:

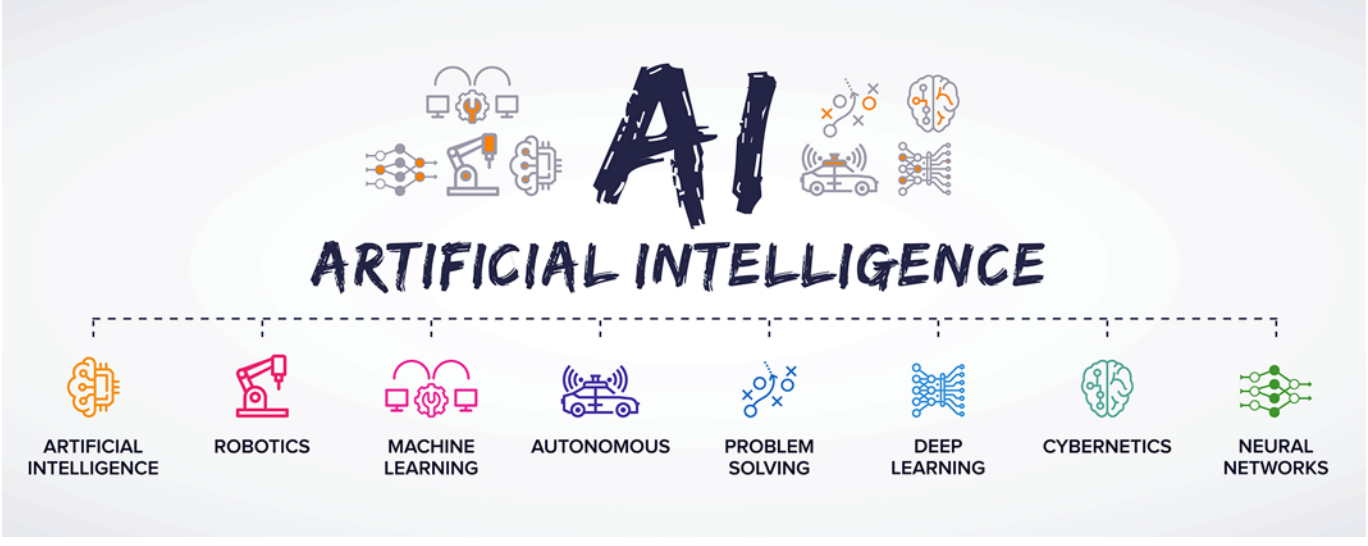
- Build and stay in the knowledge zone
- Spur innovative ideas and inspire new vistas for new opportunities
- Highlight what it takes to achieve AI with justified confidence and trust
- Achieve a balance between AI's omnipotent power and its potential downsides
- Leverage AI as a virtual tool to facilitate an individual's job efficiency and effectiveness and future job prospects, as well as the enterprise business growth

Breakthroughs and Transformational Technologies

Since the discovery of the electron in 1897 by Joseph John Thomson, striking breakthroughs of the 20th and 21st centuries include:

- Invention of the transistor in 1947
- Introduction of the microprocessor in 1972
- Official birth of the internet in 1983
- Internet-enabled hardware and applications during the decade of 1990s
- AI development in the decade of 2010s
- Introduction of AI ChatGPT-4 by OpenAI in 2023

Based on these breakthrough technologies, many products and services have been developed that improve the quality of human life and spur global prosperity—and it all came from the discovery of that tiny unit called an electron.



Operating AI demands the use of heavy-load hardware that processes algorithms, runs the models, and keeps data flowing. These bandwidth-hungry applications necessitate higher-speed data transfer, which opens a crucial role for photons by taking advantage of the speed of light to deliver greater bandwidth and lower latency and power. Hardware components typically will connect via copper interconnects, while the connections between the racks in data centers often use optical fiber. CPUs and GPUs also use optical interconnects for optical signals.

Both electrons and photons will play an increased role. AI will drive the need for near-packaged optics with high-performance PCB substrates (or an interposer) on the host board. Co-packaged optics, a single-package integration of electronic and photonic dies, or photonic integrated circuits (PICs) are expected to play a pivotal role.

AI Market and Hardware

To AI, high performance hardware is indispensable, particularly with computing chips. As AI becomes embedded in all sectors of industry and all aspects of daily life and business, the biggest winners so far are hardware manufacturers: 80% of AI servers use GPUs and it's expected to grow to 90%. In addition to GPU, the required pairing memory puts high demand for high bandwidth memory (HBM). The advent of generative AI further thrusts accelerated computing, which uses GPUs along with CPUs to meet augmented performances.

Although the estimated forecast of the future AI market varies, according to PwC[1], AI could contribute more than $15 trillion to the global economy by 2030. Most agree that the impact of AI adoption could be greater than the inventions of the internet, mobile broadband, and the smartphone combined.

AI Historical Milestones

AI is not a new term. John McCarthy coined "artificial intelligence" and held the first AI conference in 1956. "Shakey the Robot," the first general-purpose mobile robot, was built in 1969.

In the succeeding decades, AI went through a roller coaster ride of successes and setbacks until the 2010s, when key events, including the introduction of big data and machine learning (ML), created an age in which machines have the capacity to collect and process huge sums of information too cumbersome for a person to process. Other pace-setting technologies—deep learning and neural network—were introduced in 2010, with GAN in 2014, and transformer in 2017.

The 2020s have been when AI "finally" gained traction, especially with the introduction of generative AI, the release of ChatGPT on Nov. 30, 2022, and the phenomenal ChatGPT-4 on March 14, 2023. It feels like AI has suddenly become a global phenomenon. The rest is history.

AI Bedrock Technologies

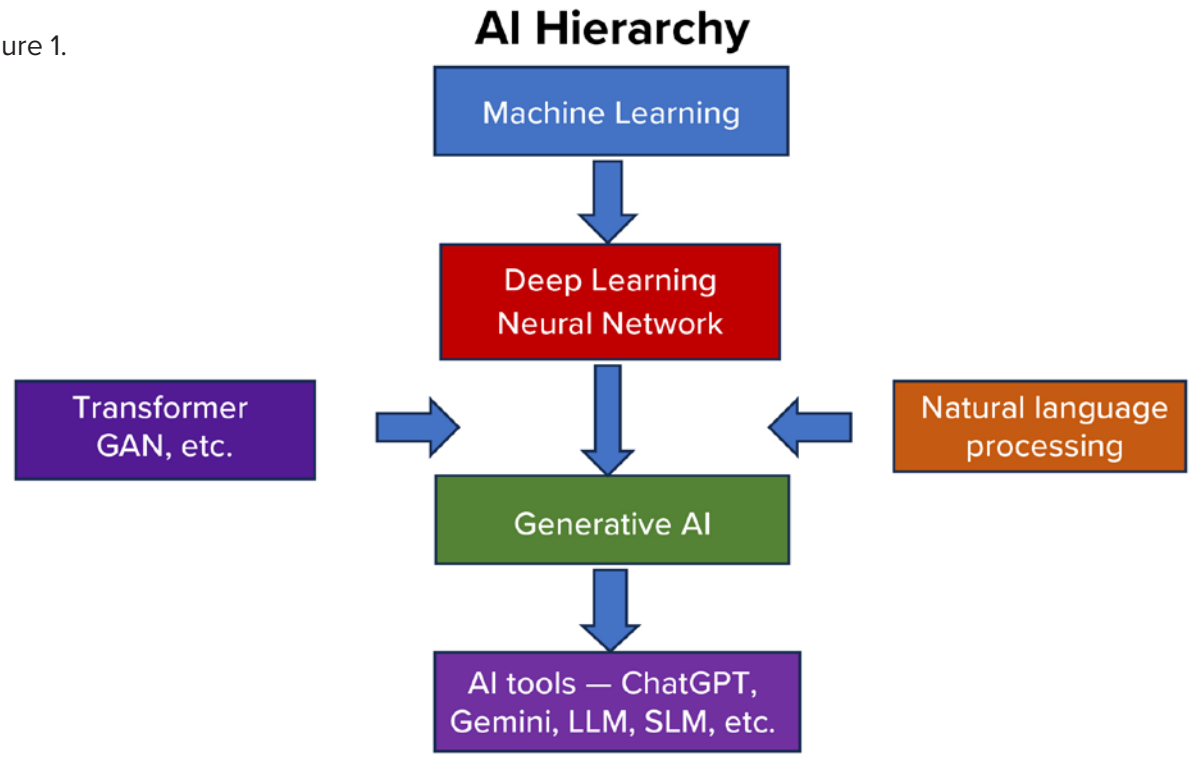
Generally speaking, AI is a digital technology that mimics the intellectual, analytical, and creative ability of humans, largely by absorbing and finding patterns in an enormous amount of information and data. AI covers a multitude of technologies, including machine learning (ML), deep learning (DL), neural network (NN), natural language processing (NLP), and their closely-aligned technologies. In one way, AI hierarchy can be shown in Figure 1, exhibiting the interrelations and evolution of these underpinning technologies.

Now I'd like to briefly highlight each technology:

Machine Learning

Machine learning is a technique that collects and analyzes data, looks for patterns, and adjusts its actions accordingly to develop statistical mathematical models. The resulting algorithms allow software applications to pre-

Figure 1.



dict outcomes without explicit programming and incorporate intelligence into a machine by automatically learning from the data. A learning algorithm then trains a model to generate a prediction for the response to new data or the test datasets.

There are three types of ML: supervised, unsupervised, and reinforcement.

- Supervised ML is task-driven and requires a data analyst to provide input and a desired output, then determine which variables the model should analyze
- Unsupervised ML is data-driven and does not have labeled data. Its focus is learning more about the data by inferring patterns in the dataset without reference to the known outputs.
- Reinforcement learning uses algorithms that learn from outcomes and decide which action to take next. In reinforcement learning, there is no data input, or desired output but the reinforcement agent decides what to do to perform the given task by learning from its experience with a trial-and-error method to achieve the maximum reward in an environment. An agent learns to make decisions by interacting with an environment and receives feedback in the form of rewards or penalties based on the actions it takes.

In addition to these basic ML techniques, more advanced ML approaches continue to emerge.

ML understands patterns and can instantly see anomalies that fall outside those patterns, making it a valuable tool in myriad applications, ranging from fraud detection and cyber threat detection to manufacturing and supply chain operation.

Deep Learning

Deep learning is a subset of machine learning based on multi-layered neural networks that learn from vast amounts of data. It comprises a series of algorithms trained and run on deep neural networks that mimic the human brain to incorporate intelligence into a machine. Most deep learning methods use neural network architectures, so they are often referred to as deep neural networks. Software architecture (type, number, and organization of the layers) is built empirically following an intu-

ition-based optimization process, with training data in the loop to tune DL model parameters. Training for DL software occurs "atomically" and with strong coupling across all layers of the DL software.

The increased accuracy of DL software requires more complex implementations in which the number of layers, their size (number of neurons), and the amount of data used for training increase enormously.

Generative AI

I tried ChatGPT to see how the bot explains generative AI:

"Generative AI refers to a category of artificial intelligence (AI) that focuses on creating new and original content. It uses models and algorithms to generate data, such as text, images, audios, or even videos, that resemble human-created content. Generative AI models are trained on large datasets and can generate creative and coherent outputs based on the patterns and information that have been learned. They have applications in various fields, including art, language, music, and more."

A generative AI model, in a mathematical representation implemented as an algorithm, can create something that didn't previously exist by processing a large amount of visual or textual data and then determining what things are most likely to appear near other things using deep learning or neural networks. Programming work goes into creating algorithms that can recognize texts or prompts. It creates output by assessing an enormous corpus of data, responding to prompts with something that falls within the realm of probability as determined by that corpus of data.

Generative AI tools offer the ability to create essays, images, and music in response to simple prompts.

My next column will highlight the foundational technologies behind AI, including the large language model (LLM) and foundation model. **SMT007**

References

1. PwC's Global Artificial Intelligence Study: Exploiting the AI Revolution, pwc.com.

Appearances

Dr. Jennie Hwang will teach a Professional Development Course, "Artificial Intelligence – Opportunities, Challenges & Possibilities," on Monday, April 8, at IPC APEX 2024. She will also teach a course titled, "High Reliability Electronics for Harsh Environments" on April 7.

Dr. Jennie S. Hwang, an international businesswoman, international speaker, and a business and technology advisor, is a pioneer and long-standing leader in SMT manufacturing since its inception, and in developing and implementing lead-free electronics technology and manufacturing.

She has served as chair of Artificial Intelligence-Justified Confidence for DoD Command and Control study, chair of AI Committee of the National Academies, and Review Panels of NSF National AI Institutes. An International Hall of Famer (Women in Technology), she has been inducted into the National Academy of Engineering, named an R&D-Stars-to-Watch, and received the YWCA Achievement Award. She has held senior executive positions with Lockheed Martin Corp., and was CEO of International Electronic Materials Corp. She is currently CEO of H-Technologies Group, providing business, technology, and manufacturing solutions.

She has served as chair of the Laboratory Assessment Board, the DoD Army Research Laboratory Assessment Board, and the Assessment Board of Army Engineering Centers. She is on the board of Fortune-500 NYSE companies and civic and university boards, Commerce Department's Export Council, National Materials and Manufacturing Board, NIST Assessment Board, various national panels/committees, and international leadership positions.

She is the author of 10 books (four as co-author) and 700+ technical/editorial publications. She is a speaker and author on trade, business, and education issues. Her formal education includes four academic degrees (Ph.D., M.S., M.A., B.S.), as well as Harvard Business School Executive Program and Columbia University Corporate Governance Program. To read previous columns, click here.