

AI FOR CREATIVE DESIGN PROCESSES: ITS CURRENT STATE AND CHALLENGES

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ABSTRACT

This paper addresses a current technological status and issues of generative AI by applying an implementation example of using AI to the new design of an automobile part by metal die casting technology. This paper also indicated that it is difficult to eliminate erroneous output from an AI that has been fed unreliable data by using Attention technology by Transformer to infer and respond to frequently occurring descriptions from data fed into the AI. In order to reduce hallucination, it is possible to make inferences while considering statistical fluctuations and uncertainties that humans are not good at by using a foundation model that has learned only from in-house data that has full knowledge of the background of the data acquisition for inference. On the other hand, the issue of the need to incorporate hardware implementation into the system due to increased power consumption.

Keywords: Generative AI, AI Assisted Design, Foundation Model, In House Data, Inference

1 INTRODUCTION: THE RISE OF GENERATIVE AI AND CURRENT TRENDS

In November 2022, OpenAI made their generative AI, ChatGPT¹, available for free, marking 2023 as a year when the potential of AI gained widespread recognition. ChatGPT, which interacts as if it understands human language, raised expectations for increasing productivity in design. However, it also highlighted the problem of AI making mistakes when retrieving data, known as "hallucination." This occurs because generative AI learns from large databases based on frequency and context, but it cannot recognize its own errors.

At the same time, there were notable attempts to use AI in creative fields. For instance, an author of a novel that won the 170th Akutagawa Prize mentioned they used AI to assist in some parts of the creative process². Similarly, software capable of generating artistic illustrations and turning them into videos gained popularity. In the JSME Design Engineering and Systems Department, research on the integration of AI in design is actively being reported³. In this context, we aim to summarize the current state and future outlook of how AI can be applied to the early stages of the creative process in design as of March 2024.

2 HISTORY OF GENERATIVE AI AND ITS POTENTIAL IN CREATIVE DESIGN

ChatGPT, a representative example of generative AI, is based on a large language model (LLM)⁴. It uses semi-supervised learning with efficient parallel algorithms, allowing it to generate high-quality outputs with minimal training. This enables AI to respond to natural, conversational instructions. However, product design is a process where manufacturers are held responsible for their outputs, making the application of generative AI still a developing area. The problem of hallucination arises because AI generates responses based on the frequency of data it has learned from, making it difficult to avoid errors when the input data is not reliable.

The underlying technology of generative AI, such as Transformers with an attention mechanism⁵, shows that AI does not have logical thinking capabilities. It simply predicts what might appear most frequently based on the data it has read. There has been serious discussion about the rapid development of AI and whether it might become so advanced that it competes with humans, raising concerns about a potential

future where robots with Artificial General Intelligence (AGI) pose risks to humanity. For example, OpenAI's board of directors expressed concerns about the rapid development of AI, advocating for slowing down progress and implementing regulations, which led to the temporary dismissal of CEO Samuel H. Altman⁶. However, Altman soon returned to his position, and his approach—accepting that generative AI still makes mistakes and that humans are much smarter—gained support.

Generative AI saw increasing use in creating literary works, artistic illustrations, videos, and music throughout 2023. In product design processes, there is potential for applying generative AI in areas where manufacturers are not directly responsible. For example, AI can be used to generate concepts for mechanical movements, discover combinations of ideas, or create visual prototypes for aesthetic purposes. Designers can then use these AI-generated suggestions to incorporate knowledge beyond their expertise, leading to a diverse range of ideas. When AI-generated ideas differ from the designer's idea, they can be used as valuable references, offering an effective way to enhance creativity.

3 OUTLOOK ON DESIGN METHODS THAT LEVERAGE AI

In the design engineering division of JSME, the concept of "design methods that leverage AI" has been proposed in technical roadmaps⁷. This paper tries to explore the possibilities of these methods based on the advances in generative AI seen in 2023.

For practical application of generative AI in design, reliable output is necessary. As of 2024, NVIDIA, a leading company in GPU design, reported a shift in AI processing from training large language models to performing inference (making predictions)⁸. This signals that the spotlight is beginning to shift to inference, where domain-specific models are trained using accurate and reliable data from companies and other organizations. LLM excels at obtaining responses based on reliable and solid data in areas that the designer or their organization does not have (but that are well known in a particular field), and this is thought to be an application where generative AI can truly demonstrate its capabilities. Examples of reliable and reliable large amounts of data include general ledgers and statements in financial statements, electronic medical records and prescriptions in medical care, statements in repairs and insurance, measurement data in maintenance diagnosis, and contracts in logistics. In the field of design, designs that utilize measurement data from devices owned by customers, data from manufacturing processes, actual feedback from lead users, and data obtained from equipment in use are conceivable. In the future, we can imagine a hallucination-free world by incorporating reliable, unique data to be referenced in design into a foundational model, and providing support with rapid output based on instructions in everyday language. Since generative AI operates on the logic of scale, it is possible to use generative AI to support decision-making in the upstream design stage, such as objectively supporting customer needs, ensuring marketability, and objectively verifying the validity of improved design proposals, especially in the design of products with many touchpoints with customers for which reliable data is easy to obtain (e.g., automobiles and smartphones).

4 AN EXAMPLE OF AI ASSISTED DESIGN AND MANUFACTURING METHOD 1: CASTING PROCESS

Figure 1 illustrates a foundational model for manufacturing automotive suspension parts through casting. The model incorporates real-world data, such as the temperature of molten steel during the casting process, the carbon and silicon content, the temperature at the time of pouring, and the elapsed time since magnesium bubbling. By training this model with reliable, measured data, statistical inference can be applied to reduce the occurrence of hallucinations. The diagram also highlights the models for materials, molds, and operators involved in the casting process.

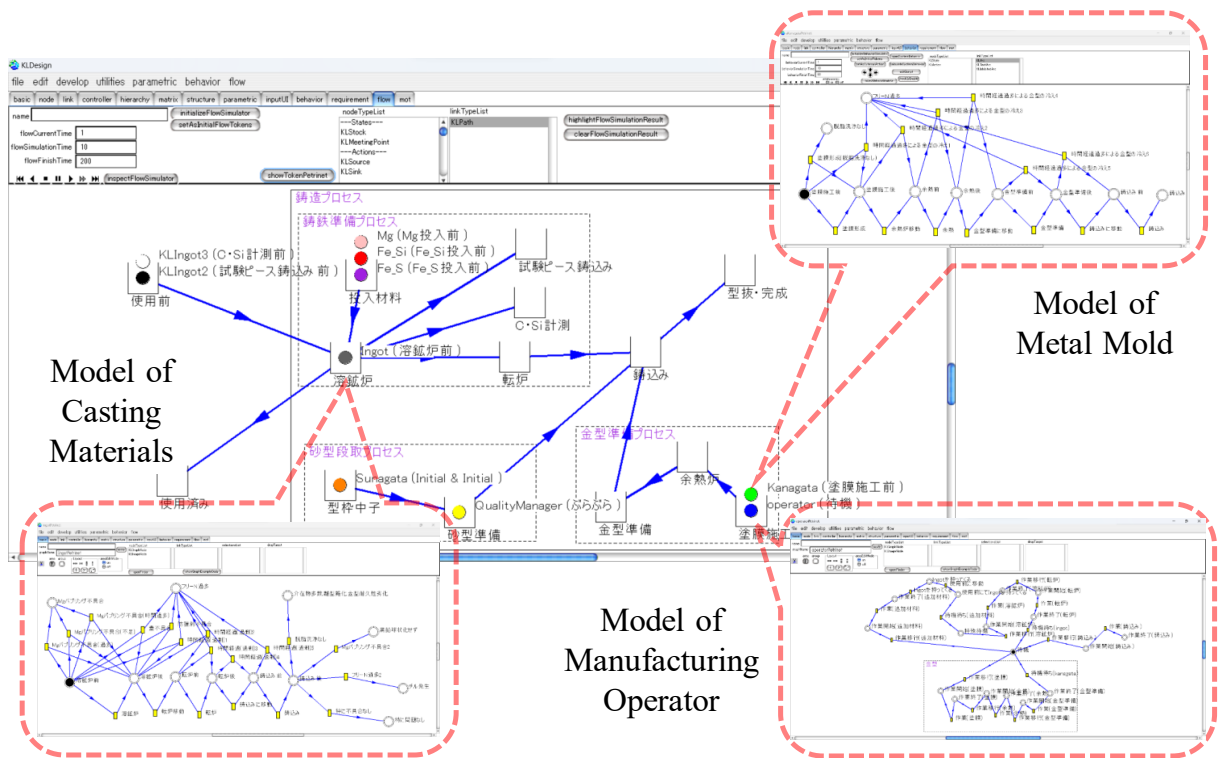


Figure 1. AI integrated manufacturing process of metal casting of automobile suspension component

5 AN IMPLEMENTATION OF AI ASSISTED DESIGN AND MANUFACTURING METHOD

Figure 2 shows the architecture of an inference system that uses AI in the casting process. Data collected by sensors during the process is stored in a data center on an AI server, where it undergoes parallel computation for training. The AI server consists of a learning section powered by GPUs and a memory storage unit (data center). The terminals used by operators in the casting process, referred to as AI edges, contain components that understand human language and locate relevant information based on user requests. By utilizing the language capabilities of generative AI, users can interact with the AI edge in their native language.

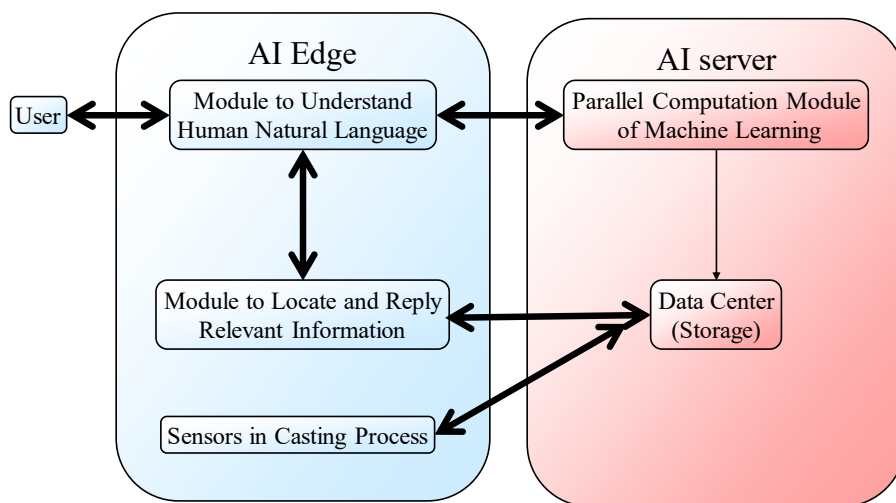


Figure 2. Server and Edge Configuration of the AI integrated manufacturing process of metal casting

6 DISCUSSION ON PROPOSED AI-ACCELERATED DESIGN METHOD

Based on these implementation and experiment study, this paper found an issue to consider which is the increasing power consumption of data centers filled with high-performance GPUs. By implementing AI as specialized semiconductor circuits, known as hardware acceleration or hard-wired technology, it is possible to perform tasks more efficiently and with less energy. This would enable the design of products with AI that operates locally on the user's device, rather than relying on centralized data centers.

7 CONCLUSION: AI AS A SIDEKICK OF THE CREATIVE DESIGN ENGINEER

In the second half of 2023, Gemini and Anthropic AI were released as generative AIs following ChatGPT, and competition between generative AIs began. The author was surprised that the usability of Anthropic A.I., which is supposed to be the latest, is comparable to that of the two leading companies, although there are differences in benchmarks. This suggests that the stage for providers of generative AI has moved from monopoly to competition, and further development through friendly competition between generative AIs is expected in the future.

This paper was written entirely by the author without using any generative AI, although such an era may be coming to an end. In fact, when the author entered this paper, including all references, into a generative AI and asked for its feedback, the generative AI gave the author specific comments on the following points: Are the cited references appropriate? Are the necessary technologies accurately explained? Are easy-to-understand concrete examples given? Are there any insights that are useful to design engineering experts? These were very helpful. In this way, this paper can foresee a future in which AI will play the role of a sidekick that is close to designers and immediately points out good points and areas for improvement, enhancing the creativity of designers. This paper would also like to note that AI is evolving very quickly and may become commonplace for future readers.

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