大規模言語モデルを用いた特許明細書生成による構想設計支援

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Ideational Design Support through Patent Specification Generation Using Large Language Models

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Abstract

Ideational design begins with vague and abstract ideas that must be transformed into concrete design concepts. Patent specifications are useful not only for protecting inventions as intellectual property but also for documenting design intent, technical problems, solutions, and expected effects. However, preparing patent specifications generally requires collaboration among inventors, engineers, and patent professionals, making the process time-consuming and costly. This study investigates the use of large language models (LLMs) to support conceptual design through patent specification generation and design knowledge extraction. For method inventions, we constructed an LLM-based workflow in which ideas discussed with an LLM were expanded into patent claims and embodiments and automatically converted into patent specifications. For product inventions, we proposed a three-layer representation consisting of a Feature Ontology, a Meta Process Model, and a Parametric Shape Space. Using two patent specifications of axial fans as case studies, the LLM extracted design intent and organized it into a meta-process model for representing design rationale, enabling visualization of innovation relationships between patents. The results demonstrate that current LLMs are effective for expanding design ideas, generating patent specifications for method inventions, and structuring design knowledge from existing patent documents. Although evaluating hardware geometries and physical phenomena remains difficult for current LLMs, the proposed approach enables knowledge sharing and supports ideational design by making implicit design intent explicit.

Keywords : Large Language Model, Model-based Development, Design Engineering, Patent Specification, Ideational Design

1. Introduction

To build a business, a company must plan the products and services that will become its commercial offerings and design the methods for realizing them. Fujita classifies the design process, from upstream to downstream, into planning and problem clarification, conceptual design, basic design, and detailed design. He defines "ideational design" as the stage spanning from planning and problem clarification through the middle of conceptual design, and discusses methods for ideational design (藤田喜久雄, 2026). New businesses are conceived from inventive ideas. At the outset of ideational design, ideas remain vague and abstract. Verbalizing an idea and verifying its content is important for improving the quality of the design. This report organizes the role of patent specifications in ideational design in manufacturing industries. In this report, we examined a method for efficiently verbalizing ideas at the ideational design stage by using large language models (LLMs) to produce high-quality patent specifications with a small number of contributors. We confirmed that ideas for inventions related to software and solutions can be concretized and expanded with LLM support. On the other hand, we found that evaluating the shape of physical objects for hardware-related inventions, and drafting specifications based on such evaluation, remains difficult. Nevertheless, LLMs were able to read the design intent of an invention from patent documents, structure it, and visualize it. This showed that design intent can be shared, and that this can support humans in generating new ideas.

2. The Role of Patents in Ideational Design

2·1 Forms of Patents

2·1·1 Inventions under the Patent System

Under the Japanese patent system, an invention is defined as a highly advanced creation of technical ideas utilizing a law of nature. A creation of technical ideas is recognized as an invention when it possesses novelty and an inventive step relative to the prior art.

Table 1　Requirements of novelty and inventive step in inventions

Novelty	The requirement that the invention does not exist in the prior art; it serves as a key criterion in patent examination.
Inventive step	Judged on the basis of whether a person skilled in the art could easily conceive the invention, in light of the problems and limitations of the prior art.

2·1·2　Items of a Patent Specification

A patent specification is written using the items shown in Table 2.

Table 2　Items of a patent specification

Claims	Defines the technical scope of the invention and the scope of the patent right.
Problem to be solved by the invention	Describes the problems and limitations of the prior art and explains what problem the invention was proposed to solve.
Embodiments	Describes concrete methods and configuration examples for realizing the invention.
Drawings	Figures that visually show the structure, operation, and processing procedure of the invention.

2·2　Types of Inventions

Under the Japanese patent system, inventions are classified into three categories: products, methods, and methods of producing a product. Table 3 describes each of these categories. Mathematical algorithms and formulas themselves do not, in principle, qualify as technical ideas utilizing a law of nature, and therefore are not patentable. However, when an algorithm is realized as concrete information processing on a computer and solves a technical problem such as reducing computational resources or improving processing speed, it can be patentable as a software-related invention.

Table 3　Types of inventions in patents

Product invention	Includes mechanical devices, components, materials, chemical compositions, computer systems, and programs. For example, the blade shape of a propeller fan or an information processing device is claimed as a product invention.
Method invention	Includes a series of processes such as control procedures, measurement procedures, and analysis procedures. The mechanism of a service is also included as a method invention.
Method of producing a product	An invention characterized by a manufacturing or processing process, such as a method of manufacturing a resin part or a method of manufacturing a semiconductor.

2·3　Description of Ideational Design in Patent Specifications

A patent specification clarifies the problems in the prior art and describes the configuration, processing procedure, and effects of the invention that solves these problems. These descriptions correspond to planning and problem clarification, conceptual design, and basic design in the ideational design process. To organize the correspondence between patent specifications and the design process, Table 4 summarizes the correspondence between the items of a patent specification and the stages of the design process. A patent specification describes planning and problem clarification, and conceptual design. Part of the basic design may also be described.

Table 4 Correspondence between patent specification items and design process

Design process stage	Patent specification item
Planning and problem clarification	Problem to be solved by the invention
Conceptual design	Claims, embodiments, drawings
Basic design	Embodiments, drawings
Detailed design	Not applicable

2·4 Trends in Patent Applications in Manufacturing

A patent that has been granted becomes an enforceable right and can prevent imitation by others. However, because a patent specification is published, filing a patent application also discloses the technology to others. In manufacturing, product inventions are filed frequently; examples include improvements to the blade shape of propeller fans and new mechanical structures. Product inventions are relatively easy to reverse-engineer by observing or disassembling an actual product. Because of this, companies tend to actively file patent applications to protect their intellectual property before others can understand the technology through analysis.

Method inventions, on the other hand, were not historically filed as actively. Because it is difficult to analyze the control or procedures of a machine from the outside, filing a patent application could conversely make it easier for competitors to catch up with the technology (石本, 2018), (後藤, 2017).

In recent years, method inventions have also been actively filed. As labor mobility between companies has increased, it has become easier for personnel to bring technical knowledge with them, and it is thought that method inventions are also filed to protect against this (河野, 2018).

In recent years, a large number of applications related to artificial intelligence (AI) technologies have been filed. For AI-related inventions, programs implementing a machine learning system or a trained model are treated as product inventions, while the procedures of the learning process or the inference process are treated as method inventions.

3. Related Work

Among related work on drafting patent specifications using LLMs, most studies address method inventions, while studies on product inventions are scarce. We first describe related work on method inventions.

3·1 Related Work on Using LLMs to Draft Patent Specifications for Method Inventions

For drafting patent specifications of method inventions, related work using LLMs exists for claim generation, figure caption generation, and evaluation of novelty and inventive step.

PatentFormer is a model proposed by Samsung that divides the patent-drafting process into stages and improves the quality and efficiency of patent specifications by applying an LLM at each stage (Mudhiganti et al., 2025). AutoPatent automatically produces a high-quality, complete patent from an inventor's initial draft (Wang et al., 2024). FlowPlan-G2P addresses the fundamental rhetorical and structural differences between scientific papers and patent specifications, and can produce the hierarchical reasoning and statutory requirements needed for patent drafting (Pan and Yoo, 2026).

3·2 Related Work on Using LLMs to Draft Patent Specifications for Product Inventions

3·2·1 Examples of Related Work

Related work using LLMs for product inventions is scarce compared with that for method inventions. PatentVision is an extension of the aforementioned PatentFormer, and proposes a multimodal LLM that generates a patent specification from drawings and claims (Yang et al., 2026). In this work, the format of claims can be arranged based on drawings, but the model cannot understand the content of the drawings to evaluate shapes or generate shapes.

Text2CAD can generate a CAD shape from text, but it cannot verify an idea based on the resulting CAD shape or generate text conforming to the format of a patent specification.

LLMs can be used to verify and evaluate design information such as CAD models and text (村上他, 2025)(片山他, 2025).

3·2·2 Difficulty of Using LLMs to Draft Patent Specifications for Product Inventions

Drafting a patent specification for a product invention requires evaluating the structure and shape of the hardware and generating text that conforms to the format of a patent specification, using expressions appropriate for demonstrating novelty and inventive step.

It has been pointed out that design includes informal knowledge, such as design intent and design effects, that is not explicitly documented in CAD models or design documents (野間口, 2002).

Nomaguchi et al. represented the design process as a meta-process model and proposed the Design Documentation Managing System (DDMS), a design knowledge management method that automatically generates and manages design documents from the operation logs of the integrated design support environment Knowledge Intensive Engineering Framework (KIEF). This method aims to acquire, share, and reuse design knowledge, including design intent and design rationale.

To evaluate novelty, it is necessary to understand the technical effects arising from differences in structure and shape between the prior art and the new technology, and to generate text conforming to the format of a patent specification using appropriate expressions. Because different patent specifications may use different terms to describe the same structure or shape, generating text that conforms to the format of a patent specification requires associating design intent and design rationale that represent the same concept but are described using different terminology.

Evaluating inventive step requires evaluating the effects of physical phenomena (structure, strength, heat) caused by the shape and structure of the invention. Text-to-CAD Generation proposes an LLM model that generates a CAD shape from text (Guan et al., 2025). Because current LLMs are not models that can predict the relationship between shape and physical phenomena with high accuracy, evaluating the inventive step or effectiveness of an invention requires verification through numerical simulation or experiment. LLMs can perform simulations by numerical computation based on a CAD shape, but no LLM model that consistently performs the process from CAD shape to simulation has been put into practical use. Moreover, the evaluation of inventive step in patent examination is based on whether a person skilled in the art (an engineer of average skill in the technical field of the invention) could easily conceive of the invention (Patent Act, Article 29, Paragraphs 1 and 2). Therefore, an LLM must have knowledge and evaluation ability not only of the effects of physical phenomena but also of the technical field of the invention as a whole.

Because the evaluation of novelty and inventive step is difficult, drafting a patent specification for a product invention is more challenging than for a method invention. Table 5 summarizes the differences between method inventions and product inventions in the evaluation of patent specifications.

Table 5 Differences between method inventions and product inventions in the evaluation of novelty and inventive step

Factor	Method invention	Product invention
Evaluation of novelty	Evaluates differences from the prior art based on differences in the logic of the processing method or procedure.	Evaluates differences that reflect design intent, arising from differences in structure or shape.
Evaluation of inventive step	Evaluates the effects produced by the logic of the processing method or procedure.	Evaluates physical phenomena such as improved performance or reliability.

3·3 Positioning of This Study

This study connects research on LLM-based “patent specification generation” with research on “design knowledge management” in design engineering. Rather than treating a patent specification merely as an intellectual property document, we position it as a document that records design knowledge in ideational design, and use an LLM to extract and structure design intent from it. Through this, we propose a framework that provides integrated support for idea generation and design knowledge sharing at the ideational design stage.

4. Experiments Using LLMs

4·1 Experiment on Supporting Generation of Patent Specifications for Method Inventions

Based on related work, method inventions can be expected to benefit from automated performance in generating patent specifications. In this report, we conducted an experiment in which an LLM was used to draft a patent specification for ideational design in manufacturing. As shown in Table 6, the use of the LLM was divided into two stages to produce the patent specification.

Table 6　Flow of the experiment supporting generation of patent specifications for method inventions

Stage 1: Idea development	The content of the idea is discussed with the LLM in a chat format. Through dialogue with the LLM, the content of the idea is concretized, and the content of the claims and embodiments is examined.
Stage 2: Drafting the specification	Based on the idea discussed in Stage 1, the claims and embodiments of the patent specification are drafted.

4·1·1　Experimental Environment

In the first stage, ChatGPT (GPT-o3) was used to concretize the idea. In the second stage, Claude Code (Claude Opus 4.1) was used as the execution environment, and we built a project environment incorporating a Skill, templates, a knowledge base, and Mermaid diagram generation tools for generating patent specifications. The generated specification was typeset with Typst, and the drawings were created by converting Mermaid diagrams to SVG.

4·1·2　Stage 1

In the experiment, we discussed a system in which an LLM automates the post-processing of numerical fluid computation and the output of improvement guidelines, and worked to concretize this idea with the LLM. This idea aims to reduce the workload of designers and improve the efficiency of design work by using an LLM to automate CAE post-processing. Technologies that let LLMs automate design work in this way have recently been filed frequently as patent applications (Pedder and Agley,). We presented the above idea to ChatGPT (GPT-o3) (OpenAI, 2026) and discussed with the LLM how to translate the idea into the claims and embodiments of a patent specification.

4·1·3　Stage 2

In this study, we built a project environment for the general-purpose AI agent Claude Code (Claude Opus 4.1) (Anthropic, 2026), incorporating a Skill, templates, a knowledge base, and a set of drawing-generation tools for patent drafting. Table 7 shows the directory structure of the project given to Claude Code. Claude Code reads the Stage 1 discussion, saved in Markdown format in the notes folder, and generates the claims and embodiments of the patent. The Skill describes the drafting policy for claims and embodiments so as to be able to address office actions such as notices of reasons for refusal from the patent office. We also provided prior-art patent documents similar to the idea concretized in Stage 1.

Table 7　Directory structure of the Claude Code project for patent specification generation

File / Folder	Description
`main.typ`	Main text of the patent specification (for PDF output).
`symbols.typ`	File that centrally manages figure numbers and reference signs.
`notes/`	Directory storing the content of discussions with the LLM and ideas in Markdown format.
`patent_diagram_toolkit/`	Tools for generating Mermaid diagrams.
`generated/`	Directory storing the generated Mermaid, SVG, and PNG files.

4·2　Experiment on Supporting Generation of Patent Specifications for Product Inventions

Generating a patent specification for a product invention, unlike for a method invention, requires understanding not only the shape and structure but also the design intent and physical effects they embody. In this study, therefore, rather than having the LLM generate the patent specification directly, we examined a method that converts design knowledge into an intermediate representation before generating the new invention.

The experiment targeted two patent documents concerning a propeller fan for an outdoor air-conditioning unit (Patent Document A, Sharp (竹田, 大塚, 2010), and Patent Document B, Mitsubishi Electric (濱田他, 2019)). Mitsubishi Electric's patent cites Sharp's patent as prior art, making this pair suitable as a target for analyzing the developmental process of an invention. Using these two patent documents as input, we had the LLM extract the design knowledge of the propeller fan and generate a meta-process model. We further attempted to generate a new draft claim using the generated meta-process model as input.

We gave Claude Code (using Claude Opus 4.8 and Claude Fable 5) a Skill that analyzes a patent specification using a three-layer structure. The first layer (L1) extracts parts and their relationships as a Feature Ontology; the second layer (L2) extracts design intent as a Meta Process Model based on the DDMS of Nomaguchi et al.; the third layer (L3) represents the shape space using constraint conditions and a parametric CAD script. We further generated an Innovation Chain between the patents using a semantic mapping (Ontology Alignment) of the part concepts extracted in L1 and the design intent extracted in L2. Finally, using these analysis results as input, we attempted to generate a new draft claim.

As shown in Table 8, we instructed Claude Code to interpret the design documents and evaluate the shape of the object using a three-layer structure. The first layer (L1: Feature Ontology) represents the design target as an ontology structure consisting of part nodes and relationship edges. The second layer (L2: Meta Process Model) is an information-derivation graph based on knowledge operations, representing design knowledge such as design intent and technical effects. The third layer (L3: Parametric Shape Space) consists of a set of constraint conditions and a parametric CAD script, and represents the shape of the design target.

Table 8　Three-layer model for representing design knowledge of product inventions

Layer	Name	Question answered	Representation
L1	Feature Ontology	What exists (What)	Graph of part nodes and relationship edges (JSON)
L2	Meta Process Model	Why it was designed (Why)	Information-derivation graph based on knowledge operations (JSON)
L3	Parametric Shape Space	What is geometrically covered (Where)	Constraint condition set + parametric CAD script

To represent design intent, the Meta Process Model of layer L2 was built using a K-code classification, shown in Table 9, based on Nomaguchi's classification of the meta-process model. The K-codes correspond to the claims and embodiments of a patent specification, and allow design intent to be expressed in the form of a patent specification.

Table 9　K-code classification of design intent and its correspondence to patent specifications

Category	Design intent	Correspondence to patent
K1	Requirement / objective	Problem to be solved by the invention
K2	Prior art / problem	Background art / prior examples
K3	Design target / structure	Claims / constituent features
K4	Design intent / rationale	Why this structure
K5	Physical phenomenon / action	Action / function / operation
K6	Effect / advantage	Effects of the invention
K7	External knowledge	Cited references / CAE / experiments

Layer L3 consists of a constraint condition set and a parametric CAD script (CADQuery). The constraint condition set verifies the geometric constraints that define the shape of the design target. We instructed the LLM to represent the shape of the object as design knowledge in the three layers, structure the design intent, and then generate a new invention.

5.　Results

5·1　Generation of a Patent for a Method Invention

Table 10 shows part of the claims, embodiments, and drawings of the patent specification generated in this experiment.

In Stage 1, we were able to expand and revise the claims through dialogue with ChatGPT. During the dialogue, taking into account the variation in the quality of feedback from human experts, we were able to incorporate into the claims the idea of weighting the data from higher-quality experts more heavily during learning. ChatGPT also proposed incorporating Chain-of-Thought (CoT) reasoning into the claims.

In Stage 2, using Claude Code, we were able to generate the claims and embodiments of the patent specification based on the idea discussed in Stage 1. We were further able to generate Mermaid diagrams based on the generated claims and embodiments. The resulting patent specification was submitted through the electronic filing system of the Japan Patent Office (Patent Application No. 2026-46687).

Table 10 LLM-based generation of a patent specification for a method invention

【発明の名称】

【0000】 回転機械の設計支援方法及び装置。

【技術分野】

【0001】 本発明は、数値流体解析（CFD: Computational Fluid Dynamics）、大規模言語モデル（LLM: Large Language Model）を用いた設計改善指針の生成、専門家フィードバックの取得、および設計改善成果に基づく専門家フィードバックの重み更新に関し、特に回転機械の設計支援方法及び装置に関する。

【背景技術】

【0002】 回転機械の設計においては、羽根形状、流路形状、及び運転条件等の設計パラメータが性能に大きく影響するため、設計段階において数値流体解析（CFD）を用いて流れ場を評価することが一般的に行われている。

【0003】 従来、回転機械の設計では、CAD により設計形状を作成し、その形状に対して数値流体解析を実行し、得られた圧力分布、速度分布、渦度分布等の流れ場データを設計者が解析することにより設計改善を行っている。

【0004】 しかしながら、流れ場の評価には高度な専門知識が必要であり、解析結果から設計改善案を導く作業は熟練設計者の経験に大きく依存するという問題がある。また、複数の設計案を比較検討する場合には多数の解析を繰り返す必要があり、設計探索に長時間を要するという課題もある。

【0008】 このような専門家によるレビューを機械学習に利用する場合、複数の専門家から得られるフィードバックの品質にはばらつきが存在する。例えば、特定の設計条件又は流れ場パターンに対して有効な助言を行う専門家もいれば、必ずしも適切な改善提案を行えない専門家も存在する。

【0009】 従来の機械学習においては、複数の人間による評価又は注釈を用いる場合に、評価者の信頼度に基づいて学習データの重みを調整する技術が知られている。しかしながら、これらの技術は主として一般的なデータラベリング又は評価作業を対象としており、実際の設計変更の結果として得られる性能改善量に基づいて専門家のフィードバックの有効性を評価するものではない。

（略）

【発明を実施するための形態】

【00032】 以下、図面を参照して本発明の実施形態を詳細に説明する。

【00033】 本実施形態の設計支援装置は、設計データ取得部（10）、流体解析部（20）、改善指針生成部（30）、フィードバック取得部（40）、重み更新部（50）、CoT モジュール（60）、および改善履歴データベース（70）を含んで構成される。

【00034】 設計データ取得部（10）は、回転機械の設計形状データ（CAD モデル）、材料物性値、運転条件パラメータ等を含む設計データを取得する。取得した設計データは、後段の流体解析に適した形式に変換される。

【00035】 流体解析部（20）は、取得した設計データに基づいて数値流体解析（CFD）を実行し、流れ場データを生成する。流れ場データには、圧力分布、速度分布及び渦度分布の少なくとも一つが含まれ、これらは改善指針生成部（30）への入力として供される。

【00036】 改善指針生成部（30）は、流体解析部（20）から受け取った流れ場データおよび設計データを入力として大規模言語モデル（LLM）を用い、設計改善指針を生成する。生成の際、CoT モジュール（60）（CoT モジュール）が改善理由を示す推論過程（Chain-of-Thought）を内部的に構築し、各推論ステップの内容および論理的連鎖を記録・参照可能とする。これにより生成された改善指針の根拠の透明性が確保される。

【特許請求の範囲】

【請求項 1】 回転機械の設計支援方法であって、 回転機械の形状データを含む設計データを取得する工程と、 前記設計データに基づいて流体解析を実行し流れ場データを生成する工程と、 前記流れ場データ及び設計データを入力として大規模言語モデルにより設計改善指針を生成する工程と、 前記設計改善指針についてエキスパートのフィードバックを取得する工程と、 前記フィードバックに基づいて前記設計改善指針を更新する工程と、 更新された設計改善指針に基づいて設計変更を生成する工程と、 を含むことを特徴とする回転機械の設計支援方法。

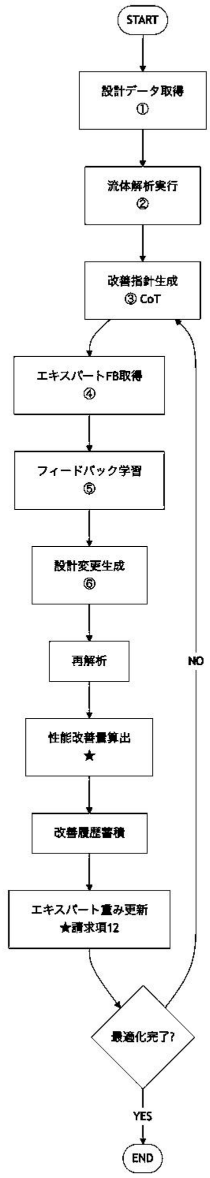
【請求項 2】 前記流体解析は数値流体解析により実行されることを特徴とする請求項 1 に記載の設計支援方法。

（略）

【請求項 12】 前記エキスパートのフィードバックに基づいて生成された設計変更について再解析又は実測評価を行い、 当該再解析又は実測評価によって得られた性能改善量に基づいて前記エキスパートのフィードバックの有効性を評価し、 当該評価結果に応じて前記エキスパートのフィードバックを学習データとして利用する際の重みを更新することを特徴とする請求項11に記載の設計支援方法。

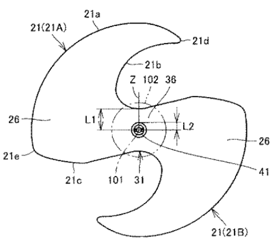
（略）

【請求項 15】 回転機械の設計支援装置であって、 設計データを取得する設計データ取得部（10）と、 前記設計データに基づいて流体解析を実行し流れ場データを生成する流体解析部（20）と、 前記流れ場データ及び設計データを入力として大規模言語モデルにより設計改善指針を生成する改善指針生成部（30）と、 前記設計改善指針についてエキスパートのフィードバックを取得するフィードバック取得部（40）と、 前記フィードバックに基づいて生成された設計変更の再解析又は実測評価による性能改善量に基づいてエキスパートフィードバックの重みを更新する重み更新部（50）と、 を備えることを特徴とする設計支援装置。

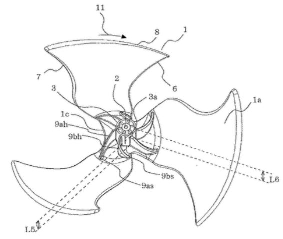


5·2 Generation of a Patent for a Product Invention

Figure 1 shows representative drawings cited from the two patents. Figure 2 shows the Feature Ontology extracted from each patent document. The LLM extracted the parts described in each patent as nodes and the structural relationships between parts as edges, visualizing the structure of both patents as a graph. Furthermore, by performing semantic mapping (Ontology Alignment) based on function, position, and connection relationships rather than part names, we were able to associate the same concept even when described using different terminology.

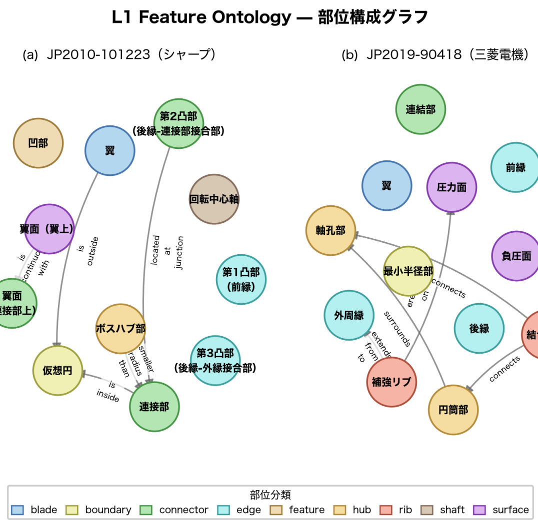


(a) Patent Document A



(b) Patent Document B

Figure 1　Patent drawings of two patent specifications



Ontology structure of Patent Document A (left) and B (right)

Figure 2　Ontology structure of two patent specifications

Figure 3 shows the two patent documents and the meta-process model newly generated by Claude Code. The LLM extracted the problems, design decisions, shape features, physical phenomena, and effects described in the patent documents, and structured them as a knowledge-operation graph based on the K-codes. This confirmed that design intent, which had previously been described only in prose, can be visualized as a causal relationship between design decisions and their rationale. Furthermore, using the design knowledge extracted in L1 and L2 as input, we generated a draft claim for a new axial fan. The resulting invention was expressed as a combination invention that inherits design elements from the two existing patents while introducing a new reinforcing structure. At this stage, however, the design intent and physical phenomena are based on LLM inference, and performance verification by methods such as finite element analysis or numerical fluid analysis is required to substantiate the inventive step. In layer L3, the validity of the shape is verified using parametric CAD. We found that the ability of current LLMs to generate three-dimensional CAD shapes is limited, and that human involvement in shape design is still required. Nevertheless, we found that the meta-process model output by the LLM could organize the design intent of a hardware product's design technology as causal knowledge. This demonstrates the applicability of LLMs to inheriting design knowledge and to supporting ideational design.

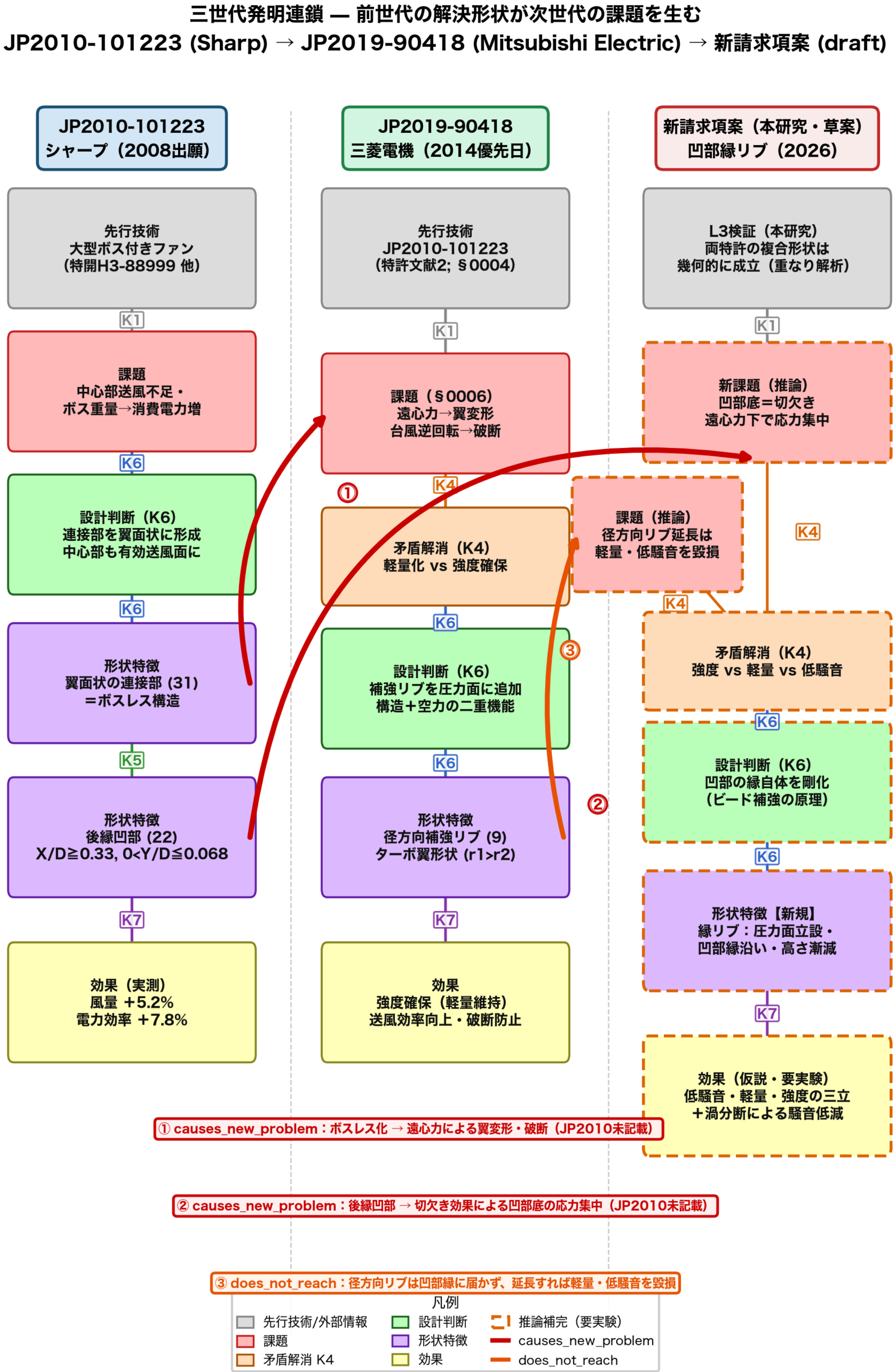


Figure 3　LLM-based generation of a patent specification for a product invention

6. Conclusion

In this study, we examined support for ideational design through patent specification generation using LLMs. For method inventions, we confirmed that dialogue with an LLM can develop an idea into claims and embodiments and automatically generate it as a patent specification. For product inventions, on the other hand, evaluating shapes and understanding physical phenomena remain difficult, but we showed that design intent can be structured and visualized using a meta-process model. This demonstrates the potential for sharing design knowledge and supporting the generation of new ideas.

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