



Digital Design Network+ Case Study 1 Individual Report

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Team	Johannes Norheim, Ryan Murphy, Christopher Baker, Juan Li
Focus	Better, Faster, With Less
Design Process	My work focuses on developing a patent knowledge base system that supports all phases of the design process.
Tools Used	Various approaches to semantic extraction and definition, along with large language model embeddings, have been used to develop a patent knowledge base system. Details are given in this report.
Links	https://invention-morphology.streamlit.app/

Executive Summary

[Please provide a one or two paragraph summarising the work you have undertaken]

A Patent Data-centric Knowledge System for Re-imagining the Drone Design Process has been proposed and demonstrated in this design challenge. The proposed system restructures the patent database through the Function-Behavior-Structure framework and the morphological chart. These approaches are chosen because they are widely accepted in the field of engineering design. The initial assessment within the team indicates that the proposed knowledge system could support various design phases, including requirements generation, concept exploration, and testing. The tool demonstration at the workshop has generated interest from the industrial partner Boeing. This work laid the foundation for further expansion and refinement of this knowledge system.

Problem

[Please provide define the existing design problem that you were seeking to overcome with new Digital Design tools]

Engineers spend significant time understanding the progression of state-of-the-art knowledge in a particular design project. The use of existing knowledge-based systems is limited due to a lack of personalization to engineers' and organizations' needs, a lack of exploratory features, interpretability issues, and high costs.

Digital Design Solution

[Please provide a description of your solution. Figures are welcome.]

To develop a more effective knowledge-based system, this research aims to structure patent information and succinctly summarize it in a format useful to engineers. The morphological chart and the Function-Behavior-Structure (FBS) framework are chosen to develop this knowledge system, as they are widely accepted and used in the engineering community. Figure 1 details the process followed in developing the knowledge system. After relevant patents were searched and selected for the drone design, FBS information was extracted from each patent abstract. A patent can have multiple FBSs

extracted and mapped coherently. The next step involves grouping similar functions across various patents. This grouping leads to the development of the patent information into the morphological chart structure. Furthermore, the grouped functions are mapped to product subsystems, enabling engineers to easily explore the relevant functions.

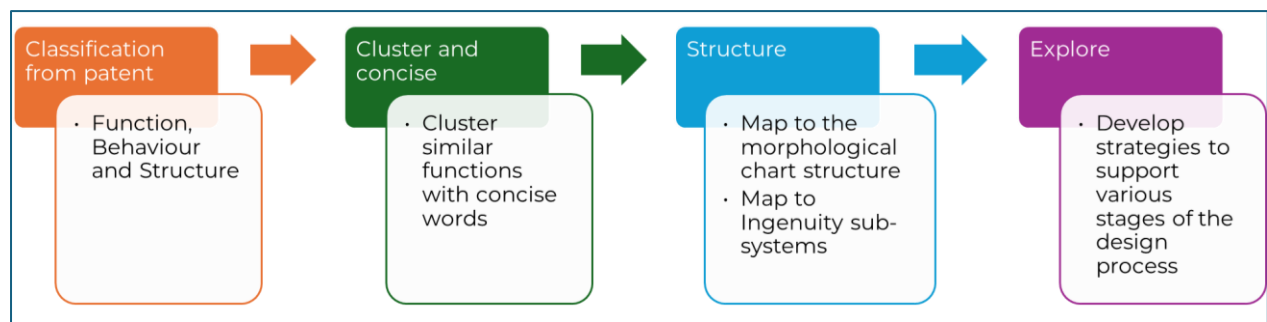


Figure 1. The process followed in developing the knowledge system

Since the focus is on imagining the drone design process, we have selected Mars Ingenuity as a test case. Patented drones related to the Mars environment were searched. To demonstrate the proposed system, 6700 patents were analyzed. Figure 2 details the tools and techniques used at the different steps in developing the knowledge system. Various heuristics have been embedded in this system based on continuous evaluation of the outcomes at each stage. The structured morphological chart, developed from an analysis of 6700 patents, is available online at <https://invention-morphology.streamlit.app/>.

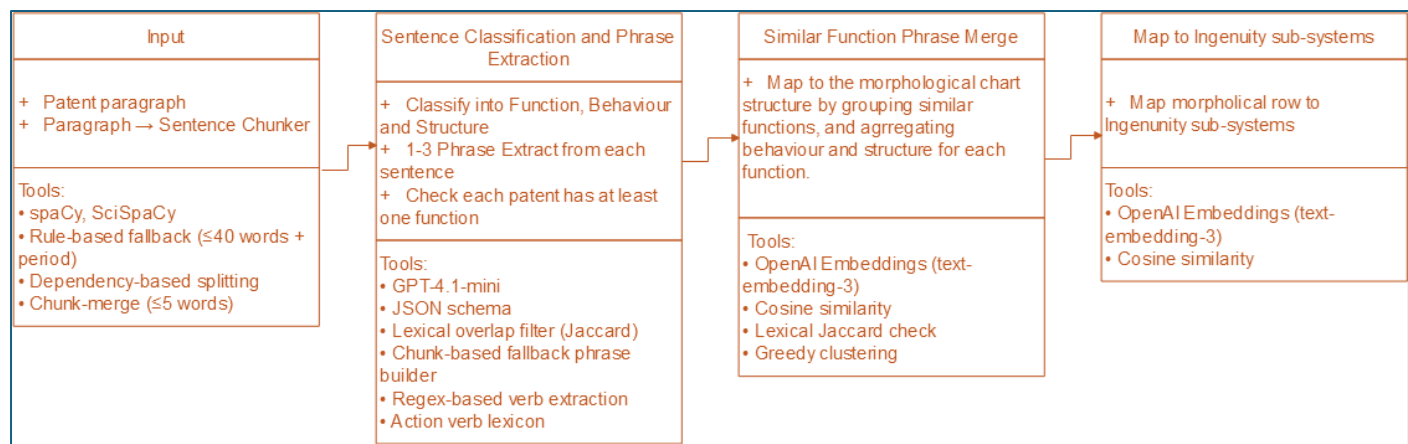


Figure 2. Tools and techniques used in developing the knowledge system

How it makes Digital Design Better, Faster and/or With Less

[Please describe how your solution improved the design process with respect to making Digital Design better, faster and/or with less.]

The team members found that the proposed knowledge-based system could be useful to them for requirement generation, conceptualization, and evaluation and testing by providing helpful information on specific functions. The main perceived merit of the proposed knowledge system is that it helps engineers find useful information in less time. Since the knowledge system could cover all stages of the design process, it could help develop more comprehensive requirements and support faster exploration of design concept generations. The system will be assessed with students, engineers, and industries to quantify these benefits. Also, finding similar research related to the

proposed solution reassures that the proposed system has significant value and warrants considerable attention [1].

Reflections

[Please provide your own reflections / learnings from doing this activity that might help inform future R&D in Digital Design. For example, where do you see the challenges? In building tools, knowledge and skills, adoption, value propositions, data flows etc...]

The best aspect of participating in this design challenge is the networking with other researchers. It's phenomenal to closely examine other research and try to integrate it into my own research. It wouldn't have interacted with them otherwise. The team worked collaboratively well and exchanged ideas openly. The workshop presentation facilitates the widespread dissemination of the solution. I am glad to receive interest from an engineer from Boeing. I hope this interest will lead to potential pathways for further research.

Although we worked well, given the timescale, the integration aspect is limited. Providing additional funding to develop more integrated solutions could lead to novel digital design techniques. Having an industrial professional on the team would have provided insightful requirements and feedback on the developed solutions.

References

[Add any references you like to support your statements]

1. Park, J., & Geum, Y. (2025). LLM-enhanced idea generation: data-driven morphological analysis with LDA and NuNER. Computers & Industrial Engineering, 111426.

Appendix

[Please provide any additional media / content that the network can use to promote your work and feature in any future content produced by the network the publicise the outputs]

I would like to receive feedback on the development system: <https://invention-morphology.streamlit.app/>. Please disseminate this link with my contact email to facilitate receiving the feedback.