ASME 2019 IDETC/CIE
International Design Engineering Technical Conferences & Computers and Information in Engineering Conference
CONFERENCE
August 18–21, 2019
Hilton Anaheim, Anaheim, CA

A Deep Learning-Based Framework to Predict Sequential Design Decisions

CIE 2019 Graduate Research Poster

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Research Motivations and Gaps

Research Motivations

- In-depth understanding of the sequential design decision would help to discover beneficial design heuristics.
- Accurate prediction of design sequences is also vital to implement and improve design automation.

Research Gaps

- Existing studies mainly focus on exploring design patterns and characterizing design sequence based on only dynamic data.
- Although deep learning has been achieved state-of-the art performance in many field, it is unexplored in design area.

Research Hypothesis & Objectives

Research Objectives

- The objective of this study is to predict human sequential design decision in engineering system design context
- Develop a framework based on deep learning models [3] (long short-term memory (LSTM)unit and gated recurrent unit (GRU)) by integrating static data and dynamic data.

Research Hypothesis

Combining static data and dynamic data in deep learning models will improve the prediction accuracy

Research Platform and Experiment

- We use **Energy3D**, a CAD-based design tool for solar system design to study design thinking research.
- Energy3D provide fine-grained design process data with a lens of high resolution in unobtrusive way.

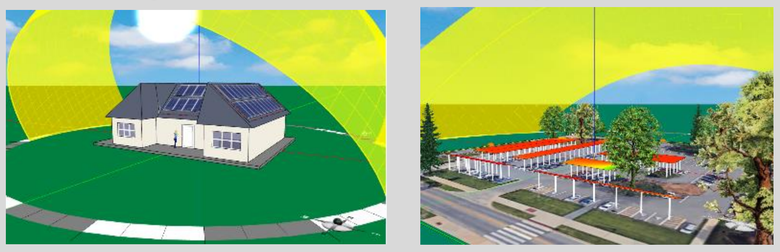


Figure 1: Design problems

Methodologies and Implementation

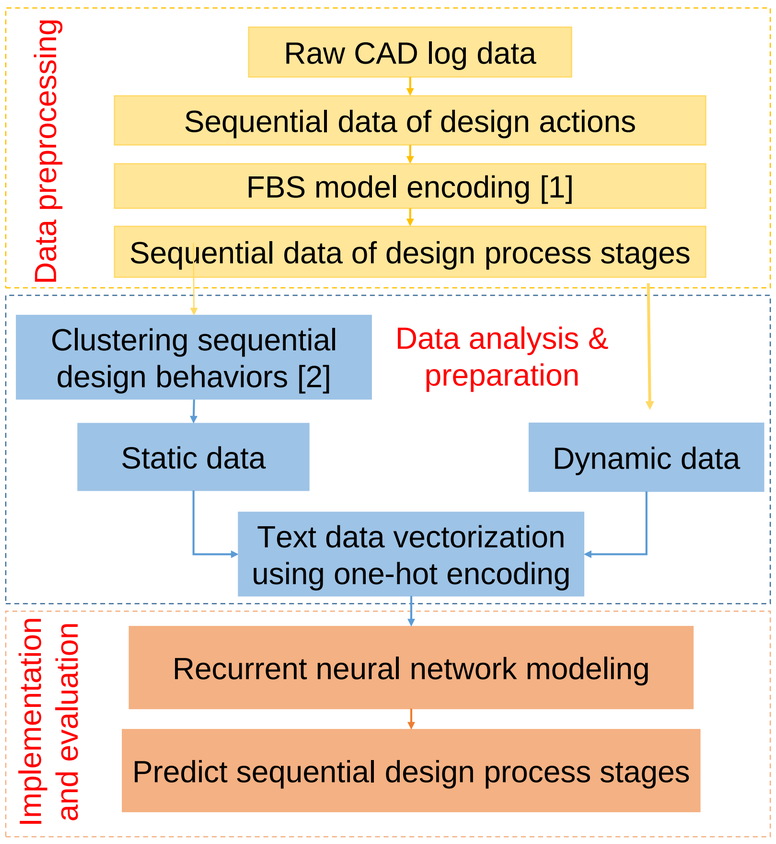


Figure 2: The general framework for combining static and dynamic data

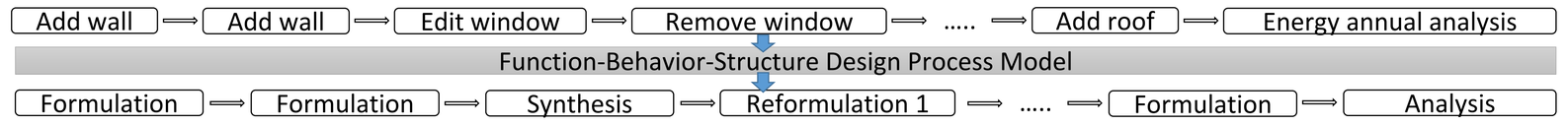


Figure 3: Transformation of the sequential data of design actions to the sequential data of design process stages based on FBS model

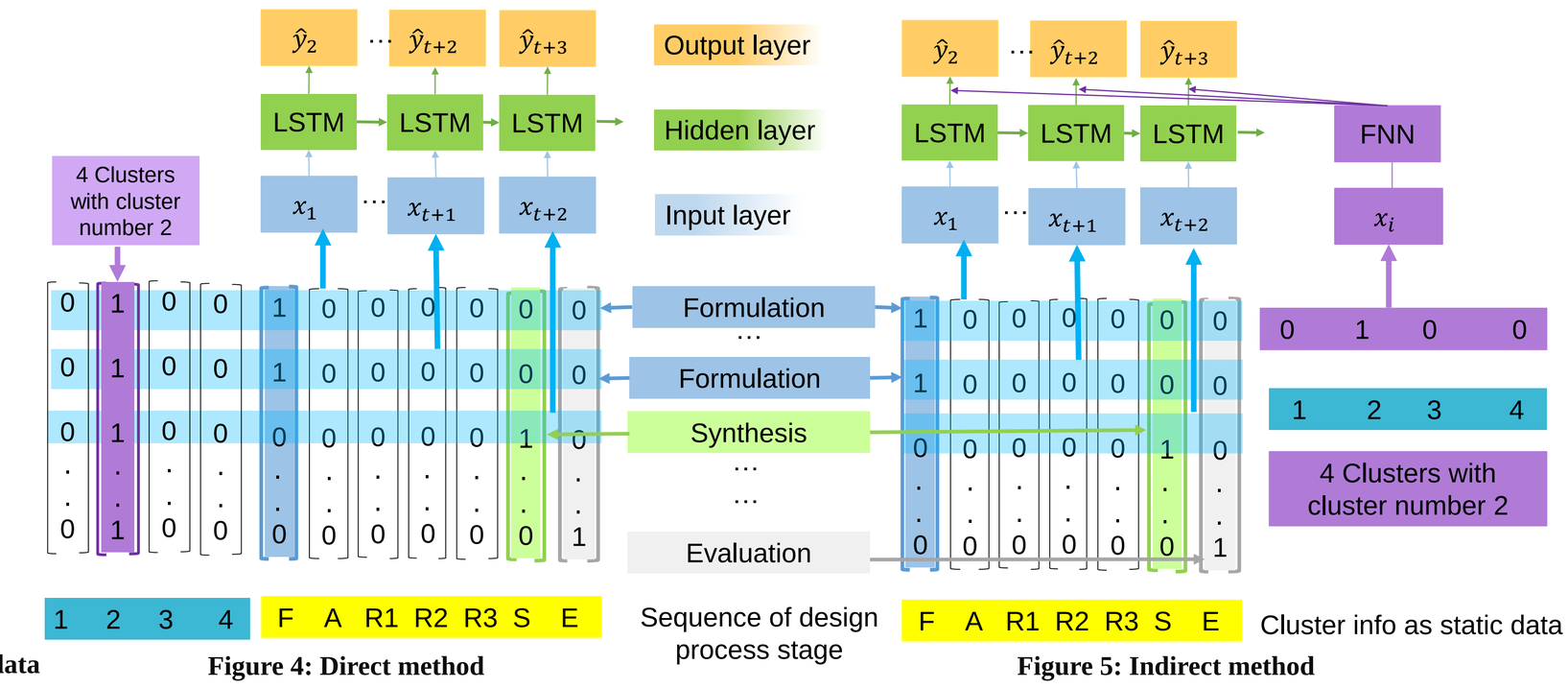
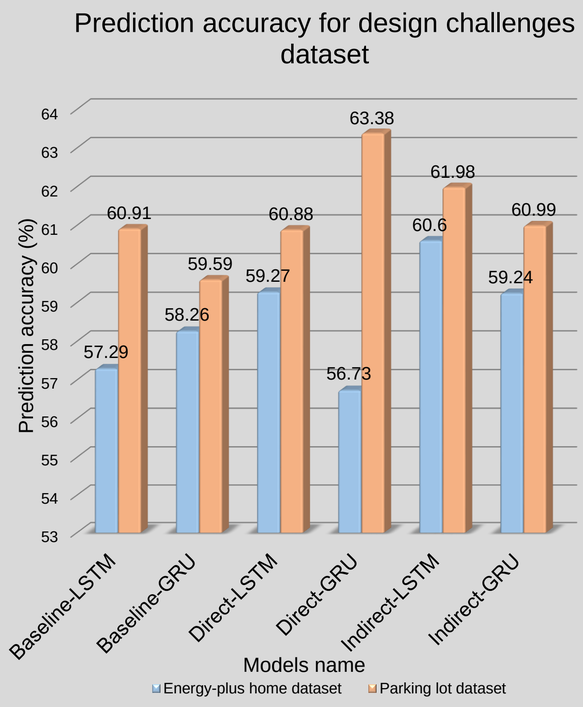
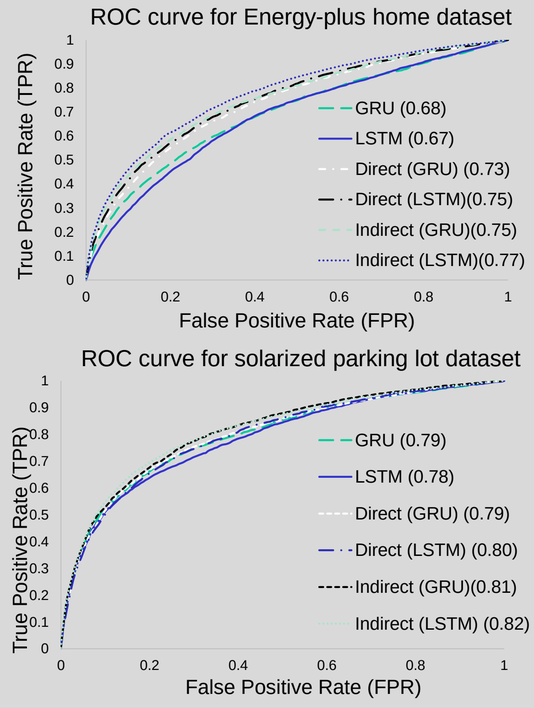


Figure 4: Direct method

Figure 5: Indirect method

Results





Future work

- A two-level framework will be developed to predict design action level sequence instead of predicting design process level sequence.
- We will add more static data by extracting psychological factors related to design thinking and cognitive skill.
- The further step of this research is to leverage the reinforcement learning as a core implementation of design automation.

References

[1] Gero, J. S., 1990. “Design prototypes: a knowledge representation schema for design”.AI magazine,11(4), p. 26.
[2] Rahman, M.H., et al. *Automatic Clustering of Sequential Design Behaviors*. in *ASME 2018 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. 2018.
[3] Goodfellow, I., Y. Bengio, and A. Courville, *Deep learning*. 2016: MIT press.

Acknowledgement

We gratefully acknowledge the financial support from the U.S. National Science Foundation (NSF) CMMI through grant # 1842588

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