Visualization of Heating and Cooling Demands

I 379C Informatics Capstone

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I. Project Overview

A prevalent issue in residential America is the presence of oversized Heating, Ventilation, and Air Conditioning (HVAC) systems. Indeed, the majority of homes with internet-connected thermostats that donated their data operate at only 50% of maximum capacity during the coldest hours, a potential consequence of oversized systems as well as homeowners adding insulation over time (Meier et al., 2019). Many homeowners and contractors often opt for larger systems in order to avoid discomfort during the hottest and coldest days of the year, but at the consequence of higher upfront cost and risks to humidity and long-term home sustainability (Djunaedy et al., 2011).

A potential source of oversized systems is a lack of intuitive visualizations, and so the primary objective of this project is to create a visualization system of the heating and cooling loads that a home will face throughout the year. In particular, developing a visualization of HVAC loads on a time-series level throughout a year can help inform better understanding and thus decisions regarding equipment sizing from both a homeowner and contractor perspective. This project aims to create a generalizable time-series visualization system based on inputs such as home schematics, local weather and climate conditions, and simulated system loads.

The main body of work for this project are as follows:

- **Background research**, such as into current visualization systems and open-source data availability. Current visualizations have indeed continued to be unintuitive to the average consumer, such as those developed by the Northeast Energy Efficiency Partnership

(2021). While providing extremely helpful information for contractors and HVAC experts, there is still an opportunity in providing intuitive visualizations to homeowners lacking prior knowledge.

- **Design of prototype visualizations and sketches**. Following design principles, this project is working within an iterative manner, moving from paper sketches to rough generated visualizations before continuing to enhance visualization detail and quality.
- **Simulation of HVAC loads**. While peak loads for many homes in the US are available through open-source storage, such as from the Open Energy Data Initiative (2022), hourly loads are often sparse or unavailable. As such, this project utilizes hourly energy loads generated by the Building Energy Optimization Tool (BEopt), developed by the National Renewable Energy Laboratory (2024). The data generated through simulation will then be refined and visualized according to the design process.
- **Reporting and Collaboration**. After developing a working system, this project is reaching out to relevant stakeholders in the HVAC industry, such as the Northeast Energy Efficiency Partnership mentioned, to gauge interest in conducting user testing and/or implementation of the new visualization option.

The work on this project is taking place within the Spring 2024 semester, ranging from January to May 2024. The work is conducted between the student, Michael Chen, and supervisor, Dr. James Howison. For a more granular timeline, most background research was conducted in February, with prototype visualization sketches and preliminary simulations as well as requests for collaboration being sent out in March. Further refinement of output data and visualization

details is taking place throughout April and May, as well as continuing to work with interested collaborators.

II. Relevance of UT iSchool Informatics Courses

There were four iSchool Informatics courses that were particularly applicable to the work in this capstone project.

I 305: Research Methods for Informatics. While this capstone is not a direct research project, the research process described in I 305 has been particularly applicable in the early stages of this project, especially in conducting a review of prior resources and literature as well as developing a value proposition for this project. The course also touched on research ethics and principles when designing research, which acted as a guiding element when looking for open-source data availability and deciding where to source project data from (in the instance of looking for open-source data, I 320D Open Source Software was also particularly applicable, and the source files for this project are also being uploaded to be open source as well).

I 320D: Data Engineering. Working with several sources of data, many of which are very large, has required many foundational elements taught in Data Engineering. Data Engineering skills have been utilized in differentiating between the different datasets and will continue to be applicable as many different sources will need to be merged and used in tandem in the culmination of the final product of this project. The manipulation of simulation and open-source

data in tandem will require several skills that were applicable to Data Engineering, such as general data wrangling as well as linking large datasets. Finally, the final project of the Data Engineering course was a dashboard of several visualizations of a cleaned dataset, which is highly relevant to this project itself as it directly relates towards data visualization and design.

I 310D: Introduction into Human-Centered Data Science. Although this project does involve direct work with data, it also carries a heavy human element of it through its main goal of making more intuitive visualizations. Creating final products that mesh well with human intuition is a core tenant of the concepts in Human-Centered Data Science, where the interpretability of the products created out of data, whether that be a visualization or a machine learning model, is granted heavy emphasis. Introduction into Human-Centered Data Science also carried with it an introduction into data exploration and choosing data visualization methods, which has proven helpful in the design of the time-series product of this project.

I 310U: Introduction into User Experience Design. The principles of design, including using an iterative process that moves from paper to rough wireframes to a more refined process, was a core component of Introduction into User Experience Design that has been extremely helpful in the process of designing the visualizations of this project itself. Creating visualizations that are both usable and explainable to stakeholders regardless of experience is a core part of this project drawn from I 310U. Furthermore, if continued collaboration with external actors takes place, continued user testing and interviews will likely be conducted to fully assess the usability of the new visualization system.

References

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