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Data Article

Data on the configuration design of internet-connected home cooling systems by engineering students

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ABSTRACT

This experiment was carried out to record the step-by-step actions that humans take in solving a configuration design problem, either in small teams or individually. Specifically, study participants were tasked with configuring an internet-connected system of products to maintain temperature within a home, subject to cost constraints. Every participant was given access to a computer-based design interface that allowed them to construct and assess solutions. The interface was also used to record the data that is presented here. In total, data was collected for 68 participants, and each participant was allowed to perform 50 design actions in solving the configuration design problem. Major results based on the data presented here have been reported separately, including initial behavioral analysis (McComb et al.) [1,2] and design pattern assessments via Markovian modeling (McComb et al., 2017; McComb et al., 2017) [3,4].

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Specifications Table

Subject area	*Engineering, Design*
More specific subject area	*Configuration design by engineering students*
Type of data	*Table*
How data was acquired	*Desktop computer*
Data format	*Raw data*
Experimental factors	*Conditions: (1) individual work and best of three individuals selected, (2) team of three with moderate interaction (3) team of three with high interaction.*
Experimental features	*Engineering students solving a configuration design task in the conditions noted above.*
Data source location	*Pittsburgh, PA*
Data accessibility	*Data is available as a supplementary attachment to this article.*

Value of the data

- This dataset is important to the field of engineering design as it provides a log of design process used by humans solving a configuration design task, both in teams and alone.
- A full and detailed account of the problem-solving process used by participants is encoded in the information shared here.
- This may serve as a baseline for comparison against design synthesis algorithms completing similar tasks, or against other experiments testing design methods with human participants.
- This may also serve to inform researchers exploring problem solving more generally, for instance in cognitive science.

1. Data

This dataset is provided as supplementary data in a CSV format. Each row in the CSV describes a single design produced during the study. Descriptions of the columns headings are provided below in Table 1.

Room numbers referenced as *XX* in Table 1 are designated in the floorplan of the home shown in Fig. 1. Note that temperature sensors were allowed to be placed outside of the home to record ambient temperature. If present, these are recorded in Room 0.

2. Experimental design, materials, and methods

2.1. Participants and conditions

This study was conducted with senior undergraduates and graduate students in engineering with ages 21–31 and a median age of 22. Participants in the study were placed in one of three conditions. Participants placed in Condition 1 worked individually. Participants in Condition 2 worked in teams of three with moderate interaction (interaction was required after every 10 individual design actions) and participants in Condition 3 worked in teams of three with high interaction (interaction was required after every 5 individual design actions). A performance-based comparison between these conditions has been published separately [1,2].

Table 1
Description of columns in attached data table.

Column header	Description
Condition	An integer indicating the condition of the individual who produced the design.
Team	An integer indicating the team of the individual who produced the design.
Participant	An integer uniquely identifying an individual within a team.
Design	An integer between 1 and 50 indicating uniquely identifying (in order) the designs produced by a participant.
Cost	Estimated capital and operating cost of the system in USD.
Processors	An integer indicating the number of processors in the design
Room_XX_Temperature	A floating point value representing the peak simulated temperature in room X in degrees Celsius.
Room_XX_Sensor	An integer indicating the presence of a sensor in room *X*. A positive value indicates that a sensor is present in the room and connected to the subsystem uniquely identified by that integer. A value of −1 indicates that a sensor is not present.
Room_XX_Cooler	An integer indicating the presence of a cooler in room *X*. A positive value indicates that a cooler is present in the room and connected to the subsystem uniquely identified by that integer. A value of −1 indicates that a cooler is not present.
Room_XX_Cooler_Flowrate	If Room_XX_Cooler is not zero, a value indicating the flowrate of air produced by the cooler in cubic feet per minute. Otherwise, value is −1.
Room_XX_Cooler_Power	If Room_XX_Cooler is not zero, a value indicating the power that the cooler uses to chill incoming air in BTUs per hour (a standard unit for air-conditioning systems). Otherwise, value is −1.

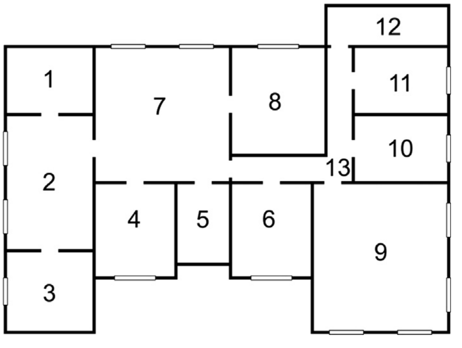

Fig. 1. Floorplan of home showing room numbers.

2.2. Design task

Participants were tasked with designing a system of internet-connected products to moderate the temperature within a home (shown in Fig. 1). Specifically, participants were instructed to minimize the peak temperature within the home (preferably below 24 °C) and minimize the total cost of the system (preferably below $20,000). Each participant performed a total of 50 design actions during a 30-min design session. Adding or deleting a product, moving a product, or modifying parameters associated with a product constituted one design action.

Three product types could be used by participants to create solutions: sensors, processors, and coolers. Sensors measured the temperature of rooms in which they were placed. Coolers serve the purpose of processing external air and delivering it to the interior of the home at a temperature that is lower than the ambient temperature. Processors served to connect sensors and coolers, taking temperature information from sensors, processing it, and then deciding whether or not to turn on coolers. Processors were only capable of receiving information from or acting on products to which they were explicitly connected by participants. In searching for an adequate solution to the design problem, participants were allowed to add, delete, and move products. They were also allowed to tune the power and flowrate of coolers. Analyses of behavioral patterns displayed while generating solutions have been published separately [3,4].

2.3. Design interface

To facilitate the design process, each participant was given access to a computer on which was loaded a design interface. The design interface allowed participants to construct and evaluate solutions and provided immediate feedback on design quality after every design modification. Evaluation of a solution consisted of a simulation based on fundamental heat and mass transfer analyses. From this simulation the peak temperature in each room and the total cost of the system (consisting of both capital and operating components) was extracted. This design interface was also used to track designer's actions, producing the data set provided here.

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Transparency document. Supplementary material

Transparency data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2017.08.050.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2017.08.050.

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