CONCEPTUAL DESIGN DOCUMENT

A logo of a person carrying a large table

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# ABSTRACT

In this document, a system designed to solve the problem statement shown below will be shown and described. An explanation for each component including how it adheres to a specific design requirement will be added.

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# PROBLEM STATEMENT

Transporting heavy furniture up and down one flight of straight stairs is difficult and potentially dangerous.

2.0 REQUIREMENTS

## 2.1 FUNCTION

To achieve the goal set by the problem statement, the requirements of function are as follows:

2.1.1 - The system shall transport furniture repeatedly up and down one floor within a residential building.

2.1.2 - The system shall accommodate up to a 4-seater sofa.

2.1.3 - The system shall accommodate up to a 5-shelf bookshelf.

2.1.4 - The system shall be reusable.

## 2.2 INTERFACING

To ensure that the system is of a proper size that is capable of being transported and capable of fitting within the stairwells it operates in, the requirements of interface are as follows:

2.2.1 - The system shall fit within a standard stairway according to Section R311.7.1 of the 2021 International Residential Code (IRC)

2.2.2 - The system shall be transportable in the back of an average American pickup truck in addition to the transported furniture.

## 2.3 SAFETY

To ensure that the system is overall safe, and does not endanger the operator or environment, the requirements of safety are as follows:

2.3.1 - The system shall cause less injury and strain than an average moving job.

2.3.2 - The system shall not destructively alter the environment.

2.3.3 - The system shall not damage the furniture.

# 3.0 SYSTEM OVERVIEW

## 3.1 CONCEPT OF OPERATIONS

The system operation is as follows. The robot is placed at the base of a straight staircase conforming to the 2021 International Residential code standards of construction[1]. The furniture is then loaded onto the robot and secured via straps. The robot is then activated and will stand up. Next the operator will pilot the robot up the stairs using a controller. Once at the top of the stairs, the robot will be deactivated, and the furniture may be removed.

## 3.2 SYSTEM COMPONENTS

A model of a machine

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**Figure 1.1: Design Overview**

### 3.2.1 Robotic Legs

To move furniture up and down stairways repeatedly and in a reusable manner [2.1.1-2.1.4], the system employs 6 individually controllable robotic legs. This choice is made as the controllability will allow for the robot to traverse any configuration of stairs allowed by the IRC construction standards[1]. To adhere to the set requirement of not destructively harming the furniture and its surroundings, as well as to cause less harm and strain than manual moving [2.3.1-2.3.3], the system’s robotic legs are also a key feature as they allow for precise positioning, and control over the balance of the robot as to minimize accidents.

### 3.2.2 Furniture Platform & Strap Connection Area

For the system to accommodate large furniture [2.1.1-2.1.4], the furniture platform is employed. The platform is sized to fit all required furniture items, and there are mounting points for straps or other hardware to lessen the chance of furniture falling off the system.

### 3.2.3 Camera and Sensors

To assist in the adaptability of the system to go up coded stairways [2.2.1], as well as people avoidance and accident prevention [2.3.1], the system has cameras on the front and back as well as a possibility of additional sensors in the future. These allow the system to know enough about its environment to minimize risk of damage to people or its surroundings.

### 3.2.4 Balancing Linear Actuators

To assist in the ability of the system to carry furniture and to do so safely [2.1.2, 2.1.3, 2.3.1], the system uses linear actuators in between the Main Body and Furniture Platform to give control over the furniture’s orientation, allowing for more and safer transportation.

### 3.2.4 Main Body

To comply with the minimum width requirement of the system [2.2.1, 2.2.2], the system is designed with a compact Main Body, where all the electronics and other internals are stored. This Main Body in addition to the protruding width of the robotic legs does not exceed 25 inches, which does not exceed the IRC codes[1].

# 4.0 CONCLUSION

As shown in the above explanations. This system concept is undoubtedly capable of performing all required actions and adhering to all requirements as intended. It can achieve its task while also reducing manual moving strain and increasing safety.

# 5.0 APPENDIX

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Requirement** | **Verification Description** | **T** | **A** | **O** | **R** |
| 1 | 2.1.1 | Test load and trial | X |  |  |  |
| 2 | 2.1.2 | Measurement/Trial | X | X |  |  |
| 3 | 2.1.3 | Measurement/Trial | X | X |  |  |
| 4 | 2.1.4 | Repeated Trials | X |  | X |  |
| 5 | 2.2.1 | Measurement and Comparison | X |  |  | X |
| 6 | 2.2.2 | Measurement and Comparison | X |  |  | X |
| 7 | 2.3.1 | Trial, followed by Analysis and Comparison | X | X | X | X |
| 8 | 2.3.2 | Trial and Observation | X |  | X |  |
| 9 | 2.3.3 | Trial and Observation | X |  | X |  |

**T** – Test and Measurement; **A** – Analysis and Simulation;   
**O** – Observation and Inspection; **R** – Reference and Datasheet

(*Requirements verification matrix. | download table - researchgate*) [2]

# 

# 6.0 ACKNOWLEDGEMENTS

The design of the robotic legs is inspired by and roughly modeled based off of the Boston Dynamics Spot Robot [3]

# 7.0 REFERENCES

[1] “CHAPTER 3 BUILDING PLANNING, 2021 International Residential Code (IRC) | ICC Digital Codes.” Accessed: Sep. 15, 2023. [Online]. Available: https://codes.iccsafe.org/content/IRC2021P1/chapter-3-building-planning

[2] “Table 1. Requirements Verification Matrix.,” ResearchGate. Accessed: Sep. 29, 2023. [Online]. Available: https://www.researchgate.net/figure/Requirements-Verification-Matrix\_tbl1\_269163835

[3] “Spot | Boston Dynamics.” Accessed: Sep. 29, 2023. [Online]. Available: https://bostondynamics.com/products/spot/