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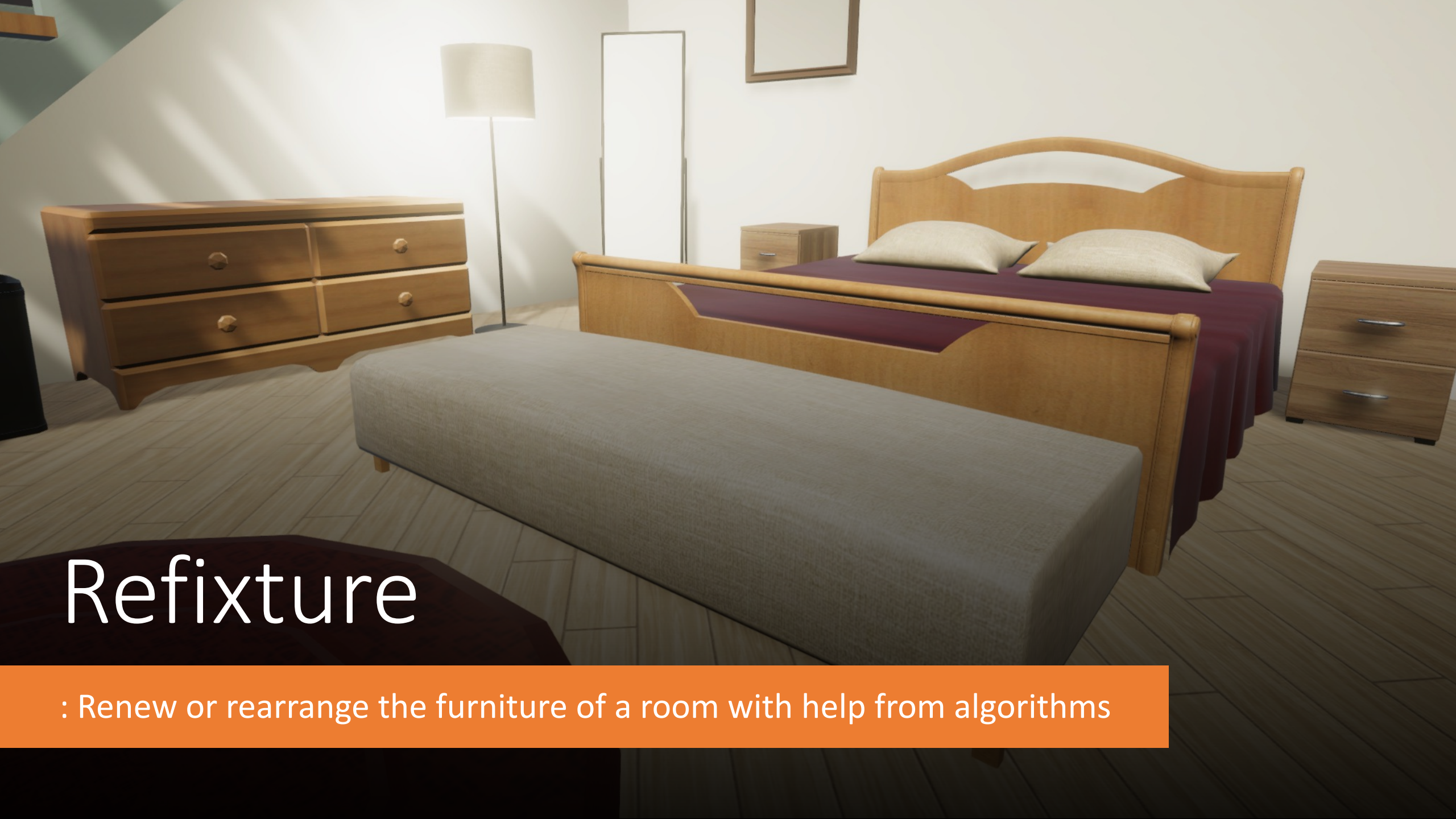
Refixture

Computer Science Capstone Project by James Cunningham



Refixture

: Renew or rearrange the furniture of a room with help from algorithms

Project Plan

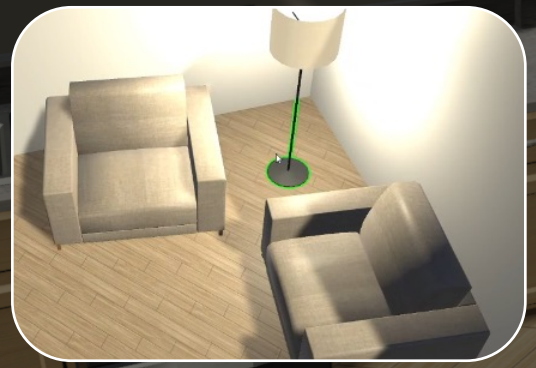
Project goals, timeline, features, and use

Project Goals

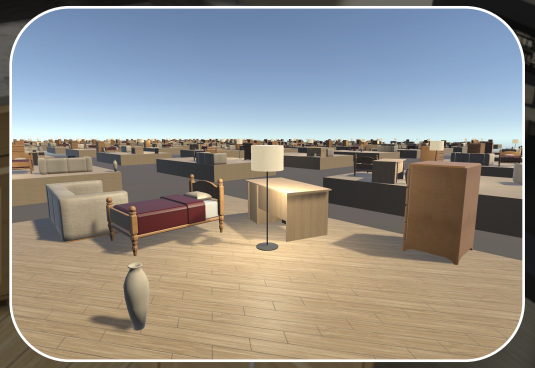
- Objectives
  - Model and rearrange furniture
  - Arrange furniture with genetic algorithm
- Challenges
  - Representing furniture in a 3D format
  - Generating pleasing designs given a set of guidelines
  - Utilizing feedback to improve usability and performance

Main Features

Define



Arrange



Generate

Save

Project Timeline

Phase 1

- Prototype
- Basic GA

Phase 2

- UI
- Variables

Phase 3

- Variety
- Testing

Rearrange

Before → After

Genetic Algorithm

How Refixture works

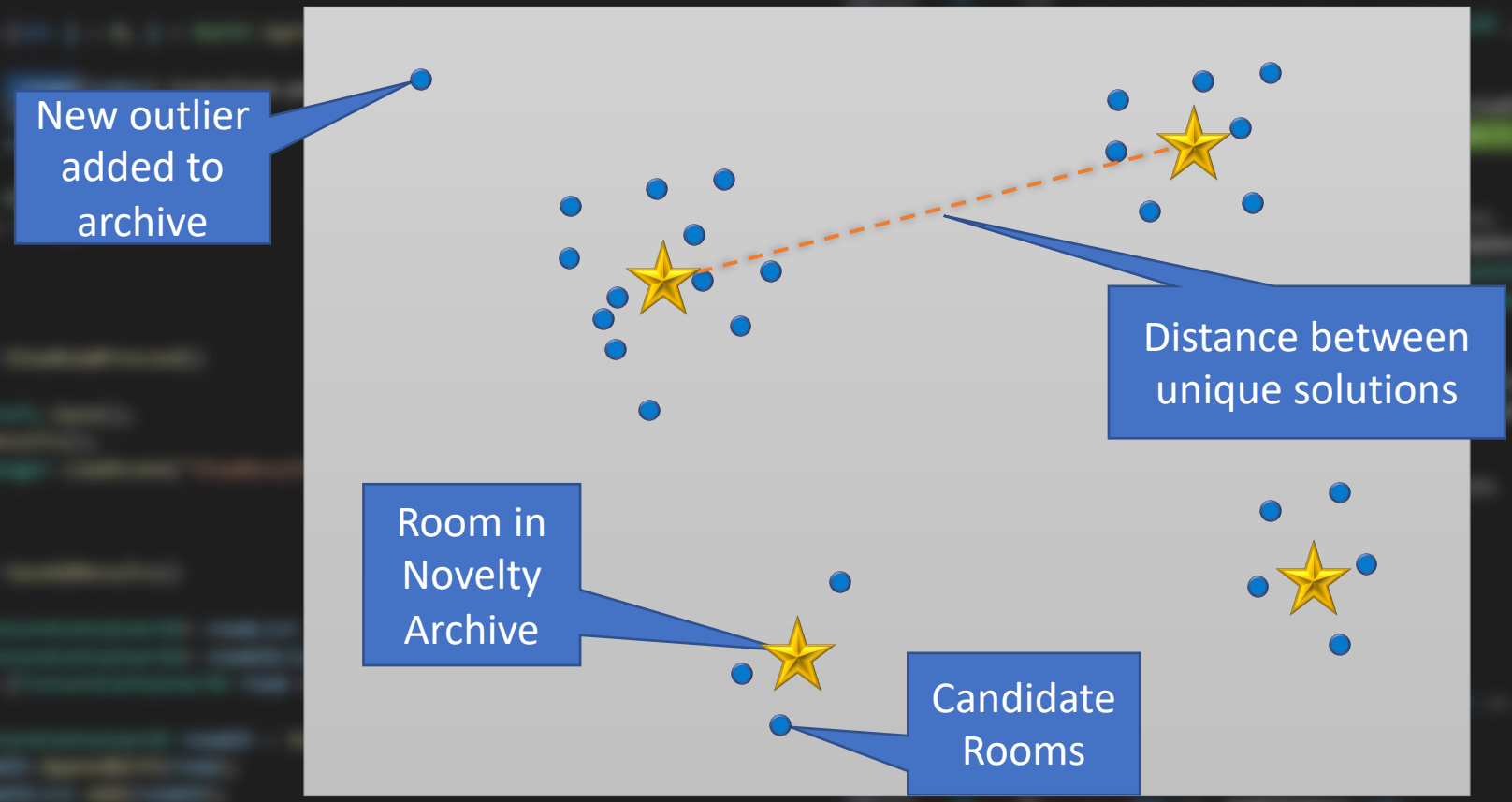
Generate Populations

Evolve better designs from a population of random rooms

How does selection work?

- Runs a tournament-based selection to determine survivors
  - Survivors copy their genetics to the next generation
  - Fitness-proportionate selection was also tested
- Survivor pairs can crossover to produce offspring
  - The offspring's furniture positions are chosen randomly from each parent
- Novelty Search
  - Diverse solutions are promoted through archiving unique solutions
  - Keeping an archive steers the algorithm away from stagnation

Search Space Using Novelty Search



Fixture Representation

- Could be static or movable
- Individual fitness
- Fixture type – multiple types
  - Bed, wall, seat?
- Properties inherited by type
  - Observes gravity
  - Must attach to ground/wall
  - Emits light
  - Interacts with other types
- Position, rotation, dimensions, and scale

Fitness is based on design principles

- No obstructions
- Maximizes open area
- Restrictions based on furniture types
- Interactions between furniture
- Natural positions

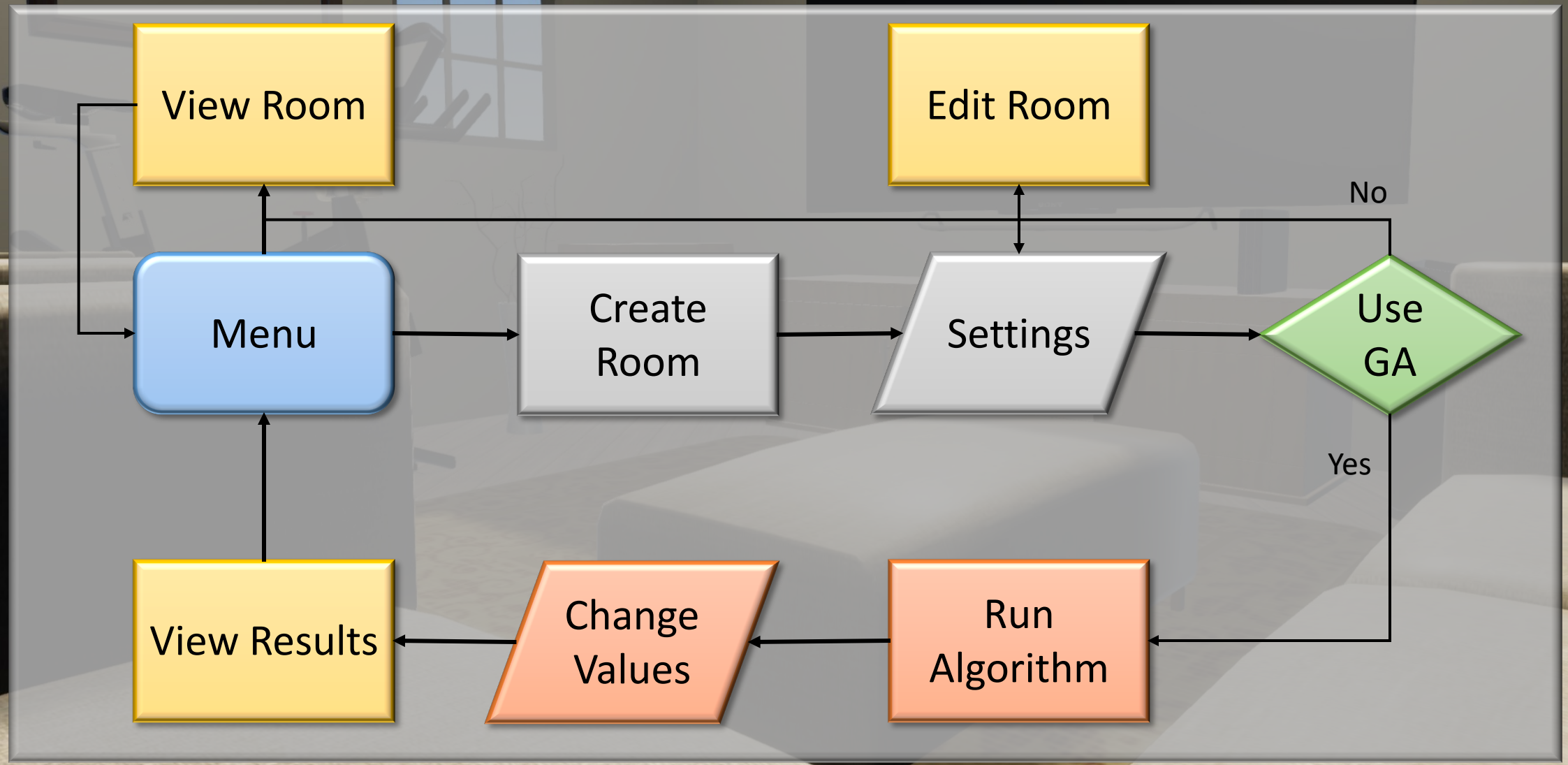
New Designs appear through mutation

- Random push
- New random position/rotation
- Align with nearest fixture/wall
- Snap to nearest fixture/wall
- Face towards another furniture

Arranging Furniture

How to use Refixture

Program Flowchart



Configuration Menu

Select Fixtures

Essentials

Bed

W: 79.39
L: 87.18
H: 39.35

Cabinet

W: 63.23
L: 26.09
H: 79.61

Coffee Table

W: 19.69
L: 35.43
H: 11.53

Desk

W: 62.99
L: 32.40
H: 29.53

Executive Desk

Room Settings

Use Imperial (inches)

Use Genetic Algorithm

Room Width: 300.00

Room Length: 200.00

Static Room Preview

Settings Screen

Save/Load

Edit Room

Fixture List

Save / Load

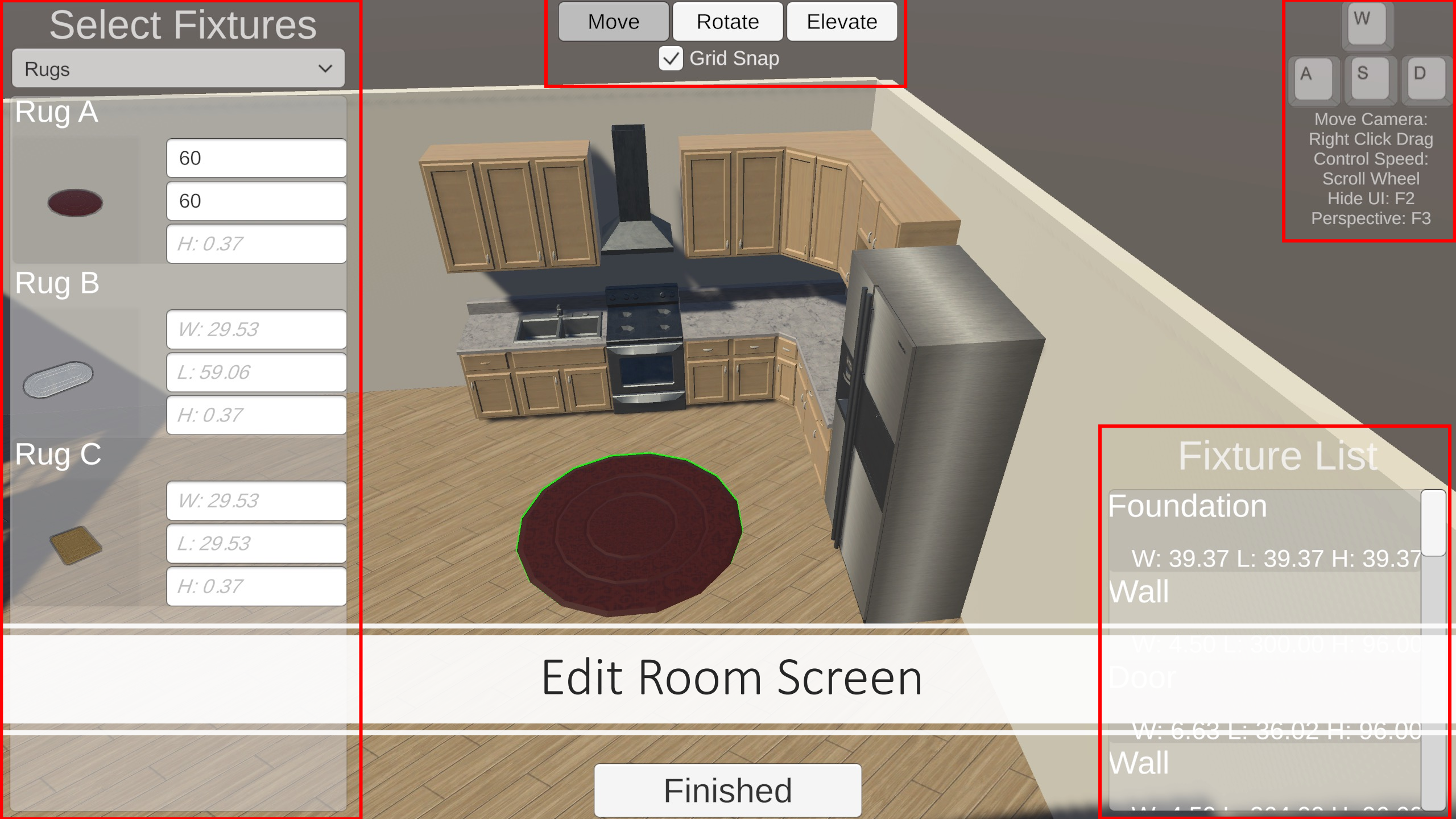
Cabinet
W: 39.37 L: 23.37 H: 76.55

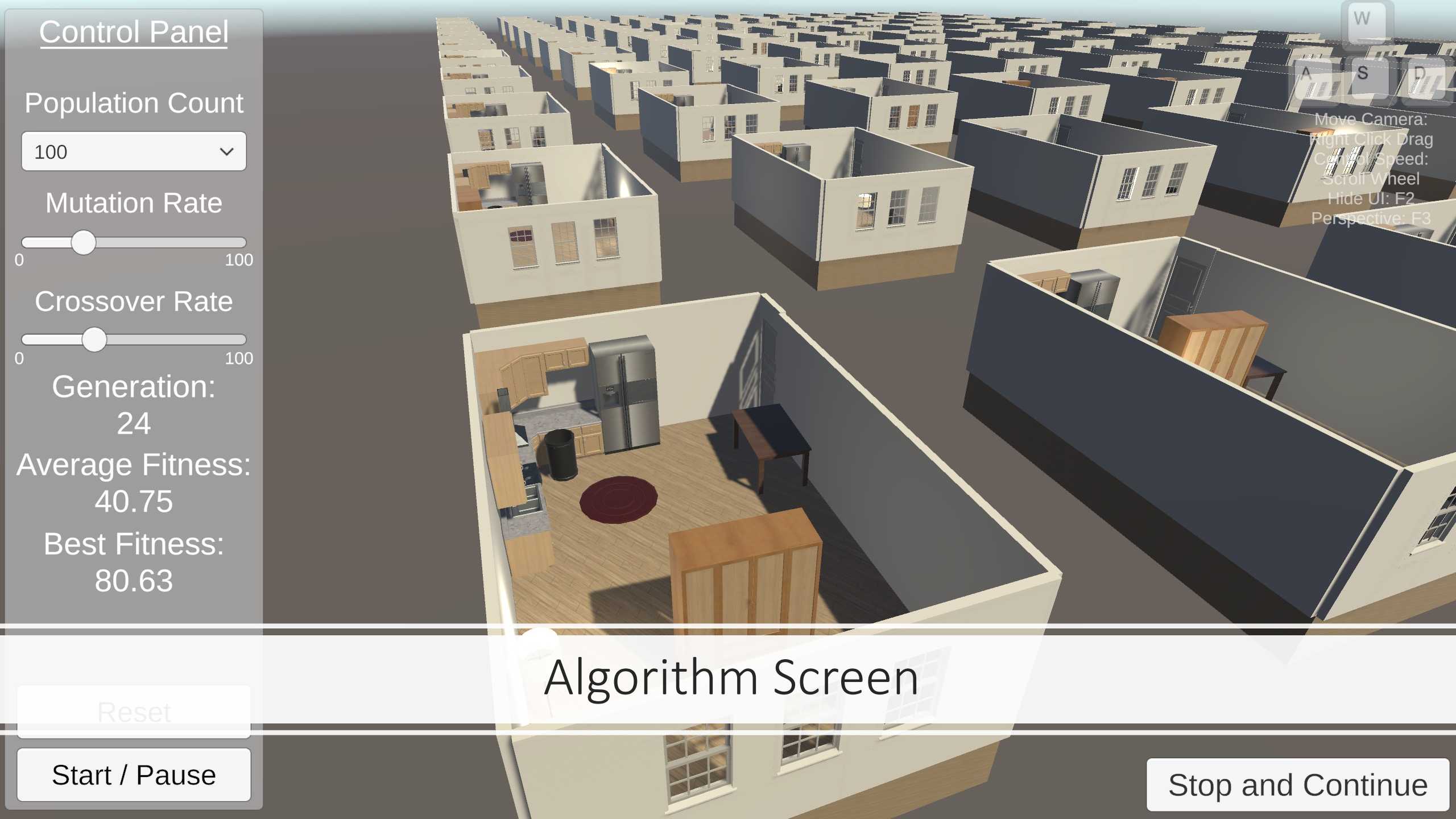
Basket
W: 29.71 L: 29.71 H: 42.29

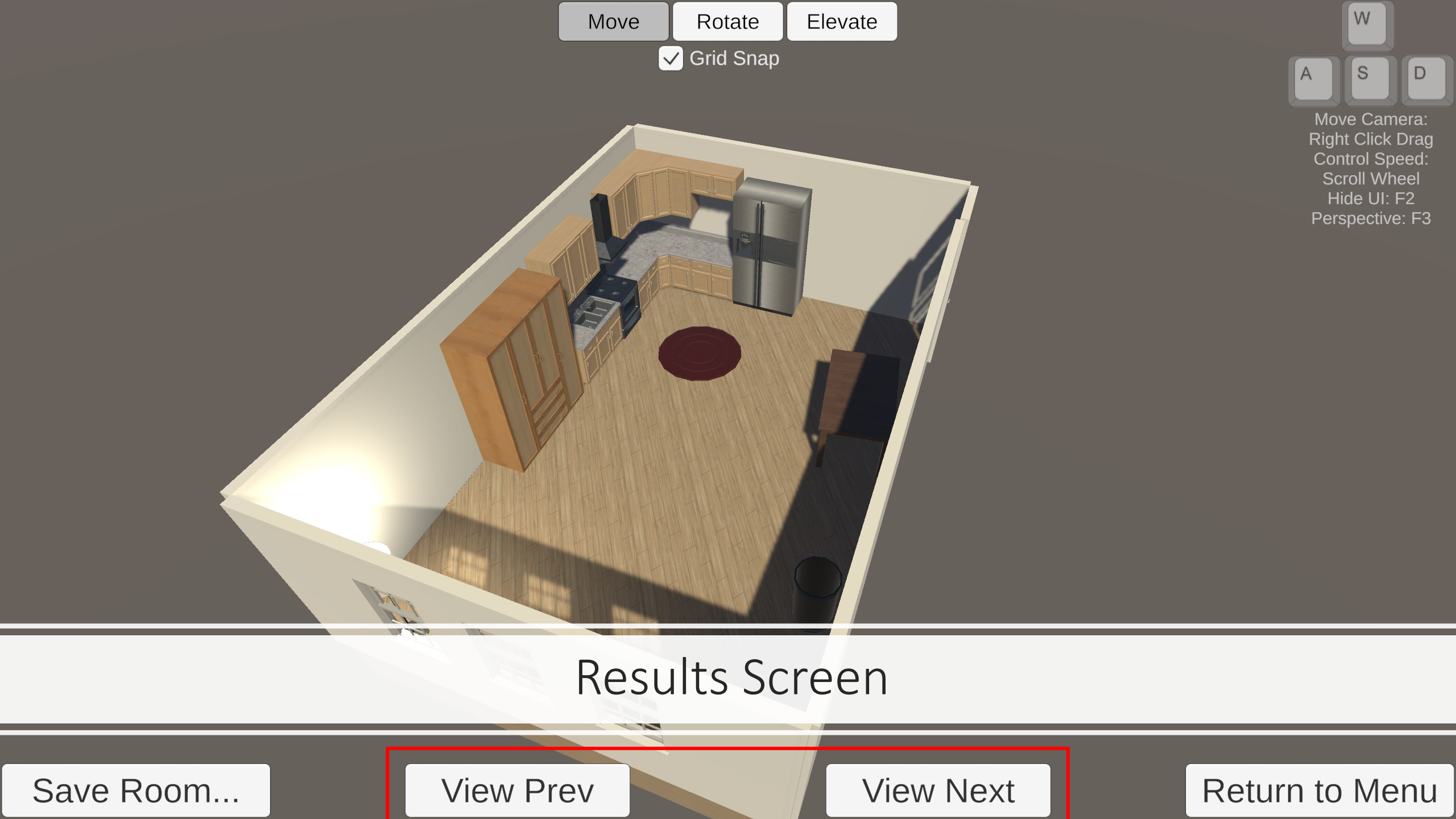
Dining Table
W: 60.57 L: 36.34 H: 30.11

Standing Lamp
W: 17.55 L: 17.30 H: 56.31

Continue


Select Fixtures
Rugs
Rug A
60
60
H: 0.37
Rug B
W: 29.53
L: 59.06
H: 0.37
Rug C
W: 29.53
L: 29.53
H: 0.37
Move
Rotate
Elevate
Grid Snap
W
A
S
D
Move Camera:
Right Click Drag
Control Speed:
Scroll Wheel
Hide UI: F2
Perspective: F3
Fixture List
Foundation
W: 39.37 L: 39.37 H: 39.37
Wall
Door
Wall
Edit Room Screen
Finished


Control Panel
Population Count
100
Mutation Rate
0
100
Crossover Rate
0
100
Generation:
24
Average Fitness:
40.75
Best Fitness:
80.63
Reset
Start / Pause
W
A
S
D
Move Camera:
Right Click Drag
Control Speed:
Scroll Wheel
Hide UI: F2
Perspective: F3
Algorithm Screen
Stop and Continue



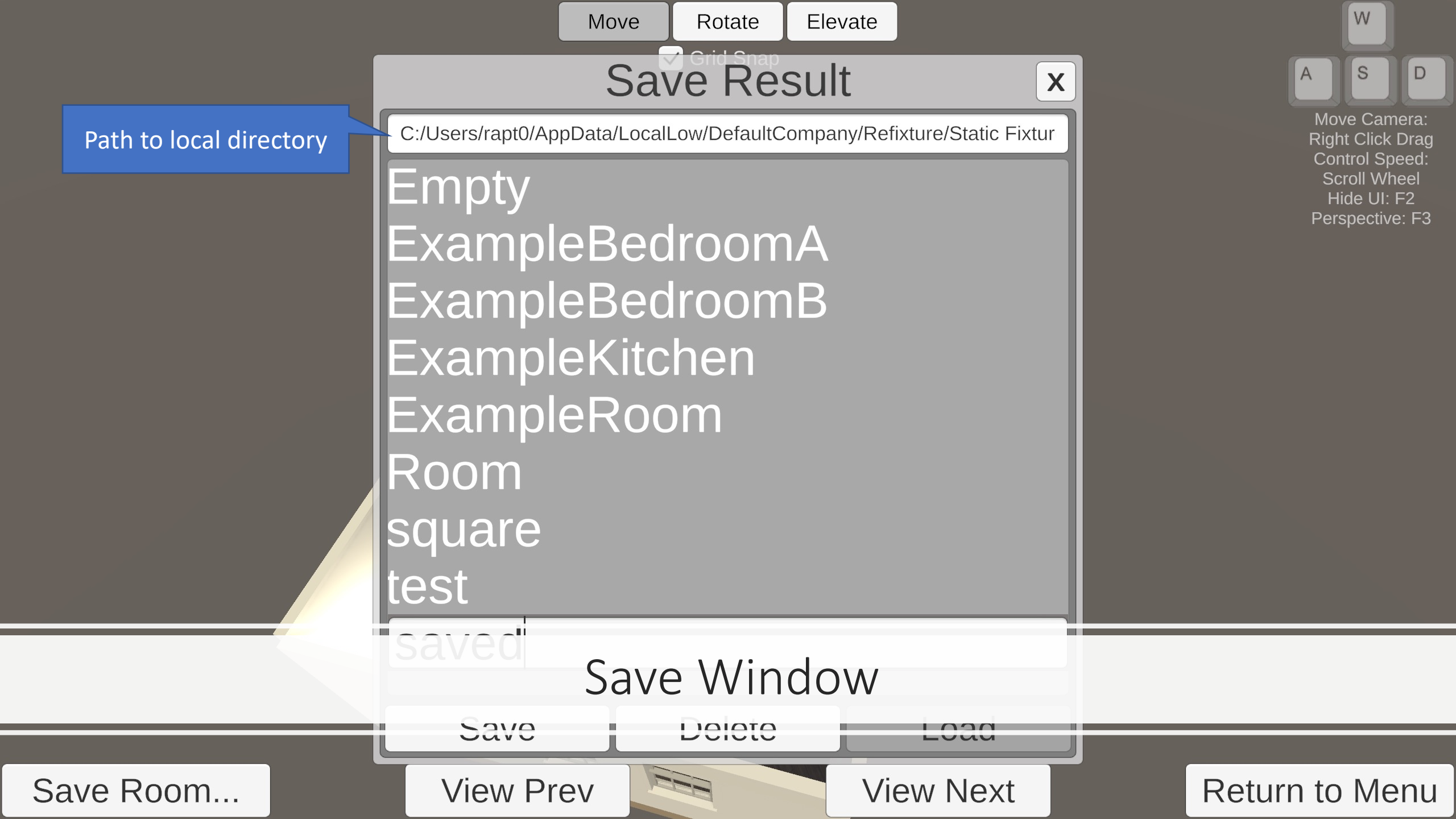
Results Screen

Save Room...

View Prev

View Next

Return to Menu


Move
Rotate
Elevate
Grid Snap
Save Result
x
Path to local directory
C:/Users/rapt0/AppData/LocalLow/DefaultCompany/Refixture/Static Fixtur
Empty
ExampleBedroomA
ExampleBedroomB
ExampleKitchen
ExampleRoom
Room
square
test
saved
Save Window
Save
Delete
Load
W
A
S
D
Move Camera:
Right Click Drag
Control Speed:
Scroll Wheel
Hide UI: F2
Perspective: F3
Save Room...
View Prev
View Next
Return to Menu

Conclusion

Testing, planned features, and distribution

Refixture Survey

Refixture Questions

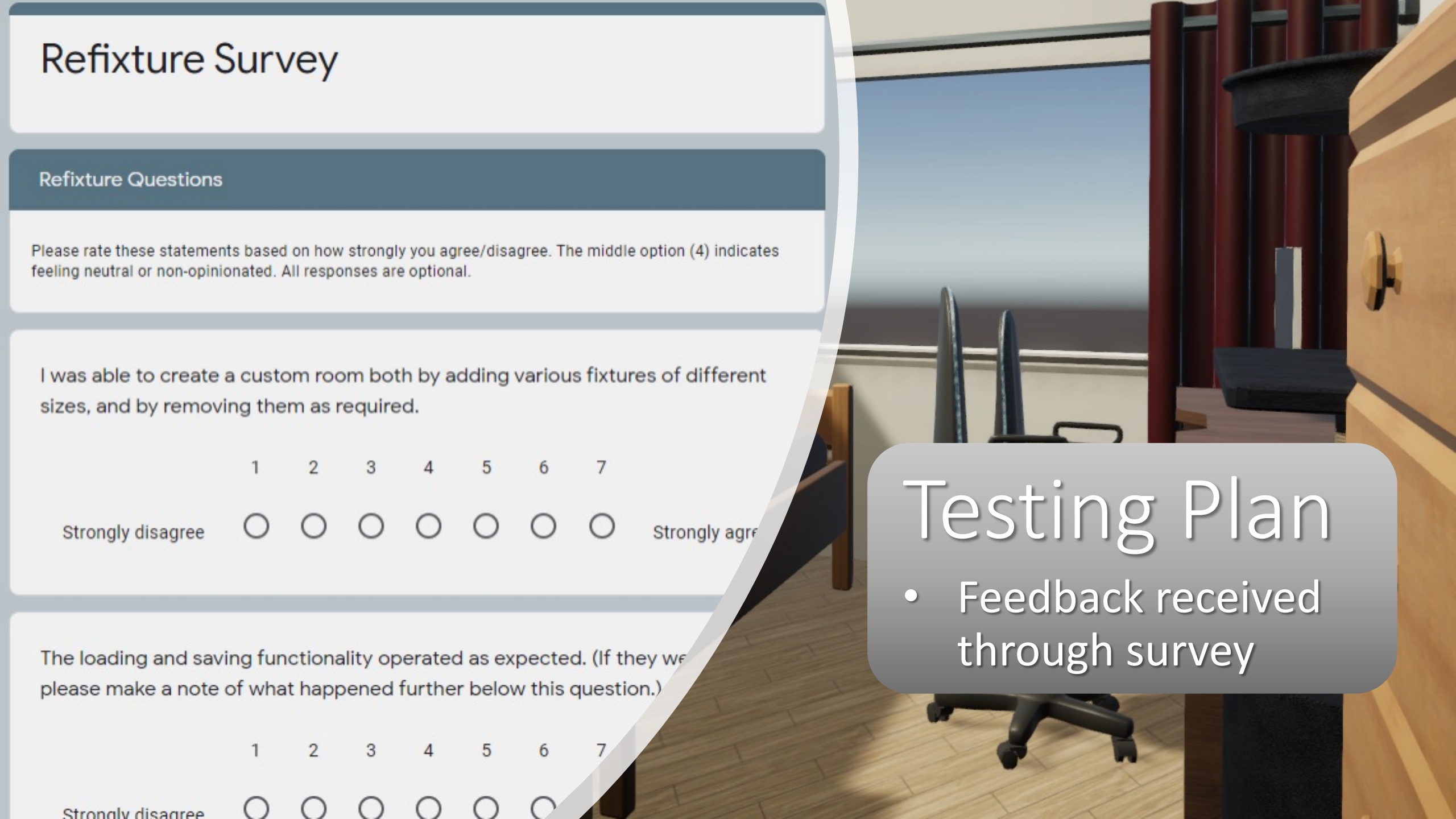
Please rate these statements based on how strongly you agree/disagree. The middle option (4) indicates feeling neutral or non-opinionated. All responses are optional.

I was able to create a custom room both by adding various fixtures of different sizes, and by removing them as required.

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agre

The loading and saving functionality operated as expected. (If they we
please make a note of what happened further below this question.)

	1	2	3	4	5	6	7
Strongly disagree	○	○	○	○	○	○	



Testing Plan

- Feedback received through survey

Feedback Summary

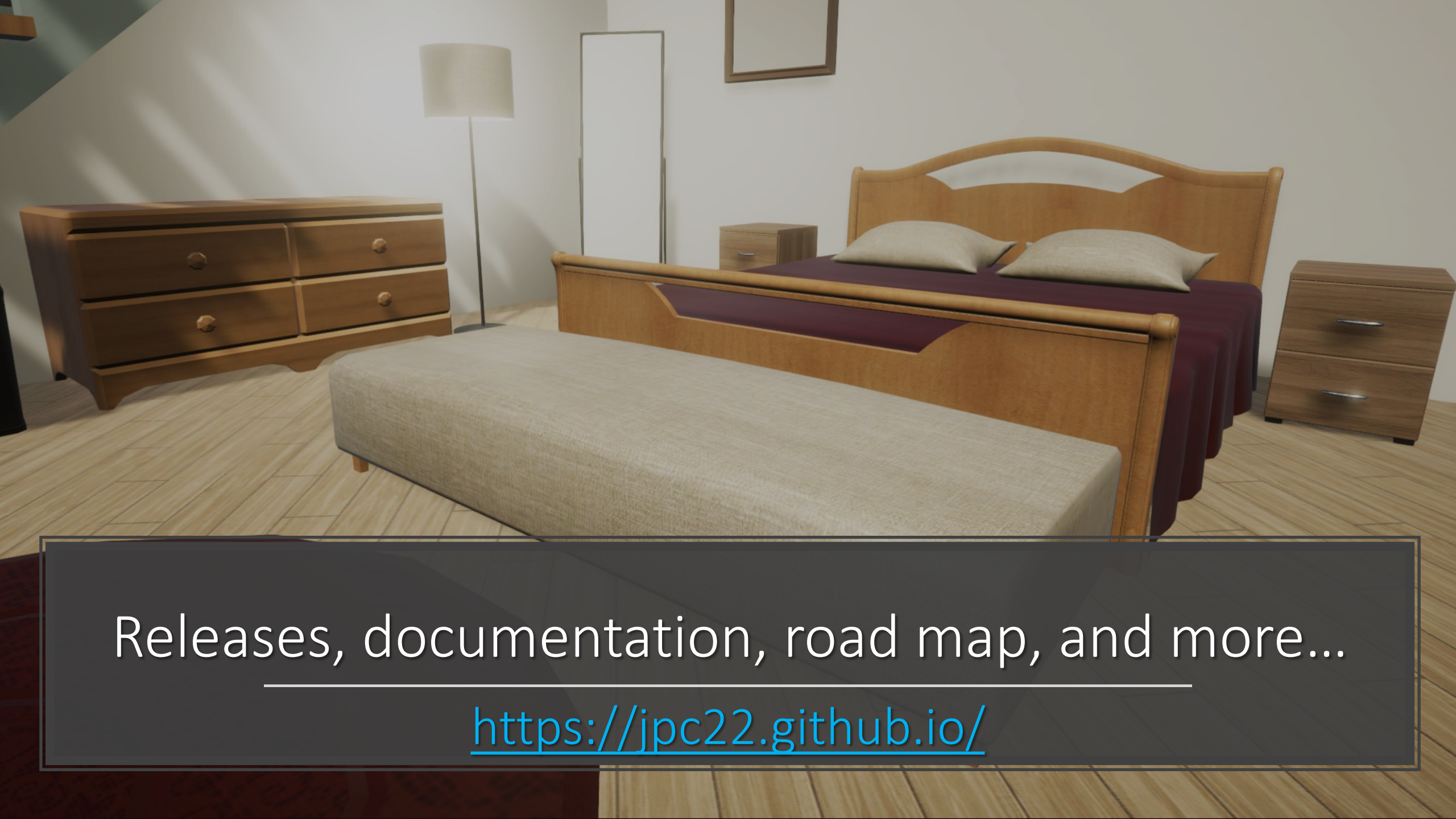
- Usability concerns
  - Users needed understanding of controls to perform tasks
  - Difficult to model variety with limited assets
- Algorithm process was unclear
  - Some prior knowledge is helpful (learning process)
- Algorithm unrefined
  - Solutions could be messy or unnatural, but did help spark creativity

Planned Features

- Address usability concerns
  - Redesigned UI and flow
  - Modify furniture's materials/color
  - Design or import custom fixtures
- Improve algorithm features
  - Improved evaluation methodology (graphical analysis)
  - Furniture grouping / interactions
  - New generation / evolution strategies
  - Pathfinding agents to improve walkability

Distribution

- Built in Unity for browser and Windows
  - Hosted on GitHub
- Assets used are royalty-free or non-commercial
- Source code and simple documentation
  - Some assets not included in source
- Website for more comprehensive presentation



Releases, documentation, road map, and more…

https://jpc22.github.io/