Computer Graphics

Assignment 1

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1. Brief Overview

This assignment implements a **2D Crowd Simulation Renderer** using WebGL, focusing on geometric rendering, triangulation, obstacle management, and interactive transformations. The program demonstrates:

- **Triangulated Layout**: Random points are generated inside a bounding rectangle and used to create a simple triangulation.
- **Obstacles**: Rectangular or square obstacles are introduced, with their corners integrated into the triangulation.
- **Crowd Representation**: Black dots represent people distributed across the triangulated space.
- **Transformations**: Obstacles can be rotated, translated, and scaled interactively using mouse operations. Each transformation updates the triangulation to ensure mesh validity.
- **Population Density Visualization**: Each triangle is assigned a density (e.g., 4 persons per triangle). Colors indicate crowding status:
    - Green → balanced density
    - Red → overpopulated
    - Blue → underpopulated
- **Dynamic Updates**: When people move between triangles, both density and colors update accordingly.

2. Questions to be Answered

Q1. Explain your strategy for user interactions.

The program is designed to be primarily **mouse-driven**, ensuring intuitive interactions:

Rotation

- Obstacles can be rotated by selecting and dragging with the mouse.
- After rotation, triangulation edges connected to obstacle corners are recomputed. Invalid edges are removed, and new edges may be interactively added to maintain correctness.

Moving

- Obstacles can be moved (dragged) directly with the mouse.
- The triangulation updates in real time to adapt to the new obstacle position.

Scaling

- Obstacles can be scaled up or down about their **center** by mouse-based resizing.
- The local triangulation updates automatically after scaling.

Density Assignment

- Each triangle is given a fixed capacity (e.g., 4 persons).
- Triangles are colored green (balanced), red (overpopulated), or blue (underpopulated).

Crowd Movement

- People (dots) can be selected and moved into other triangles by mouse clicks.

    - Upon completion of the movement, densities are recalculated and triangle colors are updated.

This strategy emphasizes **simplicity and direct manipulation**, allowing the user to interact with the scene entirely through mouse actions.

Q2. How is scaling about a corner of the quadrilateral different from scaling about the center?

- Scaling about the Center
    - Keeps the obstacle balanced.
    - All corners move symmetrically toward or away from the centroid.
    - The obstacle grows or shrinks in place without drifting across the layout.
    - In the crowd simulation context, this minimizes unnecessary disruptions to the triangulation.
- Scaling about a Corner
    - Anchors one corner while the other three vertices shift.
    - Causes asymmetric deformation and displaces the obstacle away from the anchored corner.
    - This often distorts the triangulation significantly, introducing intersecting or stretched edges.

Thus, center-based scaling provides more stable and predictable transformations, while corner-based scaling can create irregular meshes.

3. Screenshots and Significance

Figure 1: Initial triangulation layout with randomly placed points and obstacle.

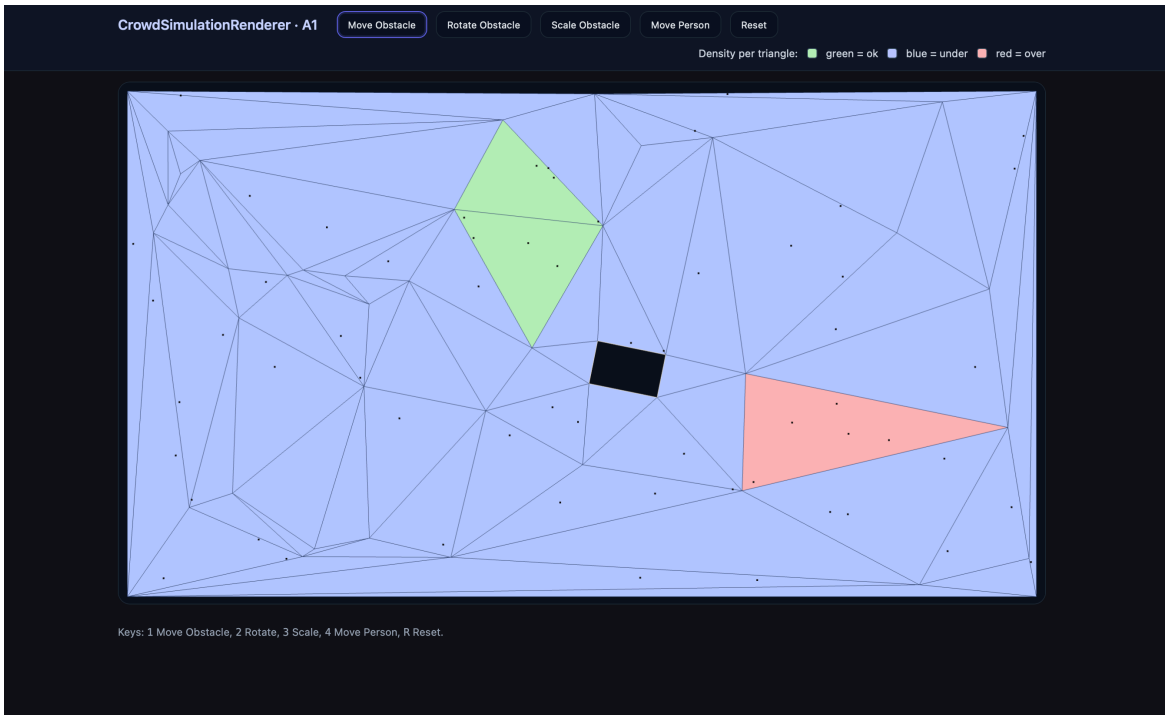


Figure 2: Obstacle rotated with updated triangulation.

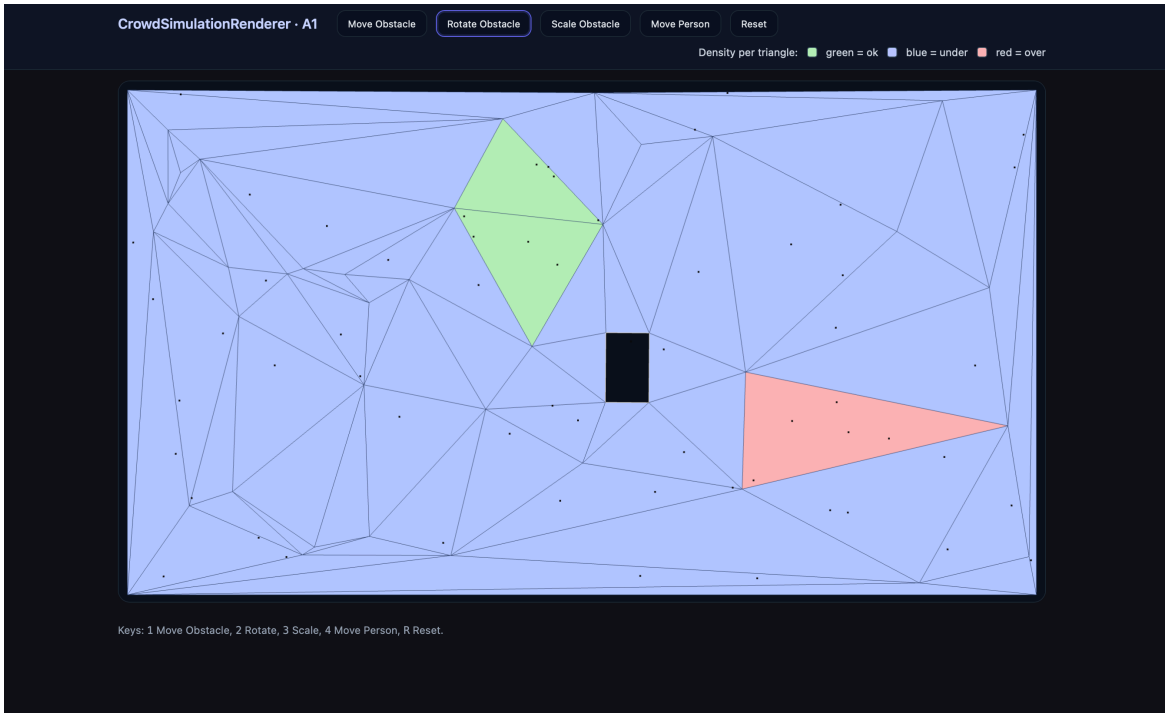


Figure 3: Obstacle translated using mouse drag.

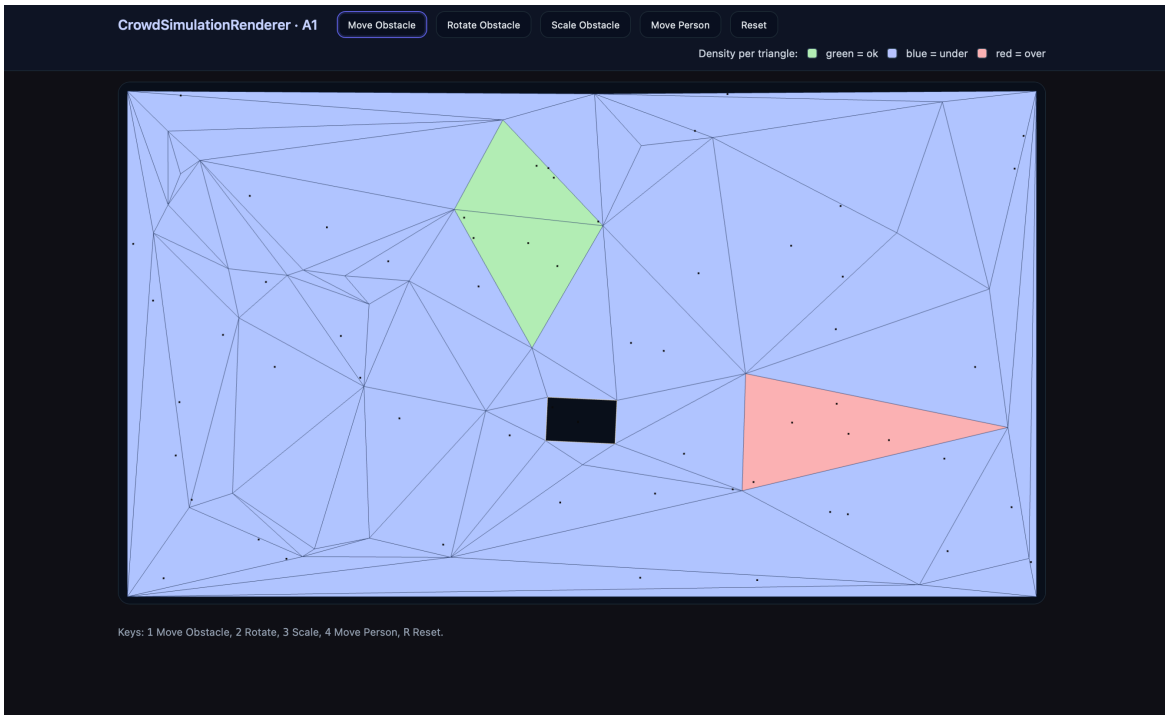


Figure 4: Obstacle scaled about center.

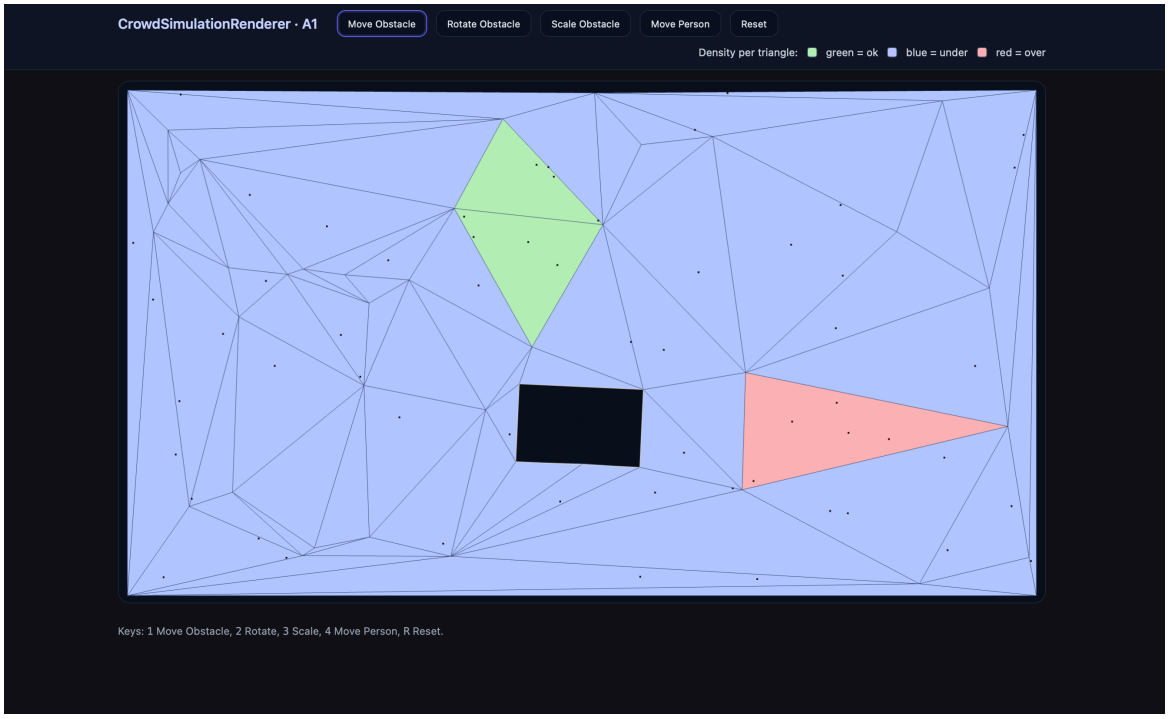
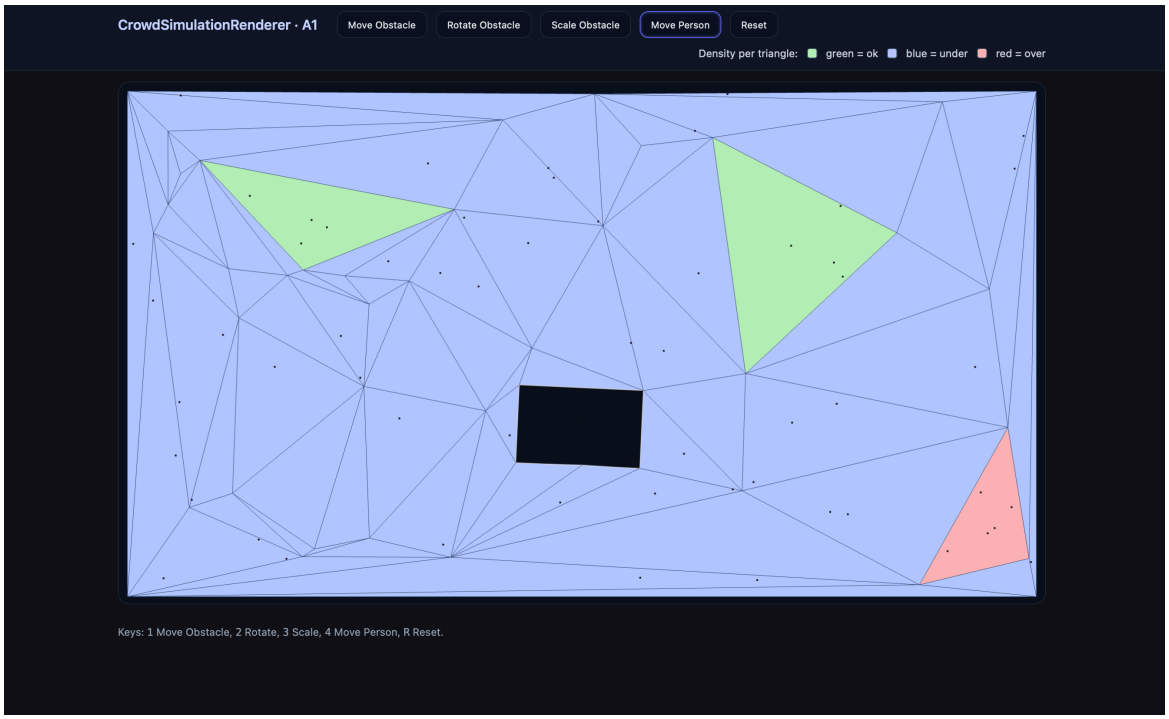


Figure 5: People moved between triangles with density updates.



4. Mouse Controls

- **Click + Drag on Obstacle:** Rotate or translate obstacle.
- **Click + Drag on Edges:** Scale obstacle (resize about center).
- **Click on People Dots:** Select and move them into another triangle.

5. Citation

A. https://webglfundamentals.org/

B. https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API/Tutorial/Getting_started_with_WebGL

C. https://en.wikipedia.org/wiki/Polygon_triangulation

6. Video Link

https://drive.google.com/drive/folders/152GZPRLxgJYE5eJMFNNHx4D9plKlTg_B?usp=sharing