Design Document - VR Wheelchair Simulator
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1. Project Overview

This project is a 3D and VR-based wheelchair simulation game built in Unity. The goal of the application is to simulate wheelchair navigation in indoor environments such as offices and classrooms, with a focus on accessibility, spatial awareness, and obstacle interaction. The game is designed to run on the Oculus Meta Quest 2 (but works on other VR headsets as well) and also supports desktop emulation.

The application is structured around a sandbox-style gameplay mode, where users can freely navigate a virtual environment at their own pace. The sandbox approach allows users to explore indoor layouts, interact with obstacles such as furniture, and receive immediate feedback through collisions and sound effects without strict objectives or time constraints.

2. Project Goals & Requirements

Functional goals

- Simulate wheelchair movement in a 3D environment
- Allow the user to navigate indoor spaces
- Detect collisions with furniture and obstacles
- Provide audio feedback on collisions
- Support VR gameplay on Oculus Meta Quest 2

Non-functional goals

- Comfortable VR experience (stable camera, smooth motion)
- Accessible UI elements (font size, brightness)
- Simple sandbox-style interaction

3. Technology Stack

- Game Engine: Unity
- Programming Language: C#
- VR Platform: Oculus Meta Quest 2
- XR Framework: Meta XR / OpenXR
- Development Platform: Windows PC
- Build Outputs:
    - Quest APK
    - Desktop emulator

4. System Architecture

User input from the VR headset and controllers is processed by the wheelchair movement controller. The movement system interacts with Unity's physics engine to move the wheelchair through the environment. Collision detection triggers audio feedback when the wheelchair interacts with obstacles such as desks or walls. Scene management handles transitions between sandbox environments and gameplay environments.

User Input → Wheelchair Controller → Physics Engine
→ Collision Detection → Audio Feedback

5. Scene & Game Structure

Main Menu
├── Sandbox Mode
│ ├── Easy
│ ├── Medium
│ └── Hard
└── Pre-Built Office Navigation Mode

The application is organized into multiple scenes that define the overall gameplay flow. The game includes a main menu, sandbox gameplay modes with varying difficulty levels, and a separate structured 3D navigation mode.

The game includes three difficulty levels that vary in environmental complexity. The easy level provides a pre-built indoor room and includes a guided tutorial in the 3D version of the game. The medium level presents an empty room, allowing users to place and navigate around obstacles more freely. The hard level provides only the floor, giving users maximum freedom to construct and explore custom layouts.

In addition to sandbox mode, the game includes a pre-built office navigation mode where users navigate a fixed indoor environment using a wheelchair.

6. Core Components

- Wheelchair Movement System
    - Handles forward motion and turning
- Collision Detection
    - Detects interaction with furniture

    - Triggers sound effects
- Accessibility Features
    - Adjustable brightness
    - Adjustable text size
- Environment Interaction System
    - Allows users to place, move, and rotate furniture objects
- User Interface Interaction
    - Supports scrolling and menu navigation
    - Enables users to adjust settings and interact with the game

7. Design Decisions & Constraints

- Chose VR to better simulate real-world navigation
- Sandbox mode allows open exploration
- The project scope was deliberately constrained to prioritize a stable and usable VR experience
- Focused on one fully functional scene before expanding

8. Future Work

- Add more furniture and office supplies to sandbox modes
- Expand accessibility settings
- Improve wheelchair physics realism
- Move tutorial fully into VR & other levels