Initial Plan

Virtual Reality educational puzzle using logic gates and 3d space limitations

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Module Code: CM2302 – 40 Credit One semester project

Overview

Throughout a computer science degree within Cardiff University, a student will encounter logic / logic gates with truth tables within modules such as CM1101 (Computational Thinking), CM1205 (Architecture and Operating Systems) and CM2207 (Introduction to the theory of computing). Whilst they serve as a good and thorough explanation of logic and gates, the modules are taught entirely theoretically and only ever implemented digitally.

This project is intended to create a virtual three-dimensional simulation of logic gate interactions through the Unity engine. The intended effect is to allow students to develop skills involving space-awareness and reverse engineering of logic from provided truth tables and statements. Specialised fields such as electrical engineering and processor architecture would benefit from this project as an additional learning step. This is because it will be designed to help bridge the gap between two-dimensional logic drawings and physical three-dimensional components that exist in space.

Once completed, the project will follow a puzzle style game that introduces different logic gates through a series of challenges. Each challenge will require the student to reverse engineer a provided truth table into a corresponding logic gate configuration. They will then bridge connections using pre-made wires and gates within a confined area. The simulation will take all possible input combinations from the truth table and light up the corresponding node and wires attached. If the student has correctly assembled the wires and logic gates, the input and output lights will be identical to the truth table provided.

Aims

1. Create a visual representation of logic gates using 3D objects and lights
2. Create a virtual environment where wires and gates can be joined together to form complete logic circuits
3. Script rooms which contain challenges based around logic gate configuration
4. Create challenges that require solutions involving orienting gates and wires in three-dimensional space
5. Create visual documentation and explanation of logic gates using the projects own objects

Objectives

Required Objectives:

1. **Basic VR environment including:**
   - 1.1. Lighting
   - 1.2. Virtual Reality “hands” or tracked controllers
   - 1.3. Enclosed room with movement boundaries
   - 1.4. Room visuals explaining the challenges

2. **Implementation of basic VR functionalities including:**
    2.1. Grabbing objects
    2.2. Placing objects
    2.3. Interacting with buttons in the environment
    2.4. Player movement and orientation system
3. **Creation of 3D objects with basic textures including:**
    3.1. Straight wire
    3.2. Right angle wire
    3.3. Splitter wire (one input into two identical outputs)
    3.4. AND gate
    3.5. OR gate
    3.6. XOR gate
    3.7. NOT gate
    3.8. Input/Output box
    3.9. Interaction buttons
4. **Virtual documentation for each logic gate including:**
    4.1. Truth table
    4.2. Visual demonstration
5. **Multiple challenges with introductions to each logic gate including at least:**
    5.1. Wire-only room
    5.2. AND room
    5.3. OR room
    5.4. XOR room
    5.5. NOT room
    5.6. At least one multi-gate room
    5.7. 1-bit adder room
    5.8. 2-bit adder room
6. **Environment functionality buttons including:**
    6.1. Test button for the logic gate configuration of the room
    6.2. Manual toggle for power of input boxes
    6.3. Spawn button for pre-made wires and gates
    6.4. De-spawn button for destruction of selected wires and gates
    6.5. Reset button for clearing the room of all wires and gates
7. **Basic environmental feedback including:**
    7.1. Changing of light on powered wires
    7.2. Audible sound effect on connection of objects
    7.3. Slight controller vibration on connection of objects
    7.4. Audible sound effect on grabbing/dropping of objects
    7.5. Audible sound effect on button interaction
    7.6. Slight controller vibration on button interaction

Optional Objectives:

1. **Additional VR Environment details including:**
    1.1. Background music / ambiance
    1.2. Detailed rooms with prefabricated furniture and objects
2. **Additional VR functionalities including:**
    2.1. Whiteboard / note writing tablet
    2.2. Saving and loading of assembled wire and gate constructions

2.3. Saving and loading of incomplete challenges and states

3. **Additional 3D object detailing including:**
   3.1. Wire and gate powered animations
   3.2. Wire and gate particle effects
   3.3. Doors and progression animations
4. **Extra documentation for logic gates including:**
   4.1. Known and taught configurations of logic gates such as one bit adder with carry bit
5. **Additional challenges including:**
   5.1. 8-bit adder room
   5.2. More multi-gate rooms

Testing and Functionality

Testing for the project will commence once the main functionalities of the project are complete and also again once the project is in its final stages. Each testing round will consist of two sets of feedbacks: one for the main VR functionalities (movement, object handling, button interaction etc) and a second one for evaluating how well students learn from the project.

The intention is to have an open invitation of 5 students within the university who study computer science in second year who will sign up and volunteer for the feedback sessions. This is where a student might start to specialise and is where the target student audience for this project will most likely be found.

All testing will require approval by the ethics committee, and an ethical approval form will be submitted by the end of second week latest. The recorded feedback will include data about the person testing as well as their opinions and any other feedback they present. These tests will be run on a local machine using both an Oculus Quest 2 and Valve Index headsets to ensure compatibility for all platforms using Unity's multi-platform VR functionalities.

Work Plan

Note: Notes on information regarding the project will be made during every step of development process and used within the final report

Week 1 (31/1/2022)

- Research into solutions and programs (Unity -XR plugins, Blender)
- Initial Plan – **Deliverable**

Week 2 (07/02/2022)

- Creation of 3D shapes and textures using Blender (3.1 to 3.9)
- Importing of shapes into Unity VR
- Creation of basic VR environment in Unity (1.1, 1.2, 1.3)
- Implementation of player movement and orientation (2.4)
- Submit Ethical Approval form – **Deliverable**

Week 3 (14/02/2022)

- Implementation of grabbing and placing objects (2.1, 2.2)
- Implementation of all buttons but test button (6.2 to 6.5)

Week 4 (21/02/2022)

- Implementation of virtual button pressing (2.3)
- Scripting of power and powered light systems (7.1)

Week 5 (28/02/2022)

- Creation of simple gate rooms including visuals (5.1 to 5.5 and 1.4)
- Scripting of test button (6.1)

Week 6 (07/03/2022)

- First stage testing – **Deliverable (First prototype)**
- Creation of virtual documentation for logic gates using created objects (4.1, 4.2)

Week 7 (14/03/2022)

- Review of first round of testing and bug fixes

Week 8 (21/03/2022)

- Implementation of the rest of environmental feedback (7.2 to 7.6)
- Finishing the rest of required rooms and visuals (5.6 to 5.8 and 1.4)

Week 9 (28/03/2022)

- Second round of testing – **Deliverable (Second prototype)**
- Consolidation of notes and planning of final report

Easter Break (04/04/2022 – 24/04/2022)

- Review of second round of testing and bug fixes
- Final report writing
- Adding optional objectives

Week 10 (25/04/2022)

- Final touches / fixes to project
- Review of report with supervisor – **Deliverable (Final draft)**

Week 11 (02/05/2022)

- Demonstration of project to supervisor and interested parties – **Deliverable (Final prototype)**
- Writing / fixes to report from review feedback

Week 12 (09/05/2022)

- Final changes to report

Hand-In (13/05/2022) – **Deliverable (Final report)**