Boston University
Electrical & Computer Engineering
EC464 Capstone Senior Design Project

Customer Installation Report

Augmented Reality Climbing Wall

by

Team 14
Augmented Reality Climbing Wall

Team Members

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Customer Installation Details

Figure 1.1 Setting up the Climbing Wall and Calibrating Projector

For the Augmented Reality Climbing Wall final product installation, all four members of Team 14, Tom, Taylor, Ryan, and Michael, installed the product in Photonics on April 20th, 2023. This location in specific was chosen as the spot to install the AR Climbing Wall as our client is an engineering professor here at BU and himself along with many others will be coming to view and test the product during ECE Day, so we installed it in Photonics in preparation for that event that will take place in the same building. The installation itself was completed in three phases as the four of us worked to prepare the climbing wall, the hardware, and the software. For the installation of the wall, we had to buy a large sheet of plywood, white paint to make sure that whatever was being projected onto the wall would appear, and finally measure and drill holes at the locations that we will be fastening the climbing holds. For the hardware, this included the placing of the 9 sensors and climbing holds to resemble a 3x3 climbing wall that was previously measured, connecting of the sensors from the back of the wall to the multiplexor and then to the raspberry pi, and the connecting of the raspberry pi to the projector using an HDMI cord and extender. Lastly, we had to ensure that the software was installed on the hardware as well as connected and working properly which included hosting the game on the web server and ensuring that it was running and perfectly aligned to work with the sensors installed on the wall. After completing all of these tasks, we tested the game and deemed that we were successful and that the AR Climbing Wall was installed.

All Requirements

Below is a list of all the materials that we have used during the creation of our project. We have split the materials into three categories–circuitry, hardware and software–and have given each material a designation on whether the material is final, eliminated, modified, or original. If the material is final, it means that the material is being used in the final product. For eliminated, that means we used that material at one point in our project but decided to either go another way or scrap that material for the final product. Lastly, if we used that material from the beginning of our project it is labeled as original, and if we did not start with the material but ended up using it or changing it to work with our project, it is marked as modified.

- Circuitry
    - Full Bridge Rectifier - final/modified
    - Diode - final/modified
    - Comparator - final/modified
        - MCP6241 Op Amp
        - Resistors
    - Multiplexor - final/modified
    - Coils - final/modified
    - Push Buttons - final/original
    - Function Generator - final/modified
    - Power Supply - final/modified
    - Jumper Wires - final/modified
    - 9V battery - eliminated
    - 9V battery connector - eliminated
    - Red LED - eliminated
- Hardware
    - Enclosure - final/original
    - Button - final/original
    - Push Button Holder - final/original
    - Coil Holder - final/original
    - Battery enclosure - eliminated
    - Raspberry Pi 4 Model B - final/modified
    - Square Board Cutout - eliminated
    - Plywood Sheet - final/modified
    - Climbing Holds - final/original
    - Bolt - final/original
    - Nut - final/original
- Software
    - Simon Game Engine - final/modified
    - Laptop - eliminated
    - Nginx Web Server- final/modified
    - CORS Header Extension - final/modified

Product Installation Testing

Figure 2.1 Testing the Climbing Wall Installation by Playing Simon Game

For this installation and testing, we ran the game locally on the raspberry pi and had it continually read the file that is being updated with the active sensor data matrix. On the raspberry pi, the game is run on a local web browser and, to access the file information, uses a web server that shows the contents of the sensor data file and an additional proxy server that attaches CORS headers to every request that is made. This is necessary as the web server does not allow GET requests from other unconfirmed browsers, so these headers need to be added to get access to the data. The raspberry pi continually sends the multiplexing sensor data to overwrite the data.txt file that is being read in the web server by the game engine.

We have extensively prototyped a system that uses AC power to transmit wirelessly through the wall. However due to space and time constraints we felt it was best to use the same enclosure hardware, but with wired holds for our installation, as to guarantee optimal game functionality. i.e. the game has been prototyped and run on a small scale with the wireless power coils, however as the system is scaled some instabilities, which lead to hampered gameplay, arise. The current hold is selected with a system of multiplexers that is designed to support up to 64 holds in total. This selection and reading post comparison is all controlled by the raspberry pi. As we have shown in previous prototype tests, we set up the multiplexing capability by connecting multiple buttons and holds to the multiplexer and grounding the unused inputs. We connected everything to the multiplexer and then connected the output to a comparator that translated the signal to a constant 3.3V if the input was greater than 0.5V and a constant 0V if it was below. This then sends the data matrix containing the current status of each hold to the data.txt file that the game engine uses as user inputs to change the game.

For this installation, we decided to use the AR Climbing Wall game Simon that we developed to demonstrate the functionality of the wall. This game seemed the most well-tailored to be played on the 3-by-3 wall that we designed for this installation as you did not need to climb it and could still be played by pressing the holds. Once installed and running, the game was able to be played very smoothly and completed all the criteria that our client was looking for in this project.

Assessment of Installation Testing

Here is the score sheet that was used to evaluate the result of testing our product during our customer installation:

Action	Correct? (1/0)
Nine holds with sensors are fastened to the wall and sensors can be pressed when grabbing hold	1
Game is projected onto the wall and shows holds in correct position	1
Hold buttons can be pressed and depressed by user without error	1
Holds only send signal of being pressed when they are pressed	1
Game plays without error and within expectations for the gameplay	1
Game successfully calibrates hold position and activates the depressed holds	1
Game reads change in depressed holds and reacts successfully	1
Total	7/7

We were very happy with how our installation went and how our product performed after being installed. The main steps for installation included setting up the hardware which mostly included the wiring of the holds to the raspberry pi, fastening of the holds and sensors onto the wall, spray painting the plywood wall to allow for the projections to display, and ensuring that the multiplexing was set up to send outputs. The additional steps for the installation included ensuring the software was functioning properly as we needed to start the game on the raspberry pi, make sure the proxy server was running, and begin the web server that the multiplexing files are transferred over. After all this installation was completed, we were able to play the game and show our client our fully completed project. Overall, we are extremely satisfied with how our final product tested during this installation and that it satisfied all the criteria set out by our client.

Client Response

As was stated before, our product was installed so that our client could see and test the AR Climbing Wall during ECE Day on May 5th. Being that ECE Day will take place in Photonics, we decided to install the product at that location so it will be easy for him to play once he attends the event. During our various meetings throughout the year, we believe that the final product that we installed satisfied all the constraints that our customer established during those meetings and we look forward to displaying the project at ECE Day.