5. EVALUATION

This section covers the testing process that was used for Gestura. Each section covers the methods that were used for a subsystem to ensure it aligns with the project's requirements and constraints.

5.1. Testing Certification – Subsystems

Gestura, a gesture based smart home system, is comprised of 5 different subsystems. They are as follows: user interface, microprocessor, data communications, gesture recognition, and power supply. These tests were created to test the effectiveness of each subsystem. It is important to make sure each subsystem works individually before testing if all the subsystems work as one system. Each subsystem has a requirement specification that must be passed before moving on to further testing. The subsystems were in categories such as responsiveness, accuracy, or intuitiveness.

5.1.1. User Interface

The user interface subsystem is responsible for letting the user interact with the system. It allows them to connect to new smart home devices and Wi-Fi networks, see recent gesture commands and set up which gestures give which commands. For this test, the design team had 20 participants use the user-interface for 5 minutes and then give a score from 1 to 5 on the intuitiveness of the layout.

Table 1: Results of User Interface Survey (Currently not finished)

User Interface Survey results					
Score	1	2	3	4	5
Number of participants					

Based on the results of the test...

5.1.2. Microprocessor

The microprocessor is one of the most important components of the device. If the microprocessor fails, the whole product will not work. Therefore, it is important tests are done to ensure that it is not overloaded and that the load does not cause the microprocessor to overheat. In the first test in **Table 2**, a test was performed for the CPU usage while under load at idle and during CPU-intensive tasks expected for the device's everyday usage.

Table 2: Test Sheet for Microprocessor

CPU usage at idle	**CPU usage with regular load**
~21%	~73%

Based on the results of this test, the product should not be overloaded even under load that will be expected during gesture recognition. This will ensure that there is no lag, which will help with the device's usability and that the chance of successful gesture recognition is not reduced because of throttling.

5.1.3. Data Communications

As the server response time is part of the time that the user must wait, it is paramount to investigate how to potentially reduce time for the server to respond and, as a result, make the responsiveness of the product

faster as our requirements outline. The first test in **Table 3** is to measure the average response time for the server to take the images from the camera and send back a gesture result to the user.

Table 3: Results of the Data Communications Test

	Server Response Time	Server Sending Time
Times (s)	~0.251	~2.315

The result of this test shows that the server response time and sending time will not have too big of an impact on the response time of the device which will make the user not have to wait an unreasonable amount of time for processing.

5.1.4. Gesture Recognition

The gesture recognition software is how Gestura recognizes hand gestures. **Figure 1** shows the results of testing the speed and accuracy of Gestura at various distances.

Test Writer: Eric Duncan							
Test Case Name:	Gesture recognition test			**Test ID #:**			
Description:	Determine the accuracy and time of gesture recognition at various distances.			**Type:**			☐ white box ☑ black box
Tester Information							
Name of Tester:	Eric Duncan			**Date:**			02/26/2024
Hardware Ver:	N/A			**Time:**			5:00 PM
Setup:	The camera is set up facing the user						
Test	**Distance (feet)**	**Time (s)**	**Accuracy**	**Pass**	**Fail**	**N/A**	**Comments**
1	2	1.4	90%	☑			9/10 gestures successfully recognized
2	5	2.7	80%	☑			8/10 gestures successfully recognized
3	10	3.5	60%	☑			6/10 gestures successfully recognized
Overall test result:				☑			23/30 gestures successfully recognized

Figure 1: Test for Gesture Recognition

The test has the camera facing the user to measure the accuracy of the gesture recognition algorithm at different distances. This test was conducted directly on the server that handles gesture recognition to mitigate inaccuracies stemming from internet connection problems. A timer was coded into the program to get accurate times of how long each run took. This test had three sections: 2, 5, and 10 feet away. Each section had 30 trials with 3 people trying the same gesture for 10 trials. The calculation for accuracy was calculated by dividing the number of successful inputs by the number of misinputs or unrecognized results. The results of this test demonstrate that Gestura meets its marketing requirements for accuracy within a 10-foot range.

5.1.5. Power Supply

The Power supply for Gestura should always be 5V and should last up to 2 days. The test will be conducted by starting with 5V and using a timer to see how long the voltage remains at 5V. When the voltage drops below 5V the timer will be stopped. The results from this test will determine the longevity of the power

supply and determine any changes that need to be made to satisfy the criteria. **Figure 2** shows the results of the test.

Test Writer: Shenna Booker							
Test Case Name:	Power Supply Testing			**Test ID #:**			
Description:	Determine how long the battery will last			**Type:**			☐ white box ☑ black box
Tester Information							
Name of Tester:	Shenna Booker			**Date:**			2/19/2024
Hardware:	Power Supply & Timer			**Time:**			3:00 PM
Setup:	The device was left on at an idle state						
Test	**Starting Voltage**	**Final Voltage**	**Time**	**Pass**	**Fail**	**N/A**	**Comments**
1	5V	5V	24Hrs	☑			
Overall test result:				☑			

Figure 2: Power Supply Testing for Gestura

The results of this section show that the device has a long-lasting battery life and can last for up to the marketing requirement of 24 hours on one charge. This ensures that our product will be convenient to use as it will not require a charge for a long time.

5.2. Testing Certification – System Testing

This is the beginning of the comprehensive system testing phase, which is a crucial step for validating our full prototype. System testing is crucial for making sure the entire system works correctly, meets the design specifications, and does what it is supposed to do. Unlike testing individual parts, system testing looks at how everything works together, including its reliability and how it interacts with other systems.

During system testing, the design team will use different methods to check everything. They will do functional testing to make sure each part of the software works correctly according to the requirements. Then, they will do performance testing to see how well the system handles different workloads. They will also do usability testing to check if the system is easy to use. Finally, they will do security testing to keep everything safe and follow the right standards.

Throughout this phase, the design team will carefully document all the tests, results, and any problems they find. This helps them fix any issues before the system is used in the real world.

5.2.1 Gesture Recognition Subsystem

The gesture recognition subsystem includes the software and hardware involved with recognizing a gesture. This includes the integration of the microprocessor, the data communications, the gesture recognition software, and the power supply subsystems. For this test, the device will be operating on the power supply on the Raspberry Pi 4 using an ethernet cable for the internet connection and connecting to

a server hosted on Google Cloud. The test was set up in a comparable way to the Gesture Recognition Software test to compare. **Figure 3 s**hows the results of the test.

Test Writer: Eric Duncan							
Test Case Name:	Gesture recognition subsystem test			**Test ID #:**			
Description:	Determine the accuracy and time of gesture recognition at various distances using all the parts of the device			**Type:**			☐ white box ☑ black box
Tester Information							
Name of Tester:	Eric Duncan			**Date:**			03/29/2024
Hardware Ver:	N/A			**Time:**			3:00 PM
Setup:	The camera is set up facing the user						
Test	**Distance (feet)**	**Time (s)**	**Accuracy**	**Pass**	**Fail**	**N/A**	**Comments**
1	2	3.1	80%	☑			8/10 gestures successfully recognized
2	5	3.7	70%	☑			7/10 gestures successfully recognized
3	10	4.3	70%	☑			7/10 gestures successfully recognized
Overall test result:				☑			22/30 gestures successfully recognized

Figure 3: Test for Gesture Recognition Subsystem

From the results of the gesture recognition subsystem for integration, Gestura has reached the goal of having a 50 percent success rate at 10 feet away as well as the time being under 5 seconds, which matches our marketing requirements and passes the test.

5.2.2 Smart Home Connection System

The smart home connection system will be used to send commands to the smart home systems that are supported by the device. The test will turn on and off a Kasa Smart Plug using the integrated design. The server is run on Google Cloud and the Kasa Smart Plug will be handled on the Raspberry Pi 4. **Figure 4** shows the result of this test.

Figure 4: Test for Smart Home Connection System (Currently not finished)

Using the data collected from these tests, the design team ensures that Gestura's subsystems are ready for integration and identifies areas of improvement. Rigorous analysis was used in each test to find the strengths and weaknesses within the subsystems.

Entering the final segments of the document, the design team reflects on the project: its lessons, its goals, and its future. This section serves not as an end but as a beginning to new endeavor