Verification and Validation Report: SE 4G06, TRON 4TB6

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Revision History

Date	Version	Notes
3/7/2023	1.0	Added Section 1, 2, and 3 - Purpose, Scope, and Background
3/7/2023	1.1	Added Section 4 - Functional Requirements Evaluation
3/7/2023	1.2	Added Section 5 - Nonfunctional Requirements Evaluation
3/8/2023	1.3	Added Section 6 - Unit Testing

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List of Tables

Symbols, Abbreviations and Acronyms

symbol	description
Age groups	(15-30, 31-50, 51-75, 75+)

1 Purpose

This VnV report's establishment is to support development of the product Synesthesia Wear. Furthermore, the actions taken in the document are linked with testing to ensure reliability and robustness of the product for adequate detection of particular sounds.

2 Scope

The focus of this document is on the output results of Synesthesia Wear when given arbitrary test inputs. Furthermore, black box testing will be used on important aspects of the output and input rather than how the results are being generated. Lastly, these tests will be based on certain implementations we have put into place to handle unexpected inputs.

3 Background

Synesthesia wear is designed with a mobile application which allows customization to occur from their mobile devices and allows users to toggle certain sounds on and off to improve usability of the watch. Synesthesia wear will be able to detect key words and sounds that are customized to the users to aid them with their lack of hearing. As a result, this helps them know when someone is calling their name, during emergencies, and many other situations within their daily lives.

4 Functional Requirements Evaluation

Id	**Ref**	**Description**	**Input**	**Expected Result**	**Actual Result**	**Result**

FRT1	FR1, FR2	Testing ability to differentiate sounds	Five different sounds	Device produces five different feedbacks	Vibration motor was able to produce different feedbacks when configured with 5 different feedback settings	Pass
FRT2	FR1	Testing in different environments	Same sound in different environments	Same feedback in all enviroments	Feedback was the same in different environments	Pass
FRT3	FR1	Testing at different ranges	Same sound at specified distances	Same feedback at specified distances	Farther distances led to inconsistencies in the feedback	Fail
FRT4	FR1	Testing its ability to ignore ambient noise	No input	No output	No vibrations are occuring when background noise is present in the environment	Pass

FRT5	FR2	Testing its ability to classify correctly	Different specified words	Feedback based on correct classification	Feedback is correct with respect to the configured sound classification settings	Pass
FRT6	FR2	Testing variability in speech	Same word said by four different people	Same feedback for all	Some inconsistencies in feedback for people with less training data samples	Fail
FRT7	FR2	Testing its ability to ignore high amplitude random sounds	Random not specified sounds	No haptic feedback	No feedback occurred for the random sound samples	Pass
FRT8	FR3	Testing newly set classifications	A newly set classification sound	The specified haptic feedback	The correct feedback for the newly configured sound occurred	Pass

FRT9	FR3	Testing removed classifications	A removed classification sound	No feedback	No feedback took place for the classification sound that was removed	Pass
FRT10	FR3	Testing reboot and memory retention	Power switched on and off and test FRT5 run again	Feedback based on correct classification	Correct feedback still occurred after the device was rebooted	Pass
FRT11	FR4	Testing haptic feedback with the device worn	Specified sound	Haptic feedback based on the sound's classification	The appropriate feedback happened even when the device was being worn	Pass
FRT12	FR4	Testing variability in haptic feedbacks	Three different specified sounds	Different haptic feedbacks that convey the specified sounds	Proper feedbacks with respect to each input sound occurred	Pass

FRT13	FR4	Testing different wearable orientations	FRT12 run on different orientations	All orientations give consistent output	The same feedback was present for any device orientation that was used	Pass
FRT14	FR4	Testing intensity of feedback wearing different clothes of varying thickness	FRT12 run on three different clothes	All clothes give consistent results	The thicker clothes lead to inconsistencies in feedback	Fail
FRT15	FR5	Testing real-time application of device	Specified sound	Correct classification within one second	Feedback had occurred within one second after an input sound had been said aloud	Pass

Table 1: Functional Requirement Tests

5 Nonfunctional Requirements Evaluation

5.1 Manual

Id	Ref	Description	Input	Expected Result	Actual Result	Result

NFRT3	NFR1	Testing button functionality based on button colour	Open Application	Different coloured buttons perform different functionalities	Buttons with similar colour performed similar functions	Pass
NFRT6	NFR1	Testing usability, accessability, findability of application and device	N/A	Achieve average score of 8 from 10 participants (rated out of 10)		TBD
NFRT7	NFR2	Testing user interface's consistency in appearance	N/A	Achieve average score of 4 out of all questions from participants		TBD
NFRT12	NFR4	Testing ability to configure different keywords on application	Click keyword selection button	Keyword configuration screen	Reached keyword configuration screen on application	Pass
NFRT13	NFR4	Testing ability to select language of use on application	Preferred Language	Application translated to preferred language		TBD
NFRT14	NFR4	Testing ability to select language of use on already set-up device	Change Language	Application translated to chosen language		TBD

NFRT15	NFR4	Testing accuracy of translated languages on application	Team translates manuals	Translated manuals		TBD

Table 2: Manual Nonfunctional Requirement Tests

5.2 Stress

Id	Ref	Description	Input	Expected Result	Actual Result	Result
NFRT11	NFR3	Check if you can configure an unrecognizable keyword	unrecognizable keyword	Keyword not supported	Keyword not supported	Pass
NFRT24	NFR11	Feed 6 samples 50 times each with random noise added. Check if correctly classified 90 percent of the time	Sound clips	90 percent correct classification	82 percent classification. See Figure 2 in Appendix	Fail
NFRT25	NFR12	Check the average battery life of the device by timing when 10 different device runs out of battery	10 fully charged devices	Average battery life of 10 devices is more than 12 hours		TBD

NFRT29	NFR16	Checking the durability of the device including material wear, battery etc	Device	Lifetime of device should be 5 years		TBD

Table 3: Stress Nonfunctional Requirement Tests

5.3 Performance

Id	**Ref**	**Description**	**Input**	**Expected Result**	**Actual Result**	**Result**
NFRT1	NFR1	Checking what the initial state of application is.	Open Application	Home Page of Application	Home Page of Application	Pass
NFRT2	NFR1	Can users find the pairing button of the application.	Open the Application, Click pair button	User clicks pair button under 10 seconds	Users found pairing buttons under 10 seconds	Pass
NFRT4	NFR1	Checking if application correctly goes to pairing page.	Open the Application, Click pair button	Pairing page of Application	Pairing page of Application	Pass

NFRT5	NFR1	Checking if application correctly goes to keyword selection page.	Open the Application, Click keyword selection button.	Keyword Selection page of Application	Keyword Selection page of Application	Pass
NFRT8	NFR3	Check to see if the application connects to the device through bluetooth	Open application, click pair button on both device and application	Device pairs to Phone	Device Pairs to Phone	Pass
NFRT16	NFR5	Checking if users can pair a device to phone in under 5 minutes	Open application, click pair button on both device and application	3/4 Users fully pair device in under 5 minutes	4/4 Users pair device under 5 minutes	Pass

NFRT19	NFR9	A sound will be fed to the device that includes a keyword device should be able to provide feedback in under 1 second 8/10 times	Sound that includes a keyword	8/10 keywords detected in under 1 second	9/10 Keywords detected. See Figure 1 in Appendix	Pass
NFRT20	NFR9	Checking how fast the UI of application responds to user input	User Input	Average of 100 inputs is under 1ms		TBD
NFRT21	NFR9	Checking that application can separately connect to 5 independent devices	Pairing button on both application and device	5/5 devices pair in under 1 minute	All 5 paired in under 1 minute each	Pass
NFRT30	NFR17	Let 10 people use device for 3 days record how many say it inhibits their lives	unpaired device and unopened application	8/10 participants do not the device to inhibit their lives		TBD
NFRT32	NFR17	Check to see if users can install the application on IOS and Android	Click Install	installed application on IOS and Android	Installed on Android	Fail

Table 4: Performance Nonfunctional Requirement Tests

5.4 Security

Id	Ref	Description	Input	Expected Result	Actual Result	Result
NFRT9	NFR3	Checking if application pairs to device that is not in pairing mode	Click pair Button	Device not found	Device not found	Pass
NFRT10	NFR3	Check if user can Login to application without a registered account	Invalid Login Credintials	Account not found	Account not found	Pass

Table 5: Security Nonfunctional Requirement Tests

5.5 Recovery

Id	Ref	Description	Input	Expected Result	Actual Result	Result
NFRT18	NFR8	Check to see if a initially paired device will automatically repair when taken out of range than put back into range	Take device in/out of range	device should rapair 90 percent of the time	device repaired 100 percent of the time	Pass
NFRT22	NFR9	Checking to see how long it takes a paired device to repair when brough back into range.	place device back into range	Average time of reconnection should be 10 seconds or less	Average time was 6 seconds	Pass

Table 6: Recovery Nonfunctional Requirement Tests

5.6 Visual

Id	Ref	Description	Input	Expected Result	Actual Result	Result
NFRT17	NFR6	people from different age groups will be shown icons found in application and asked if they can identify their meaning	N/A	All 5 icons named by 3/4 participants of each age group		TBD
NFRT23	NFR10	Check if battery is visual on the final device	N/A	Battery should not be visible	Battery is not visible	Pass
NFRT31	NFR17	Check if the device is adjustable such that it fits on different sized wrists	Adjust size	Should fit wrists of size 6-8.5 inches	Fits specified Wrist sizes	Pass
NFRT34	NFR25	Check if the code has anything that would be offensive to any groups	N/A	There should not be anything offensive present	Nothing that is offensive was found	Pass

Table 7: Visual Nonfunctional Requirement Tests

5.7 Load

Id	Ref	Description	Input	Expected Result	Actual Result	Result

NFRT26	NFR12	Device will be turned on for a duration of 5 hours during which keywords will be fed at randon time intervals. Test passes if device reacts at each interval	Sound clips	Device should react at each of teh 5 random intervals	device reacts at 5/5 intervals	Pass

Table 8: Load Nonfunctional Requirement Tests

5.8 Regulation

Id	Ref	Description	Input	Expected Result	Actual Result	Result
NFRT35	NFR26	Team of lawyers will check if the project as a whole corresponds with all legal rulations and requirements.	N/A	Project follows all legal requirements		TBD

Table 9: Regulation Nonfunctional Requirement Tests

5.9 Upgrade

Id	Ref	Description	Input	Expected Result	Actual Result	Result

NFRT27	NFR12	Helper code will be used to check if application is currently up if application goes down the developers will recieve an email	N/A	Application should have a continous uptime of 1 year		TBD
NFRT28	NFR15	Check if products supports up to 10 keywords 2 years after launch.	10 keywords	product will support at minimum 10 keywords		TBD
NFRT33	NFR20	Try and using the device 24 hours after a major update has been pushed to the application	Input a sound	Device should retain 100 percent functionality		TBD

Table 10: Upgrade Nonfunctional Requirement Tests

6 Unit Testing

The following test cases were derived from the unit test section shown in Synesthesia Wear's *VnVPlan.pdf Document* as well as the modules shown in the *MIS.pdf Document*. Furthermore, inapplicable tests from the VnVPlan were not included in the following table as they were not feasible with our current implementation.

Id	**Ref**	**Description**	**Input**	**Expected Result**	**Actual Result**	**Result**

UT1	M4, M9	Testing accuracy of the microphone to detect sounds	3 Different Sample Recordings	3 Distinct Sample Recordings in memory buffer that match the inputs respectively	The detected sounds matched the input sounds	Pass
UT3	M8	Testing bluetooth's ability to send signals accurately	Sample classification signal asserted on software	Feedback signal asserted on hardware	According to the classification signal, the correct feedback signal was sent to the vibration motor	Pass
UT4	M7	Testing classification module's ability to accurately categorize sound data	Stored samples of sound data in the memory buffer	Accurately classified Sound Data	The classification of the input sound samples were accurately categorized with a confidence level of 80% or more	Pass

UT5	M7	Testing classification module's ability to change its sound classification settings	New Classification settings	Classification settings have been changed on the app	The settings displayed on the settings page match the newly inputted classification settings	Pass
UT6	M4, M7	Testing feedback module's ability to transmit accurate feedback signals according to the settings	Feedback signal is asserted	Vibration detected in the bracelet that coincides with the feedback signal	Vibration motor went off appropriately with respect to the settings configured on the app	Pass
UT9	M2, M8	Testing bluetooth connection ability	Enable bluetooth connection	Bluetooth connection connected in under a minute	Bluetooth connection was established within 10 seconds	Pass

UT10	M2, M9	Testing bluetooth connection's ability when devices go in and out of range	Separate the connected devices 10 or more metres away, wait at least 5 seconds, then bring the devices closer together	Bluetooth will disconnect and reconnect when devices are back in range to each other	Bluetooth was unable to automatically reconnect when devices went back in range	Fail
UT11	M4	Testing noise filtering module's ability to remove noise from a sample sound	Digital data with one or more sounds	Same digital sound recording but with less noise	The output still had noise but notably less compared to the original sound file	Pass

UT15	M5	Testing app interface's ability to respond quickly to a user input	User input	User Interface response within 1ms	The app was appropriately able to respond as soon as a button was clicked or an input was submitted	Pass
UT16	M5	Testing app interface's ability to respond the same across different systems (Android, Windows, IOS)	User Input	Same User Interface response on all the different devices	N/A (The app has not yet been implemented on different IOS systems)	N/A

Table 11: Unit Tests

7 Changes Due to Testing

Test results marked as Fail require revisions in future implementations.

7.1 Changes Due to Functional Requirement Tests

- Add capability to detect sounds at greater distance (¿15m)
- Update sound detection performance to be more generalizable (i.e. detect sound from different individuals)

7.2 Changes Due to Nonfunctional Requirement Tests

- Add

7.3 Changes Due to Unit Tests

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8 Traceability Matrices

All of our tests can be traced back to either functional requirements, non-functional requirements and modules.

Test	**Requirements**				
	FR1	**FR2**	**FR3**	**FR4**	**FR5**
FRT1	X	X			
FRT2	X				
FRT3	X				
FRT4	X				
FRT5		X			
FRT6		X			
FRT7		X			
FRT8			X		
FRT9			X		
FRT10			X		
FRT11				X	
FRT12				X	
FRT13				X	
FRT14				X	
FRT15					X

Table 12: Traceability between functional requirement tests and functional requirements

Given our size of non-functional requirements, we have grouped some of the tests into test types for ease of understanding.

Test Cases	**Requirements**
Manual Non-functional	NFR1
	NFR2
	NFR4
Stress Non-functional	NFR3
	NFR11
	NFR12
	NFR16
Performance Non-Functional	NFR1
	NFR3
	NFR5
	NFR9
	NFR9
	NFR17
Security Non-Functional	NFR3

Table 13: Traceability between test cases and non-functional requirements

Modules	**Unit Tests**									
	T1	**T3**	**T4**	**T5**	**T6**	**T9**	**T10**	**T11**	**T15**	**T16**
Login Module M1										
Bluetooth connection Module M2						X	X			
Keyword Selection Module M3										
Output Signal Module M4	X				X			X		
Profile Module M5									X	X
Battery Status Module M6										
Sound Classification Module M7			X	X						
Bluetooth Communication Module M8		X			X	X				
Microphone Module M9	X						X			

Table 14: Traceability between modules and unit tests.

Appendix — Test results

Response Time

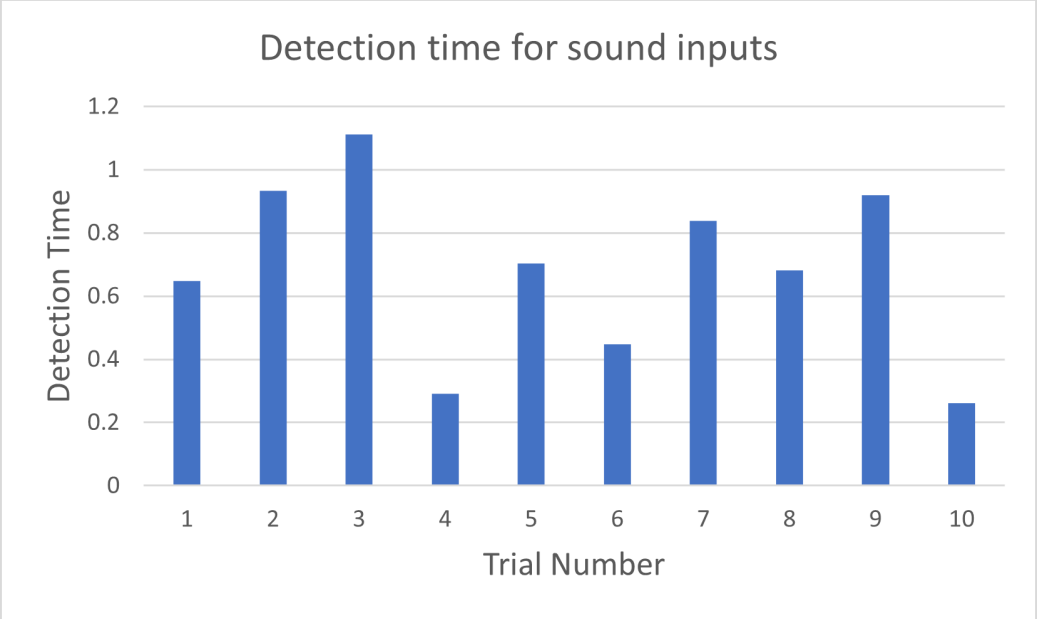

Figure 1: Detection time for sound inputs

Model Accuracy Histogram

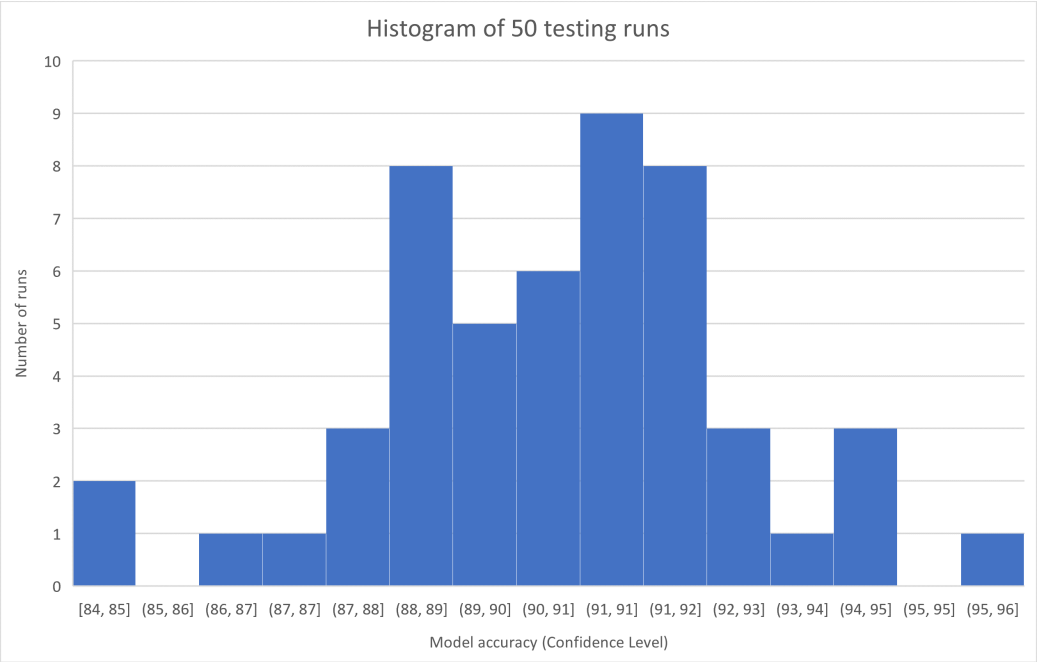

Figure 2: Histogram of 50 testing runs

Appendix — Reflection

Reflecting on the VnV plan has showed difference between the predicted output in VnV plan compared to experimental ones found in the VnV report. This difference was still used to utilize our time effective by making the tests more concise and increase their usefulness. For example, a functional requirement test 3 is TBD in the VnV report compared to the predicted VnV plan which produces haptic feedback.

Multiple other tests were founded to be based on reality which will be conducted after the final revision is completed. An example is NFRT 7, to test this we would need the finalized product design which would come later in the project to ensure no time is taken away from the usability of the device.

To improve upon the differences between the two documents the team will collaboratively brainstorm ideas on every test and how it will conducted

within the time frame given, rather then the unrealistic output of the devices. For example, testing an invalid keyword. Questions that we'd bring up would be, what would be considered an invalid keyword? Further, think about the consequences if the test fails and what the back up plan would be. Try looking for alternative options to get the desired output needed for the device to function as required.