

Verification and Validation Report: Mechatronics

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March 7, 2023

1 Revision History

Date	Version	Notes
Date 1	1.0	Notes
Date 2	1.1	Notes

2 Symbols, Abbreviations and Acronyms

symbol	description
T	Test

[symbols, abbreviations or acronyms – you can reference the SRS tables if needed —SS]

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3 Functional Requirements Evaluation

Section 5 from VV Plan

Hardware:

1. Camera Detection
2. Raspberry Pi

Machine Learning:

1. Joint Recognition
2. Display coordinates in space
3. Detecting multiple pairs of hands
4. Detecting multiple pairs of hands
5. Trainable Model

Real-time Data Processing

1. Process data in real-time

HARDWARE FUNCTIONAL REQUIREMENTS

The reference for ASL alphabet is Table #

ID	Description	Requirement Reference	Input	Expected Output	Actual Output	Result
T1	Camera is set up on Raspberry Pi	CFR1	Raspistill command to take a picture	A picture	A picture	Pass
T2	Real-time video is captured and displayed on screen	CFR1, CFR2	Views in front of the camera	Views in front of the camera are displayed	Views in front of the camera are displayed	Pass
T3	Testing hand detection at a distance	CFR1	hand gesture for "d"	d	d	Pass
T4	Testing if different webcams or cameras impact a sentence	CFR1, CFR2	Sign the sentence "how do you do" alphabetically through 5 different cameras			Pass
T5	Testing hand detection with multiple hands	CFR3	hand gestures for "d"	d	d	Pass
T6	Testing hand detection for similar gestures	CFR1	hand gesture for "m"	m	n	Fail

T7	Testing hand detection for motion (no input)	CFR1	Static hand gestures (no motions)	No output	z/d	Fail
T8	Testing hand detection for motion	CFR1	hand motion for “z”	z	z	Pass
T9	Testing hand detection for hand at the edges of the camera detection area	CFR1	hand gesture for “d”	d	d	Pass
T10	Mode Selection	N/A	number “2” on keyboard	System goes into “Training Mode”	System goes into “Training Mode”	Pass
T11	String display for one hand gesture	N/A	Any hand gesture except for the gesture for “Speak”	Text representing the hand gesture is displayed	Text representing the hand gesture is displayed	Pass
T12	String display for a series of hand gestures (slow)	N/A	A series of hand gestures (except for “Speak”) with a pause of 2 seconds	Text representing each hand gesture is displayed as a string	Text representing each hand gesture is displayed as a string	Pass

T13	String display for a series of hand gestures (fast)	N/A	A series of hand gestures (except for "Speak") with a pause of less than 2 seconds	Text re-presenting each hand gesture as a string	Some gesture's tests are not displayed	Fail
T14	Modifying string display	N/A	Pressing "Backspace" or "Space"	"Backspace" deletes a character, "Space" adds a space	"Backspace" deletes a character, "Space" adds a space	Pass
T15	Testing hand detection for a series of hand gestures (fast)	CFR1	A series of hand gestures performed in a very fast speed	Letters for corresponding hand gestures	Some letters are missing	Fail (need to increase fps)

Table 1: HARDWARE FUNCTIONAL REQUIREMENTS

MACHINE LEARNING FUNCTION REQUIREMENTS

ID	Description	Requirement Reference	Input	Expected Output	Actual Output	Result
M1	Testing for joint tracking when hiding joints	MLFR1, MLFR5, NFR2	Hand Gesture for “m” and “n” (covering thumb)	Able to recognize hidden joints	Able to recognize hidden joints	Pass
M2	Testing for joint tracking when overlapping hands	MLFR1, MLFR3, MLFR5	Hand Gesture for “S”, “M”, “N”, “R”	Able to separate different hand joints from each other	Able to separate different hand joints from each other	Pass
M3	Testing if joint lines are properly aligned with the user’s joints and move accordingly at the center	MLFR1, MLFR6, NFR2	Moving hand from one side of the screen to the other in rapid succession	Able to overlay joint lines on user’s hand continually and is centered on the hand	Able to overlay joint lines on user’s hand continually and is centered on the hand	Pass
M4	Testing if a joint overlay will be placed on more than two hands	MLFR1, MLFR3, NFR2	Having a third hand in the frame after the initial two	Unable to detect the third hand	Unable to detect the third hand	Pass
M5	Testing if detected joints are from one individual (the user)	MLFR1, NFR1, NFR3	Have two people with one hand each in the frame	Detects the hand from one person as opposed to two	Detects both the hands of both people	Fail

M6	Testing if the co-ordinates (x,y) of each joint is accurately recorded	MLFR2	Repeatedly recording the gesture “a” at the center of the screen	0,0,0,-0.374045802,- 0.038167939,- 0.709923664,- 0.381679389,- 0.824427481,-0.72519084,- 0.824427481,-1,- 0.541984733,- 0.65648855,-0.671755725,- 0.86259542,-0.564885496,- 0.610687023,- 0.465648855,- 0.389312977,- 0.328244275,- 0.72519084,-0.480916031,- 0.885496183,- 0.366412214,- 0.541984733,- 0.251908397,- 0.305343511,- 0.122137405,- 0.763358779,- 0.251908397,- 0.870229008,- 0.160305344,- 0.519083969,- 0.076335878,- 0.282442748,0.106870229,- 0.770992366,- 0.045801527,- 0.847328244,- 0.015267176,- 0.603053435,0.038167939,- 0.419847328	0,0,0,-0.374045802,- 0.038167939,- 0.709923664,- 0.381679389,- 0.824427481,-0.72519084,- 0.824427481,-1,- 0.541984733,- 0.65648855,-0.671755725,- 0.86259542,-0.564885496,- 0.610687023,- 0.465648855,- 0.389312977,- 0.328244275,- 0.72519084,-0.480916031,- 0.885496183,- 0.366412214,- 0.541984733,- 0.251908397,- 0.305343511,- 0.122137405,- 0.763358779,- 0.251908397,- 0.870229008,- 0.160305344,- 0.519083969,- 0.076335878,- 0.282442748,0.106870229,- 0.770992366,- 0.045801527,- 0.847328244,- 0.015267176,- 0.603053435,0.038167939,- 0.419847328	Pass
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[illegible]

M9	Test if TTS string creation speed can keep up with signing speed at one gesture per second	MLFR6, MLFR4, NFR1	Signing letters in sequence at one gesture per second	a b c d e f g	a b c d e f g	Pass
M10	Test if a .tfite file can be generated from the CSV files	MLFR5, NFR5	A CSV file with data points from different ASL gestures	A .tfite file that can be used to recognize the gestures that were recorded	A .tfite file that can be used to recognize the gestures that were recorded	Pass
M11	Testing if retraining by adding new data points can change recognition	MLFR7, NFR1, NFR5	Adding 50 accuracy data points to the gesture "Hello"	The accuracy prediction increases	The accuracy prediction decrease from 60% to 80%	Pass
M12	Test accuracy by signing different sequences of gestures / introducing variance into the system	MLFR4, NFR1	Sign letters in sequence of a,b,c,d then sign with d, f, z, j	a,b,c,d d,f,z,j with 100% accuracy	a,b,c,d d,f,z,j	Pass

M13	Testing for gesture variation based on user habits through retraining	MLFR7, NFR1, NFR3, NFR7	Retraining the model with a different method of signing “Hello”	Hello	Hello	Pass
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Table 2: MACHINE LEARNING FUNCTION REQUIREMENTS

Real-time Data Processing

ID	Description	Requirement Reference	Input	Expected Output	Actual Output	Result
1	test process data in real-time	RDP1	hand gestures for "d" and "a"	Output the corresponding letters "da" right after the hand gestures	Letters "da" were detected and displayed right after the hand gestures	Pass
2	Testing if the relative coordinates (x,y) is written to the CSV file	RDP1, NFR5	Hand gesture for "a"	Coordinates with identifier "0" (identifier for the letter "a") are written to the CSV file	Coordinates with identifier "0" were written to the CSV file	Pass
3	Testing if the point history coordinates (x,y) is written to the CSV file	RDP1, NFR5	Hand gesture for "j"	Multiple coordinates with identifier "9" (identifier for the letter "j") are written to the CSV file	Multiple coordinates with identifier "9" get written to the CSV file	Pass
4	Text to Speech	RDP2	Hand gesture for "Speak"	Current string is read out and then cleared	Current string is read out and then cleared	Pass
5	Text-to-speech in real-time for individual letters	RDP2	Hand gestures for "a", "b" and "c"	Audio output for letters "a", "b" and "c"	Audio output for letters "a", "b" and "c"	Pass
6	Text-to-speech in real-time for sentence	RDP2	hand gesture for "I love you"	Audio output for "I love you"	Audio output for "I love you"	Pass

7	Switching from translating mode to retraining mode stop detecting hand gestures	N/A	Pressing either 2 or 3	The interface no longer tries to record hand motion	The interface no longer tries to record hand motion	Pass
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Table 3: Real-time Data Processing

4 Nonfunctional Requirements Evaluation

accuracy, usability, portability, cultural

ID	Description	Requirement Reference	Input	Expected Output	Actual Output	Result
1	Test if GUI is displayed on screen	N/A	Program is started and camera is turned on	The resolution, FPS, mode, and current text are displayed on screen	The resolution, FPS, mode, and current text are displayed on screen	Pass
2	Test if gestures are not written to string when in training mode	N/A	Program is started, in training mode, and gestures are being performed	Nothing is being added to the string	Nothing is added to the string	Pass
3	Test if output is accurate for variations in user gestures	NFR7	Trying three variations of "Hello"	Hello	Hello	Pass
4	Usability: the ease of use of a user without the knowledge of ASL		Instructions and example hand gestures are provided to the user	The user should know how to use the ASL device and can input some sample ASL words after reading the instructions	The user is able to use the ASL device and input some sample ASL words after reading the instructions	Pass

5	Test if the Raspberry Pi can capture and translate ASL in real time		Program is started on the Raspberry Pi	The Raspberry Pi should be able to use the camera to detect and translate ASL in real time	The Raspberry Pi camera does not display the video with an adequate frame rate, making translation undoable	Fail
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Table 4: accuracy, usability, portability, cultural

4.1 Usability

4.2 Performance

4.3 etc.

5 Comparison to Existing Implementation

This section will not be appropriate for every project.

6 Unit Testing

7 Changes Due to Testing

[This section should highlight how feedback from the users and from the supervisor (when one exists) shaped the final product. In particular the feedback from the Rev 0 demo to the supervisor (or to potential users) should be highlighted. —SS]

8 Automated Testing

9 Trace to Requirements

10 Trace to Modules

11 Code Coverage Metrics

Appendix — Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Reflection. Please answer the following question:

1. In what ways was the Verification and Validation (VnV) Plan different from the activities that were actually conducted for VnV? If there were differences, what changes required the modification in the plan? Why did these changes occur? Would you be able to anticipate these changes in future projects? If there weren't any differences, how was your team able to clearly predict a feasible amount of effort and the right tasks needed to build the evidence that demonstrates the required quality? (It is expected that most teams will have had to deviate from their original VnV Plan.)