Verification and Validation Report: Mechtronics Enigeering

Team 32, Wingman, SmartVault
Edward He
Erping Zhang
Guangwei Tang
Peng Cui
Peihua Jin

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1 Revision History

Date	Version	Notes
2023-3-7	0	Finish the required parts
2022-3-28	1.0	Add missing elements, such as list of content, list of figures, and list of tables
2022-3-30	1.1	Add section 7 for better understanding
2022-3-31	1.2	Revise Section 5, 6 to match with the content in VnVPlan doc
2022-4-3	1.3	Revise the traceability table in section 9 to match with SRS and VnVPlan doc

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2   Purpose

This document is intended to support the systematic plan for testing the functionality of the system. It meant to show the system has met the requirements in both software and hardware aspects mentioned in requirements document. In particular, this document will describe the testing results. By the end of testing process, it can be shown that the system is working properly and available for usage.

3   Scope

The document would pay attention to the different functionalities being discussed within the VnVPlan documentation. In addition, it would undergo the testing processes as if it was a black box, which will emphasis on the inputs and outputs of the system instead of the internal process and mechanics.

4   Background

SmartVault is designed to assist the user to remember where his/her belongings are and the most recent time the user had used or placed their belongings. The proposed system is capable of tracking and following human activities to position itself best for capturing any moving objects caused by the user. The system will identify each item that is being moved and record/update their corresponding positions. The user then has the ability to interact with our system through an interface and select which item the user is looking for. Given this information, our system would identify where that specific item is and assist the user to locate their belongings in a short time. This section will not be appropriate for every project.

5 Functional Requirements Evaluation

5.0.1 Image Processing and Storage Functional Requirements

Manual Testing   Testing shown:

Test Number	IPR1-1
Requirement Reference	IPR1
Requirement	The system should be able to identify human's body
Input	Images of the working environment and a human show up in the environment
Desired Output	Coordinate of the detected human body, terminal shows "human coming"
Actual Output	Correct coordinate of the detected human body, terminal shows "human coming"
Conclusion	Pass as expected

Table 1: IPR1-1

Test Number	IPR1-2
Requirement Reference	IPR1
Requirement	The camera should keep following the human
Input	Images of the working environment and a human show up in and then walk around in the environment
Desired Output	Coordinate of the detected human body, terminal continuously updating the coordinate
Actual Output	Coordinate of the detected human body, terminal continuously updating the coordinate
Conclusion	Pass as expected

Table 2: IPR1-2

Test Number	IPR1-3
Requirement Reference	IPR1
Requirement	The system should be able to detect human's leaving
Input	Images of the working environment and a human show up in and then disappear in the environment
Desired Output	Terminal said "human leaving"
Actual Output	Terminal said "human leaving"
Conclusion	Pass as expected

Table 3: IPR1-3

Test Number	IPR2-1
Requirement Reference	IPR2
Requirement	The system should be able to identify new objects introduced in the area
Input	Images of the working environment and a new object was placed in the environment
Desired Output	A image highlighted with newly-added objects after the process of image subtraction being applied
Actual Output	Correct Coordinate of the detected new objects and outlining them with boxes
Conclusion	Pass as expected

Table 4: IPR2-1

Test Number	IPR2-2
Requirement Reference	IPR2
Requirement	The system should be able to identify removed or lost objects in the area
Input	Images of the working environment and object being removed out of the environment
Desired Output	A image with nothing after the process of image subtraction being applied
Actual Output	An output where the removed item can not be found inside the figure
Conclusion	Pass as expected

Table 5: IPR2-2

Test Number	IPR2-3
Requirement Reference	IPR2
Requirement	The system should be able to identify the recorded objects updated in the area
Input	Images of the working environment with object in different location in the environment
Desired Output	Coordinate of the new location of detected moving objects and highlight the new location
Actual Output	Correct Coordinate of the new location of detected moving objects and highlight the new location
Conclusion	Pass as expected

Table 6: IPR2-3

Test Number	IPR3-1
Requirement Reference	IPR3
Requirement	The camera should rotate back to initial position when no human detected
Input	Images of the working environment and a human show up in and then disappear in the environment
Desired Output	Camera rotate back to the initial position after user disappear
Actual Output	Camera rotate back to the initial position after user disappear
Conclusion	Pass as expected

Table 7: IPR3-1

Test Number	IPR4-1
Requirement Reference	IPR4
Requirement	Different Images should have different location of the object in the environment
Input	Images of the working environment and object in the environment
Desired Output	The re-location mode should be activated
Actual Output	The re-location mode is activated
Conclusion	Pass as expected

Table 8: IPR4-1

Test Number	IPR5-1
Requirement Reference	IPR5
Requirement	To check the record in the local folder, it should store two photos in total, one with create data/time information shall be inside the 'item' folder, and the other will be inside the 'location' folder
Input	The automatic testing tool will activate the photo storage function
Desired Output	The photos taken by the camera with create date/time
Actual Output	
Conclusion	Pass as expected

Table 9: IPR5-1

Automatic Testing   Testing shown:
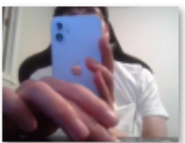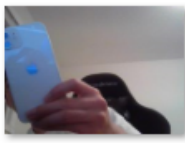
Test Number	IPR6-1
Requirement Reference	IPR6
Requirement	The system should only make any update inside the location folder
Input	Start running the fileStorage function with the parameter, 'u', as updating
Desired Output	Only item1 get updated
Actual Output	Only item1.png get updated Comparison shown:
Conclusion	Pass as expected

Table 10: IPR6-1

Test Number	IPR7-1
Requirement Reference	IPR7
Requirement	The object information in the file folder should have unique IDs
Input	The automatic testing tool will call the file storage module and send the object information to the module
Desired Output	The different objects information will be stored in the folder with unique ID
Actual Output	The different objects information are stored in the folder with unique ID
Conclusion	Pass as expected

Table 11: IPR7-1

Test Number	IPR8-1
Requirement Reference	IPR8
Requirement	The photos in the file folder should be sorted
Input	The automatic testing tool will call the photo storage function and send the photo to the module
Desired Output	The photos in the data storage module should be in ascending order of time
Actual Output	The photos in the data storage module are in ascending order of time
Conclusion	Pass as expected

Table 12: IPR8-1

Test Number	IPR9-1
Requirement Reference	IPR9
Requirement	The photos in the file folder should be sorted
Input	The automatic testing tool will call the photo storage function and send the photo to the module
Desired Output	The photos in the data storage module should be in ascending or descending order of objects IDs
Actual Output	The photos in the data storage module are in ascending or descending order of objects IDs
Conclusion	Pass as expected

Table 13: IPR9-1

5.0.2 UI Interface Menu

Manual Testing   Testing shown:
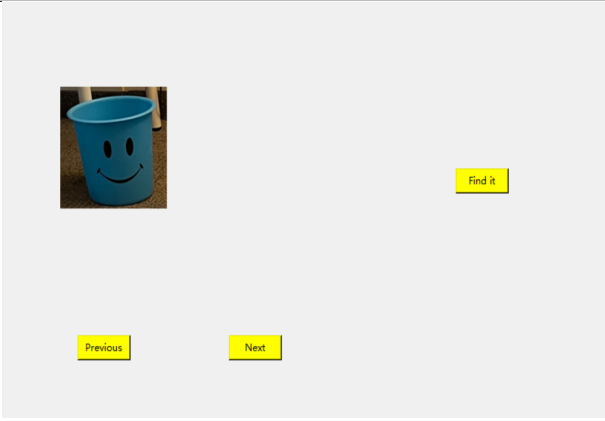
Test Number	UIR1-1
Requirement Reference	UIR1
Requirement	The UI should notify the user when the user highlights certain item
Input	User's manipulation to the user interface
Desired Output	The graphical displays to the user
Actual Output	
Conclusion	The test is successful

Table 14: UIR1-1

Test Number	UIR2-1
Requirement Reference	UIR2
Requirement	The UI should be able to let the user to change the sorting method
Input	User chooses another sorting method
Desired Output	The change between ascending and descending order
Actual Output	The change between ascending and descending order
Conclusion	The test is successful

Table 15: UIR2-1

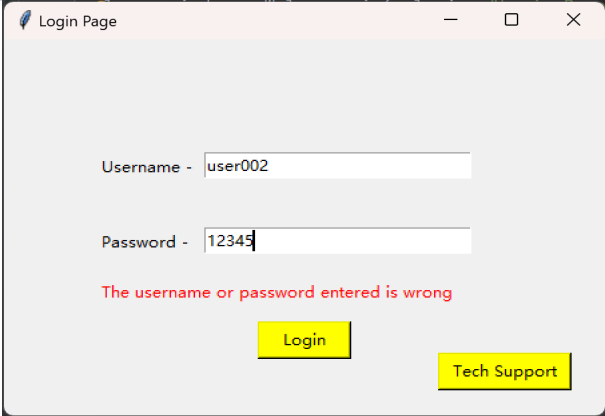| Test Number	UIR3-1
Requirement Reference	UIR3
Requirement	The UI should let the user have an access to the main menu
Input	The correct input of the password
Desired Output	Show the main menu in the UI window
Actual Output	Show the main menu in the UI window
Conclusion	The test is successful

Table 16: UIR3-1

Test Number	UIR3-2
Requirement Reference	UIR3
Requirement	The UI should notify the user when the user has a wrong password input
Input	The wrong input of the password
Desired Output	There should be a text notification shown on the window
Actual Output	
Conclusion	The test is successful

Table 17: UIR3-2

Test Number	UIR4-1
Requirement Reference	UIR4
Requirement	The system should give the response on status identifier
Input	User changes and unplugs the camera to insert a fault
Desired Output	The graphical displays to the user
Actual Output	The application cannot be allowed to run since the camera is unplugged.
Conclusion	The test is successful

Table 18: UIR4-1
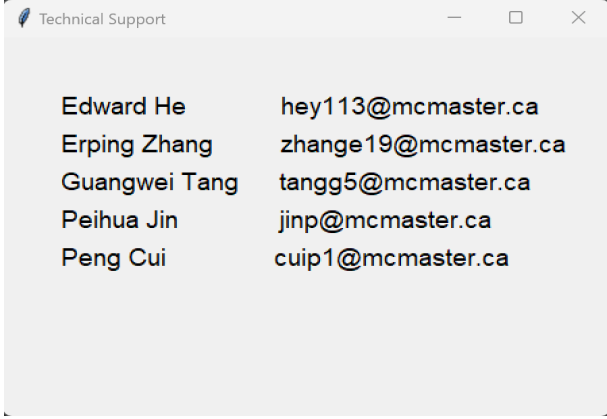
Test Number	UIR5-1
Requirement Reference	UIR5
Requirement	The UI should be able to provide technical support to the user
Input	The user press the technical support button
Desired Output	The technical support window is shown
Actual Output	
Conclusion	The test is successful

Table 19: UIR5-1

6 Nonfunctional Requirements Evaluation

6.1 Usability

Test Number	APR1-1
Requirement Reference	APR1
Requirement	The User is able to launch the program without help
Input	The survey paper
Desired Output	An average of high rating shown on the paper
Actual Output	An average of 9.3 points on the rating of the usability of the program
Conclusion	The test is successful

Table 20: APR1-1

Test Number	EUR1-1
Requirement Reference	EUR1
Requirement	Users without electronics and coding background will be able to connect the hardware and use the program
Input	Users are asked to connect the hardware and start the program
Desired Output	There should not be any unclear instructions for the user to proceed. The hardware system including the Arduino board, camera and mount should be clarified for people to plug the wires
Actual Output	As camera,Arduino board and the motor are already attached to the mount. User just need to plug the wires to corresponding pins then they can simply start the program with one click
Conclusion	The test is successful

Table 21: EUR1-1

Test Number	EUR2-1
Requirement Reference	EUR2
Requirement	The User is able to find the desired item without help
Input	The survey paper
Desired Output	An average of high rating shown on the paper
Actual Output	An average of 9.1 points on the usability of finding the item
Conclusion	The test is successful

Table 22: EUR2-1

6.2 Performance

Test Number	SLR1-1
Requirement Reference	SLR1
Requirement	The User is able to find the desired item within certain time constraint
Input	Information of the object is entered properly
Desired Output	The response time of the system to show the location of the object should be less than 5 second
Actual Output	The average seconds is below 5 seconds
Conclusion	The test is successful

Table 23: SLR1-1

Test Number	SCR3-1
Requirement Reference	SCR3
Requirement	Rotation speed of the camera should be appropriate and will not damage other parts under the condition the camera have to rotate from one end to the other
Input	Human walk through the camera and leave the capture region at high pace
Desired Output	The camera will detect the human body and starts to follow the human movement. Once the human accelerate and leave the region, the camera will stop tracking and the rotation speed will not be fast enough to damage other parts
Actual Output	The camera will rotate to the human position and follow the movement once it detects the existence of human body. As the human quickly leave the capture region, the camera stops tracking and take a photo of the current frame. After 5 seconds, it will rotate back to the original position. There are no parts being damaged during the movement. And the angular velocity is under 30 degree/seconds
Conclusion	The test pass as expected

Table 24: SCR3-1

Test Number	PAR2-1
Requirement Reference	PAR2
Requirement	The location value displayed should always be whole number
Input	The target object will be moved one small step at a time
Desired Output	The location value displayed should always be whole number
Actual Output	The displayed value is a whole number
Conclusion	The test is successful

Table 25: PAR2-1

Test Number	RAR1-1
Requirement Reference	RAR1
Requirement	The user's work space is limited by certain angles
Input	The camera will keep rotating
Desired Output	The camera would never exceed the range of -180 degrees and +180 degrees
Actual Output	The motor stops at 180 degrees even if the human is still moving in a certain direction.
Conclusion	The test is successful

Table 26: RAR1-1

Test Number	RFR2-1
Requirement Reference	RFR2
Requirement	The user is required to give appropriate instruction
Input	Wrong parameters will be entered into input boxes
Desired Output	The program will return error messages
Actual Output	Errors detected
Conclusion	The test is successful

Table 27: RFR2-1

7   Demonstration Testing Requirement

This section is aimed to test the stability and basic functionality for Revision-0 Demonstration.
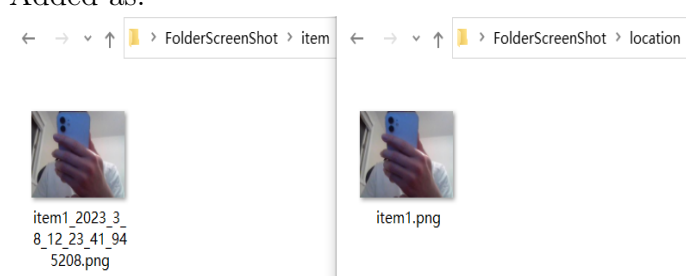
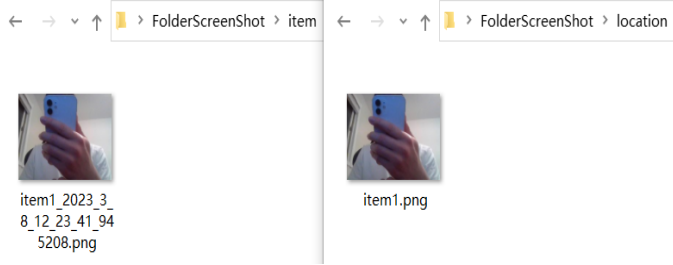| Test Number	DTR1
Requirement Reference	IPR5
Requirement	To store the initial frame
Input	(1, 'i')
Desired Output	Adding item1_{date and time}.png, item1.png
Actual Output	Added as:
Conclusion	Pass

Table 28: DTR1

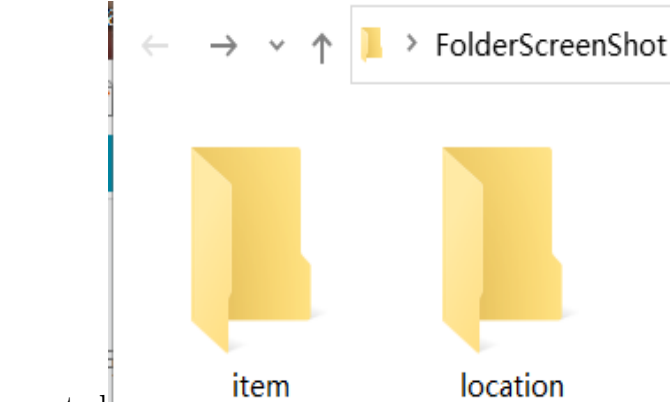| Test Number	DTR2
Requirement Reference	IPR5, IPR7
Requirement	To check whether the frame is stored in the correct path
Input	(1, 'i')
Desired Output	item{num}_{date and time}.png is stored in 'item', item{num}.png is stored in 'location'
Actual Output	item1_2023_3_8_12_23_41_945208.png is within 'item', item1.png is inside 'location'
Conclusion	Pass

Table 29: DTR2

Test Number	DTR3
Requirement Reference	N/A
Requirement	To create 3 folders sequentially
Input	createFolder() being called
Desired Output	3 folders (FolderScreenShot, item, location) created
Actual Output	3 folders (FolderScreenShot, item, location) created
Conclusion	Pass

Table 30: DTR3

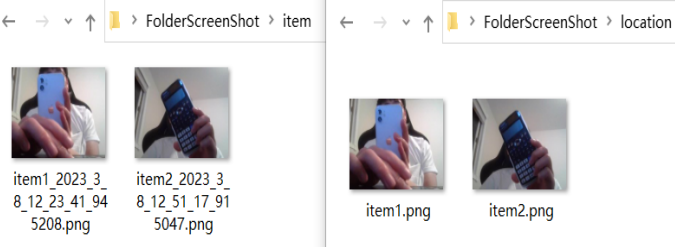| Test Number	DTR4
Requirement Reference	N/A
Requirement	Do nothing if they have already existed
Input	createFolder() being called
Desired Output	No change
Actual Output	No change
Conclusion	Pass

Table 31: DTR4

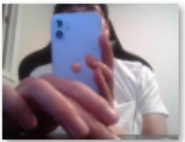| Test Number	DTR5
Requirement Reference	IPR5, IPR6
Requirement	To check whether the frame for the second item is captured
Input	(2, 'i')
Desired Output	Adding item2_{date and time}.png, item2.png
Actual Output	Added as:
Conclusion	Pass

Table 32: DTR5

Test Number	DTR6
Requirement Reference	IPR4, IPR6
Requirement	To check whether the location frame for the first item is updated, meanwhile the second item won't get affected
Input	(1, 'u')
Desired Output	item1_{date and time}.png should remain, item1.png shall be updated
Actual Output	Only item1.png get updated Comparison shown:
Conclusion	Pass

Table 33: DTR6

8   Changes Due to Testing

Based on the feedback from Rev 0 demo, we have conducted our test case based on larger room with more complex background environments. During the early stages of testing process, performance reliability issues were found, which led to changes to the main algorithm which aims to lower the light sensitivity to increase the repeatability of the test cases.

Taking notes from our discussion with users, we tried to best limit the user interaction with the system. Users is only required to interact with the user interface which has adapted to user feedback to improve usability.

Another point noted was that users would like to have more detailed time for searching specific items. This will be implemented in the upcoming milestone where some other quality of life update will be implemented.

9 Traceability Matrices

9.1 Traceability for Image Processing and Functional Requirements

Test Method	Requirement	Test Number
Manual	IPR1	IPR1-1
Manual	IPR1	IPR1-2
Manual	IPR1	IPR1-3
Manual	IPR2	IPR2-1
Manual	IPR2	IPR2-2
Manual	IPR2	IPR2-3
Manual	IPR3	IPR3-1
Manual	IPR4	IPR4-1
Manual	IPR5	IPR5-1
Automatic	IPR6	IPR6-1
Automatic	IPR7	IPR7-1
Automatic	IPR8	IPR8-1
Automatic	IPR9	IPR9-1

Table 34: Traceability for Image Processing and File Storage Testing

Test Method	Requirement	Test Number
Manual	UIR1	UIR1-1
Manual	UIR2	UIR2-1
Manual	UIR3	UIR3-1
Manual	UIR3	UIR3-2
Manual	UIR4	UIR4-1
Manual	UIR5	UIR5-1

Table 35: Traceability for UI Interface Menu

9.2 Traceability for Nonfunctional Requirements

Test Method	Requirement	Test Number
Structural, Manual	APR1	APR1-1
Functional, Manual	EUR1	EUR1-1
Functional, Manual	EUR2	EUR2-1
Functional, Manual	SLR1	SLR1-1
Functional, Manual	SCR3	SCR3-1
Functional, Manual	PAR2	PAR2-1
Functional, Manual	RAR1	RAR1-1
Functional, Manual	RFR2	RFR2-1

Table 36: Traceability for Usability and Humanity Requirements

9.3 Traceability for Demonstration Testing Requirements

Test Method	Requirement	Test Number
Manual	IPR5	DTR1
Manual	IPR5, IPR7	DTR2
Manual	N/A	DTR3
Manual	N/A	DTR4
Manual	IPR5, IPR6	DTR5
Manual	IPR4, IPR6	DTR6

Table 37: Traceability for Image Processing and File Storage Testing

References

Appendix — Reflection

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

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.)

One of the biggest area of difference between VnV plan and VnV report is from some of the changes to the functional requirements. Our system is no longer tracking human hands, which reflected in the VnV report where we did not test that specific requirement. Another difference is that we modified the logic of camera and motor movement. The purpose of this modification is to satisfy the image process requirement, which cause we add a new requirement and test case compare with the VnV plan. What's more, The test for opening the technical support window is added because the path for the customer to ask help from the program developer is important. Since VnV plan was made prior to us finalizing the implementation, we had made several assumptions that were later modified. However, most of our VnV plan turned out to be feasible and essential for the validation of our project. Since we developed our testing plan based on input/outcome, the change to our anticipated algorithm did not affect the general path for our VnV report. The proposed testing case in VnV plan were tested and validated.