Verification & Validation

Mechtron 4TB6 • Prof. Alan Wassyng

Group 34

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1. Table Of Revisions

Version	Date	Authors	Description Of Revision
0	2022-02-06	Abdulrahman Elgendy Ahmed Afifi Mina Ghaly Omar Mouftah	Initial revision of the Verification & Validation document
1	2022-03-31	Abdulrahman Elgendy Ahmed Afifi Mina Ghaly Omar Mouftah	Updated all verification & validations as well as traceability matrices.

2. Purpose

The purpose of this project is to create a system that enables users to control their blinds remotely and automate them based on their personal preferences. Users will have the option of choosing a brightness level that they prefer through a web-app, and the system will continue to adjust the blinds in order to maintain the desired brightness level. Users will also have the option of manually adjusting the blinds through their smart device by increasing/decreasing the blind angle until they reach their desired brightness. All automated blinds currently on the market must be purchased as a full set, which can be quite expensive. Moreover, any accessory that tries to automate traditional blinds lacks many features when it comes to customization and truly smart features. This project is meant to allow owners of non-smart blinds the option of automating their blinds at a lower cost with similar functionality to smart blinds.

3. Scope

The scope of this document is to discuss the different test criteria required to validate the 5 modules of the Intellux system. The UI, database, sensors, control and mechanical modules will be verified based on the several test cases explained in this document to ensure each module meets the requirements set in the system requirements document submitted by the team. It is important to note that some non-functional requirements will not be tested as they are considered to be subjective and could be viewed differently by each individual user. Moreover, some functional and non-functional requirements were modified and new ones were added since the last requirements document that was submitted.

4. Background

Intellux is designed to allow users to have full control over their beaded blinds. It offers Auto Mode for when the user wants to input a desired brightness level that is maintained throughout the day by automatically rotating the blinds to achieve this desired brightness. Manual Mode is designed to provide the user the ability to adjust the blinds however they want by inputting what angle they want to turn them too.

Intellux will be able to store preferences for multiple users and users can switch between which preferences are active in a simple manner. Any user connected to the same network as Intellux will be able to use both Auto and Manual Modes.

5. Test Cases

5.1. Testing Plan & Testing Factors

Table 1: Intellux User Interface Module Test Plan

Component	Test Plan Test Factors
User Interface Module	The main goal of testing the user interface is to ensure that users can interact with the apparatus with ease. All testing was done through trial on a functional development level user interface and results were verified through apparatus response and backend information comparison. Tests were done on several devices to ensure that functionality was consistent over different platforms.

Table 2: Intellux Database Module Test Plan

Component	Test Plan Test Factors
Database Module	The main goal of testing the Database is to ensure that data can be stored accurately and in a timely manner. All testing was done through trial on a functional development level user interface and through backend manual testing on the database. Results were verified through apparatus and user interface response and backend information comparison. Tests were done on several devices to ensure that functionality was consistent over different platforms.

Table 3: Intellux Sensors Module Test Plan

Component	Test Plan Test Factors
Sensors Module	Testing the sensors is done to ensure proper functionality, accuracy and reliability of the sensors used in the Intellux apparatus. Since the sensors measure the internal and external brightness, verifying they work as intended is crucial to the system's operation. The sensors will be tested in a plethora of situations with varying light intensity levels to ensure the reading accuracy.

Table 4: Intellux Control Module Test Plan

Component	Test Plan Test Factors
Control Module	The main goal of testing the control module is to ensure that the algorithms that run the different modes of operation such as (manual mode & auto mode) are operating correctly and meet the specified functional requirements. The main factor that was considered when creating the test cases was ensuring the correct control logic was

	implemented in the control algorithms to avoid hazardous consequences. Another important factor was ensuring the correct communication between the control module and the user interface & mechanical modules

Table 5: Intellux Mechanical Module Test Plan

Component	Test Plan Test Factors
Mechanical Module	Testing on the mechanical module was done to ensure the successful operation of the Intellux device on any beaded vertical blinds with reliable performance and versatility. The mechanical module should allow users to install Intellux on any existing blinds with relative ease. The tests for this module were done to warrant safety of operation by minimizing user contact with moving parts and limiting speeds but to also find a balance for quick functionality. Each functional and nonfunctional requirement was tested with the entire module to make certain all parts of the module are able to work together smoothly.

5.2. Intellux User Interface Module

Table 6: Intellux User Interface Module Test Cases

Test Number	Description	Requirement Reference	Inputs	Expected Outputs	Actual Outputs	Result
1	Test UI apparatus response after UI communication	AFR1	Input brightness of ‘50’ in auto mode in UI	Apparatus receives desired brightness of ‘50’	Apparatus receives desired brightness of ‘50’	Pass
2	Test UI communication with apparatus at from a minimum distance of 5m (testing room length)	AFR2	Input brightness of ‘50’ in auto mode in UI from distances [5m-10m]	Apparatus receives desired brightness from distance > 5m	Apparatus received desired brightness of ‘50’ from up to 9.5 m away	Pass
3	Test UI notification when desired brightness is not achievable	AFR3	Input brightness of ‘100’ in auto mode when achievable brightness is ‘80’	UI notification indicating desired brightness is not achievable	**Notification Received:** indicating desired brightness is not achievable	Pass
4	Test UI does not allow user to activate Auto Mode at night	AFR4	Attempt to activate Auto Mode at local sunset	UI notification indicating Auto Mode is not permitted	**Notification Received:** Auto Mode not	Pass

			timing	at this time	permitted	

5.3. Intellux Database Module

Table 7: Intellux Database Module Test Cases

Test Number	Description	Requirement Reference	Inputs	Expected Outputs	Actual Outputs	Result
1	Test Database can store at least 10 users	AFR5	Create 10+ Users in the UI	All 10 users are displayed in the User table	All 10 users are displayed in the User table	Pass
2	Database Updates in real time for user creation	AFR6	Create user: {username: Omar; preferences:70}	User is added to User table {username: Omar; preferences:70}	{username: Omar; preferences: 70} is saved in database	Pass
3	Database Updates in real time for user deletion	AFR7	{username: Omar; preferences:70} is removed from database	{username: Omar; preferences:70} is removed from database	{username: Omar; preferences: 70} is removed from database	Pass
4	Database Updates in real time for editing user preferences	AFR8	Edit user: {username: Omar; preferences:70} to Create user: {username: Omar; preferences:90}	User {Omar} preferences changed from {70} to {90}	User {Omar} preferences changed from {70} to {90}	Pass

5.4. Intellux Sensors Module

Table 8: Intellux Sensors Module Test Cases

Test Number	Description	Requirement Reference	Inputs	Expected Outputs	Actual Outputs	Result
1	Exposing sensor to extreme	IFR1	0-10 Lux	0-0.5V	0.42V	Pass

	darkness					
2	Exposing sensor to dark indoor levels	IFR1	50-200 Lux	0.6-1.0V	0.73V	Pass
3	Exposing sensor to moderate indoor light levels	IFR1	201-1,000 Lux	1.1-1.5V	1.33V	Pass
4	Exposing sensor to bright indoor levels	IFR1	1,001-5,000 Lux	1.6-2.0V	1.83V	Pass
5	Exposing sensor to cloudy outdoors	IFR1	10,001-30,000 Lux	2.1-2.5V	2.26V	Pass
6	Exposing sensor to bright outdoor levels	IFR1	30,001-100,000 Lux	2.6-3.3V	3.21V	Pass
7	Verifying manufacturer error by testing the same brightness	IFR11	2,500-5,000 Lux	1.6-2.0V	1.78V	Pass

5.5. Intellux Control Module

Table 9: Intellux Control Module Test Cases

Test Number	Description	Reference	Inputs	Expected Outputs	Actual Output	Result
1	Recognize when the brightness level in the room is not at the desired level during auto mode	IFR2	-Desired brightness = 2.0V - Internal brightness = 1.0V	-Blinds open - internal brightness between [1.9, 2.1]	Internal Brightness = 1.95	Pass
2	Maintain brightness in the room to ∓ 5%	IFR3	- external brightness = [1.32V - 3.3V] - internal brightness = 1.0V	-Blinds close -internal brightness between	Brightness = 0.332	Pass

			-Desired brightness = 0.33V	[0.3135, 0.3465]		
3	Maintain brightness in the room to ∓ 5% until another request is sent within 10mins	IFR5	-external brightness = [1.32V - 3.3V] - internal brightness = 1.0V - Desired brightness = 0.33V After 10 minutes: -2nd Desired brightness = 0.66V	Initial output: -internal brightness between held between [0.3135, 0.3465] for the next 10 minutes Output after 10 minutes: -Blinds close -internal brightness between [0.627, 0.693]	Brightness = 0.332 After 10 min: Brightness = 0.658	Pass
4	**Undesired event:** Desired brightness level < External brightness	IFR8	- external brightness = [0V - 1.32V] -Desired brightness = 3.3V	Intellux App receives a notification from the apparatus saying that the target brightness could not be achieved and displays it to the user.	**Notification received: "**Target brightness could not be achieved"	Pass
5	Check auto-mode behavior after sunset	IFR9	Attempt to activate auto mode at local sunset timing	auto mode will not activate	Auto mode did not activate	Pass
6	Check awareness of current blinds angle position	IFR10	-full range motor steps = 2,000 -current blinds angle = 90° -current stepper position = (90°/180°) * 2,000 = 1,000 -desired blinds angle	-To move to the desired blinds angle, the stepper motor should take 2,000* (120°-90°)/ 180° = 333 steps in the positive rotation direction, and	Current blinds position = 1,333	Pass

			= 120°	the apparatus should save its current stepper position as 1,000 + 333 = 1,333 which is equivalent to the 120° blinds angle		
7	**Undesired event:** Launch any mode before calibrating	IFR13	-uncalibrated system - manual mode desired blinds angle = 90°	User instructed to calibrate system first	**Notification received:** User instructed to calibrate system first	Pass

5.6. Intellux Mechanical Module

Table 10: Intellux Mechanical Module Test Cases

Test Number	Description	Requirement Reference	Inputs	Expected Outputs	Actual Outputs	Result
1	Timing constraint test	IFR4	initial angle = 180° final angle = 0°	rotation time = 6 seconds	rotation time = 5.8 seconds	Pass
2	Range of rotation test (fully close outwards then fully close inwards)	IFR6	initial angle = 180° final angle = 0°	Blinds fully closed outwards → Blinds fully closed inwards	Blinds fully closed outwards → Blinds fully closed inwards	Pass
3	Rotation speed test (rotation speed <= 30°/sec)	IFR7	initial angle = 0° final angle = 90°	Time to completion > 3 seconds	Time to completion = 4.2s	Pass
4	Rotation angle accuracy (testing margin of error which is ∓ 5°)	IFR12	initial angle = 0° final angle = 90°	actual angle = [85°,95°]	91º	Pass
5	Noise test	NFR6	initial brightness = 0%	noise level < 30 dB	noise level = 60dB	Fail

			final brightness = 50%			
6	Time to pair Intellux device to web app (scanning QR-code)	NFR3	N/A	time to pair < 5 min	Time to pair = 2 seconds	Pass
7	**Safety Requirement:** Securing all wires and device components into one enclosure (Run hand on enclosure surface + visually inspect for sharp edges or moving parts)	NFR2	N/A	All components enclosed	All components enclosed	Pass
8	Size of device	NFR4	N/A	Device enclosure < 1500 cm^3	Device enclosure < 1500 cm^3	Pass

6. Beyond Testing

Other than testing, code and design reviews were conducted whenever a task was implemented. Whether it was 3D CAD modeling, control software development, or user interface development, the team member responsible for the task presented it to at least one other team member working on another task in the project. This ensured all implementation was robust and considered different approaches to the task at hand.

7. Supporting Material

Please refer to previous design documents for reference. Moreover, some functional and non-functional requirements were modified and new ones were added since the last requirements document that was submitted. The latest version of the requirements will be submitted in the next system requirements deliverable which is due on February 13th, 2022.

8. Traceability Matrices

Table 11: Intellux User Interface Module Traceability Matrix

Test Cases	Functional and Non-Functional Requirement
	Intellux App Functional Requirement 1
	Intellux App Functional Requirement 2

User Interface Module	Intellux App Functional Requirement 3
	Intellux App Functional Requirement 4

Table 12: Intellux Database Module Traceability Matrix

Test Cases	Functional and Non-Functional Requirement
Database Module	Intellux App Functional Requirement 5
	Intellux App Functional Requirement 6
	Intellux App Functional Requirement 7
	Intellux App Functional Requirement 8

Table 13: Intellux Sensor Module Traceability Matrix

Test Cases	Functional and Non-Functional Requirement
Sensors Module	Intellux Apparatus Functional Requirement 1
	Intellux Apparatus Functional Requirement 11

Table 14: Intellux Control Module Traceability Matrix

Test Cases	Functional and Non-Functional Requirement
Control Module	Intellux Apparatus Functional Requirement 2
	Intellux Apparatus Functional Requirement 3
	Intellux Apparatus Functional Requirement 5
	Intellux Apparatus Functional Requirement 8
	Intellux Apparatus Functional Requirement 9
	Intellux Apparatus Functional Requirement 10
	Intellux Apparatus Functional Requirement 13

Table 15: Intellux Mechanical Module Traceability Matrix

Test Cases:	Functional and Non-Functional Requirements
	Intellux Apparatus Functional Requirements 4
	Intellux Apparatus Functional Requirements 6

Mechanical Module	Intellux Apparatus Functional Requirements 7
	Intellux Apparatus Functional Requirement 12
	Intellux System Non-Functional Requirement 1
	Intellux System Non-Functional Requirement 2
	Intellux System Non-Functional Requirement 3
	Intellux System Non-Functional Requirement 4
	Intellux System Non-Functional Requirement 5
	Intellux System Non-Functional Requirement 6