System Requirements

Mechtron 4TB6 • Prof. Alan Wassyng

Group 34

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1. Table Of Revisions

Version	Date	Authors	Description Of Revision
0	21/10/2021	Abdulrahman Elgendy Ahmed Afifi Mina Ghaly Omar Mouftah	Initial revision of the system requirements document

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 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. Currently in the market, all automated blinds must be purchased as a full set. Moreover, any accessory that tries to automate traditional blinds lacks many features when it comes to customization and truly smart features. Being able to automate a user's pre-owned traditional blinds will save users money and supply them with many automation features that provide convenience on a daily basis.

Users will interact with Intellux through a user interface that is wirelessly connected to an apparatus. The apparatus will be able to automatically adjust the blinds to reach the desired inputs of the user in the user interface. Users will also be able to adjust the blinds manually through the application. More details will be provided throughout the rest of this document.

3. Scope

The scope of the project is to design a system that will take multiple factors into consideration, and based on the programmed algorithms, it will be able to make decisions that reflect the user's desires. These factors include but are not limited to user inputs and preferences, multiple variables measured by the lux sensors, and other variables related to the apparatus such as blind angle. The system will offer multiple modes and features that the user will be able to choose from to satisfy their needs.

In-Scope items include the following:

- Awareness of indoor and outdoor lux levels
- Aware of current blind angle
- Two-way communication between the application and the apparatus
- Ability to move the blinds to satisfy user input

- Ability to notify the user if desired brightness is not achievable

Out of scope functionality include:

- Any failures specific to the user's smart device
- Any failures resulting from lack of power supply

4. Context Diagram
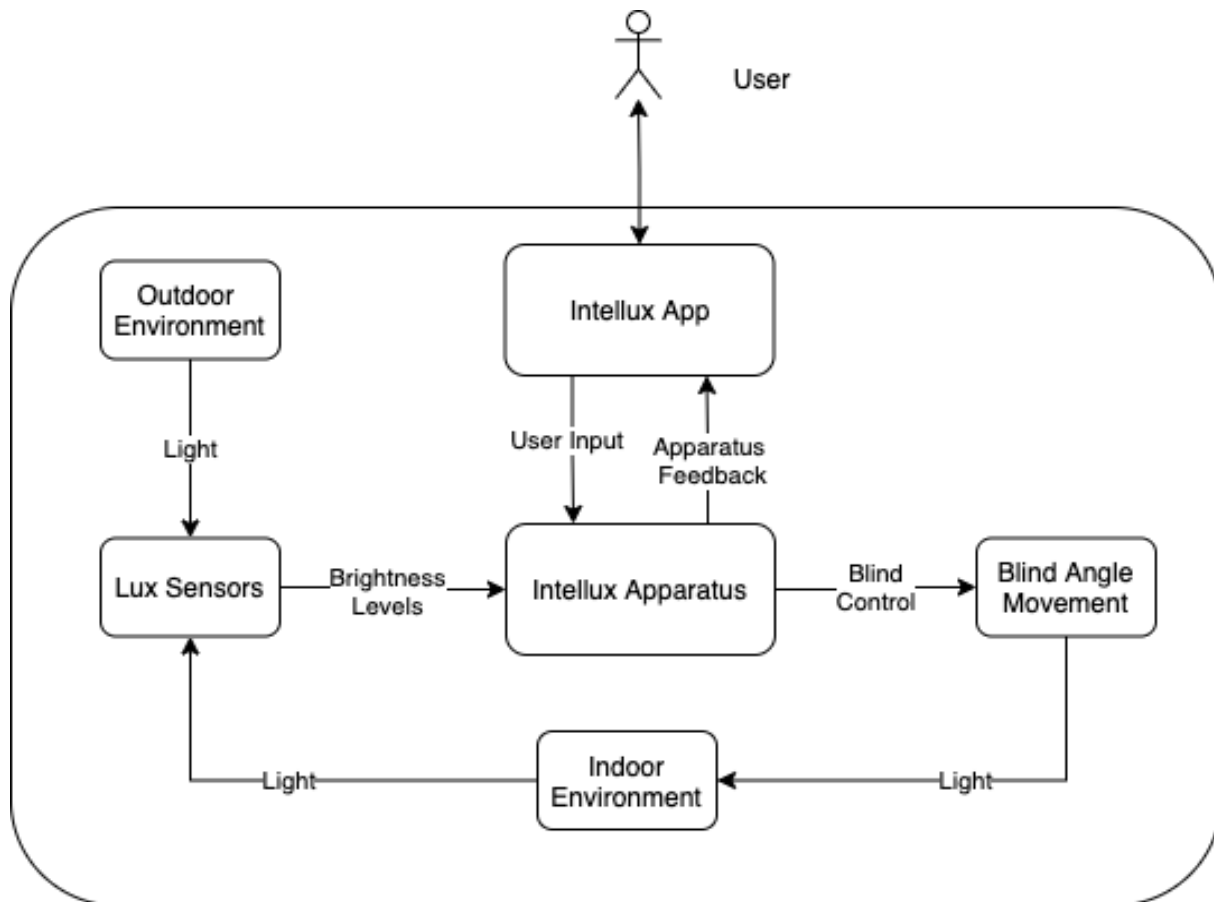

Figure 1: Intellux Context Diagram

5. Behavior Overview

Typically, the user would open their Intellux application and connect to the Intellux apparatus they wish to operate. Once the devices are paired, the user is now free to select the mode of operation, the two available options are Auto mode and Manual mode. In Auto Mode, the user would simply select the level of brightness they wish to have in their room and Intellux would handle the rest. By measuring the brightness of the room and the external brightness, Intellux would be able to determine if the desired level is possible. Once it determines that it is possible, the blinds will automatically be rotated to match the actual measured indoor brightness with the user's desired selection. The blinds should also automatically maintain this level of brightness throughout the day until it is no longer possible to do so. At night, Intellux would switch to Manual mode. If the user selects to operate the device in Manual mode, the application will only require an angle input from the user and the blinds will be rotated to match the user's selection.

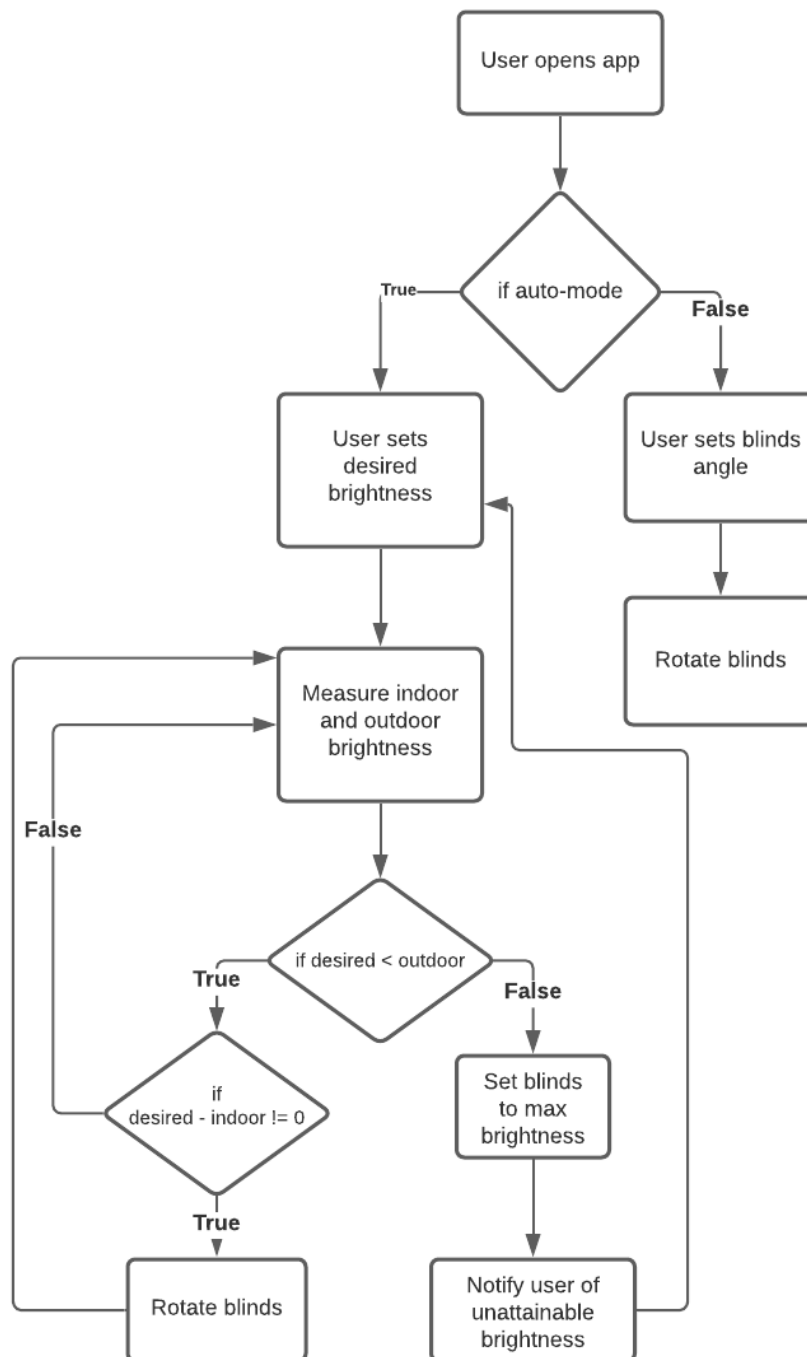# 6. Required Behaviour Description

Figure 2: State Machine Diagram

There are two modes of operation for Intellux: Auto mode and Manual mode. These describe the different functionalities of Intellux where in Auto mode, Intellux is required to automatically adjust the angle of the blinds to match the user's brightness preferences. In Manual mode, the user would open and close the blinds to the angle they desire. The following is a table describing the behavioral diagram above.

Table 1: Behaviour block diagram description

Step	Behaviour	Mode	Description
1	User opens app	N/A	The user will open the app to see the blinds paired with the device to begin interacting with Intellux. Proceed to Step 2.
2	If auto-mode	N/A	The system will check if the user has selected to operate in Auto or Manual mode. If Auto mode, proceed to Step 3. Otherwise, go to Step 10.
3	User sets desired brightness	Auto	In Auto Mode, the user will set the brightness they wish to have in the room. Proceed to Step 4.
4	Measure indoor and outdoor brightness	Auto	Intellux must measure the current brightness of the room as well as the external brightness to know the maximum currently attainable brightness level. Proceed to Step 5.
5	If desired < outdoor	Auto	If the user has set a brightness level higher than is currently attainable, go to Step 8. Otherwise, proceed to Step 6.
6	If desired - indoor != 0	Auto	If the indoor brightness is still not matching the user's desired brightness, proceed to Step 7.
7	Rotate blinds	Auto	Rotate the blinds to match the desired brightness. Proceed to Step 4 to automatically repeat the process.
8	Set blinds to max brightness	Auto	Set the blinds to the currently maximum attainable brightness. Proceed to Step 9.
9	Notify user	Auto	Notify the user that the desired brightness is currently unattainable and that the blinds were set to the current maximum attainable brightness. Proceed to Step 4.
10	User sets blinds angle	Manual	In Manual mode, the user will set the blinds to the angle they desire. Proceed to Step 11.
11	Rotate blinds	Manual	Rotate the blinds to match the given angle in Step 10.

7. Variables and Constants

7.1. Monitored Variables

Table 2: Intellux monitored variables

Variable	Unit	Description
m_brightnessIn	lux	Measurement of brightness inside the living space
m_brightnessExt	lux	Measurement of brightness outside the living space
m_desiredBrightness	lux	The desired lux value
m_blindsAngle	degrees	The current angle at which the blinds are placed
m_isAutoMode	Boolean	Check if the system is running in Auto mode
m_desiredBlindsAngle	degrees	The desired angle the blinds should be placed at - **Manual Mode Only**

7.2. Controlled Variables

Table 3: Intellux controlled variables

Variable	Unit	Description
c_blindsAngle	degrees	The angle at which the system can place the blinds

7.3. Constants

Table 4: Intellux constants

Variable	Unit	Description
k_motorSpeed	degrees/sec	The speed at which motor will rotate the blinds
k_maxAngle	degrees	Maximum Angle the blinds will reach
k_minAngle	degrees	Minimum Angle the blinds will reach

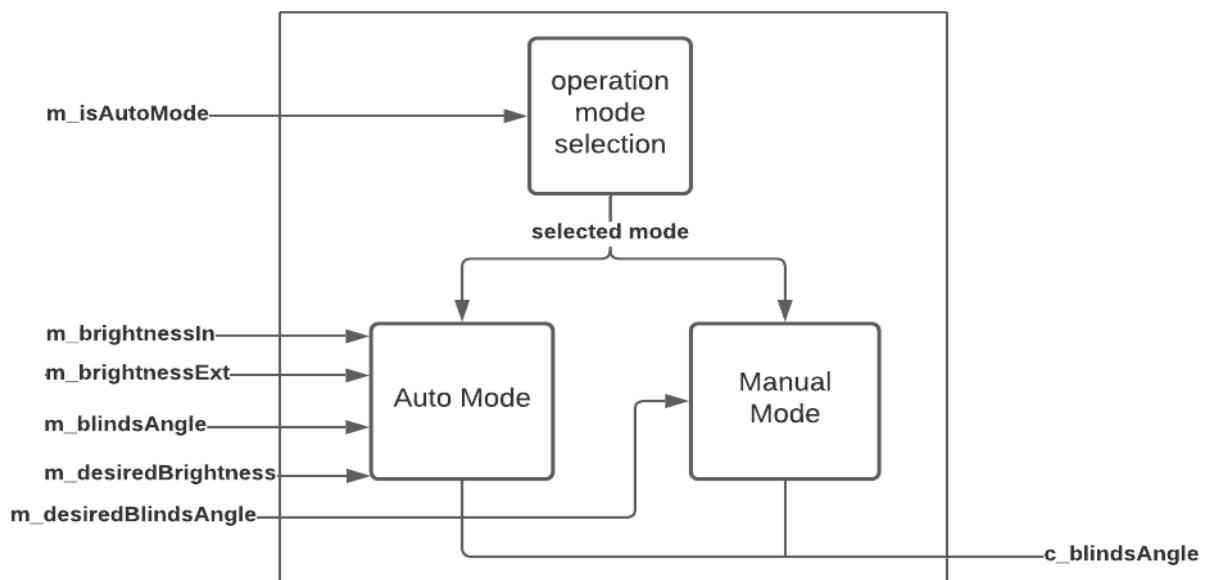# 8. Functional Decomposition Diagram

8.1. System-level FDD
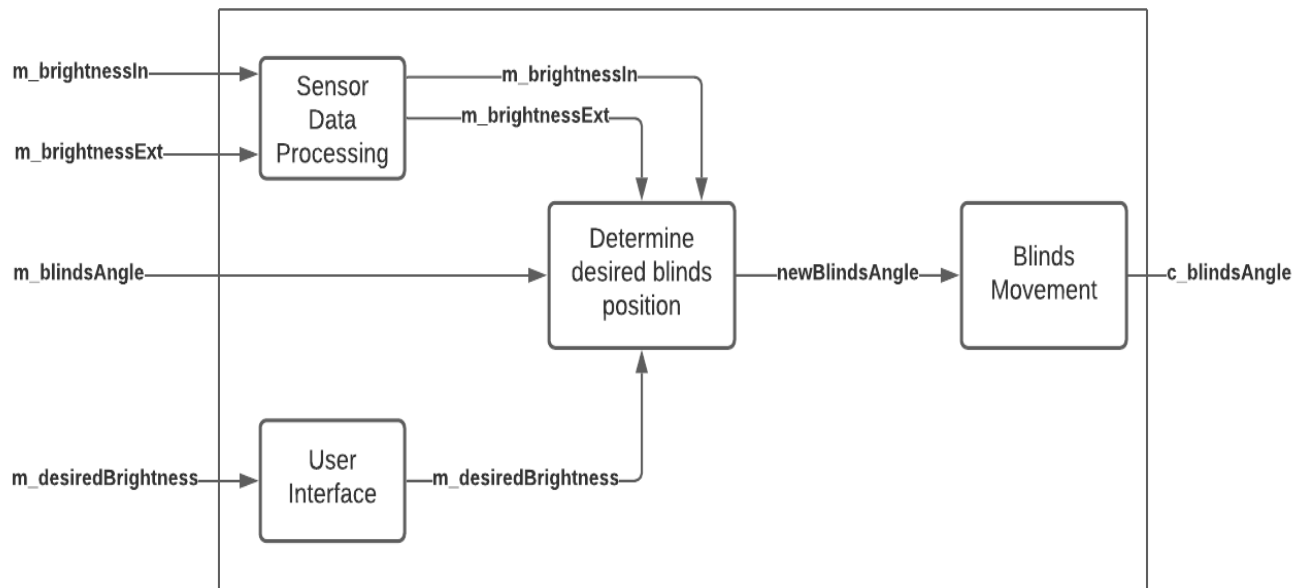

Figure 3: System-Level FDD

8.2. Auto-Mode FDD
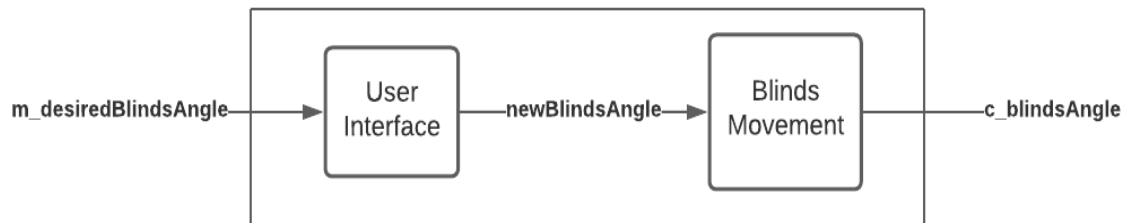

Figure 4: Auto-Mode FDD

8.3. Manual-Mode FDD

Figure 5: Manual-Mode FDD

9. Functional Requirements

9.1. Intellux App Functional Requirements

Table 5: Application functional requirements and rationale

AFR1	The Intellux app must allow the user to input the desired brightness level during the day
Rationale	Intellux should automatically rotate the blinds to match the user's brightness selection throughout the day without any further interaction.
AFR2	The Intellux app should be able to communicate with the Intellux apparatus within a 5m range
Rationale	Wireless operation via the application within a reasonable range is expected.
AFR3	The Intellux app should be able to notify the user when the external brightness level is below the desired brightness level
Rationale	The user should be informed if the desired brightness is no longer possible.
AFR4	The Intellux app should prevent the user from accessing Auto-mode during night time
Rationale	Intellux auto-mode would not be able to operate at night and must prevent the user from a redundant setting.

9.2. Intellux Apparatus Functional Requirements

Table 6: Intellux apparatus functional requirements and rationale

IFR1	The Intellux apparatus should be able to measure the brightness levels internally and externally
Rationale	This information will be used to set the indoor brightness given the external and internal measurements.
IFR2	The Intellux apparatus should be able to determine when the brightness level in the room is not at the desired brightness level
Rationale	This is to automatically rotate the blinds to adjust for the mismatch in brightness levels.
IFR3	The Intellux apparatus must be able to adjust the blinds angle to reach the (desired brightness levels $\mp 5\%$) in the room

Rationale	A margin of error should be allowed as it'll be difficult to reach an exact desired brightness level and to prevent frequent/infrequent rotation.
IFR4	When a new desired brightness level is received from the Intellux App, the Intellux apparatus must be able to reach the desired brightness level within 6 seconds
Rationale	This is to prevent Intellux from taking too much time to adjust the brightness in the room and to ensure a smooth operating speed.
IFR5	The Intellux apparatus must keep the internal brightness within the range until a new desired brightness level is received
Rationale	This is to prevent Intellux from lagging the brightness differential outside the 5% margin.
IFR6	Intellux should be able to rotate the blinds with a range of motion of 0° (fully closed) to 90° (fully open)
Rationale	A full range of motion is necessary for a complete application of the system in both ON and OFF states.
IFR7	Intellux must be able to adjust the blinds angle with a maximum angular speed of 30 degrees/second
Rationale	This is to prevent excessive speeds from being reached, as they may damage the blinds
IFR8	The Intellux apparatus should communicate with the Intellux app when the external brightness level is below the received desired brightness level
Rationale	By communicating with the app, the user can be notified of the apparatus' state.
IFR9	The Intellux apparatus must turn to manual operation when its night time outside
Rationale	The manual operation would allow the user to override the automated rotation and set a desired angle for the blinds.
IFR10	The Intellux apparatus should be aware of its current position and the maximum rotation available
Rationale	This is to avoid over-rotation for the minimum and maximum edge cases.

10. Non-functional Requirements

Table 7: Intellux system non-functional requirements

NFR1	Intellux should be able to attach to existing bead-chain blinds
Rationale	Intellux should need as little alterations to the existing blinds as possible to attach.
NFR2	There should be no exposed wiring from Intellux's casing
Rationale	This is to avoid any electrical safety issues.
NFR3	Pairing the application to the apparatus should be a simple process
Rationale	A quick and simple pairing process with few steps is needed to avoid user frustration.
NFR4	The casing should not be too bulky
Rationale	This is to avoid excess protrusion causing an eyesore.
NFR5	Intellux should be visually appealing
Rationale	The installation will be near a window so Intellux should not stand out for being an ugly apparatus.
NFR6	Intellux should operate quietly
Rationale	The operation of the actuator should not be unpleasantly loud.

11. Normal Operation

11.1. Description

When operating under normal conditions, Intellux constantly measures the brightness inside the living space and compares it to the desired brightness inputted by the user. The goal is to always keep the m_brightnessIn variable equal to the m_desiredBrightness variable with a 5% tolerance. Intellux also measures the brightness outside the living space to inform itself on how much it should turn the blinds in order to match the desired brightness with the indoor brightness.

11.2. Normal Use Cases

11.2.1. Auto Mode

During the daytime, Intellux constantly measures the brightness inside the room and compares it to the desired brightness fetched from the application. If the two values do not match then Intellux will adjust the blind angles and repeat the process until the two values (m_brightnessIn & m_desiredBrightness) match within a certain tolerance.

- Cloudy Day:
    - Intellux should compare the desired brightness level inputted by the user to the level of brightness outside the living space. If the level of brightness outside the living space is lower than the one desired by the user, then Intellux opens the blinds at full brightness and notifies the user that the inputted level of brightness cannot be achieved.

11.2.2. Manual Mode

Intellux could be turned into manual mode through the Intellux phone application. In manual mode, Intellux stops measuring brightnesses and simply opens the blinds to the angle inputted by the user on the app.

- Night Time:
    - Intellux should be able to detect when the sun is down based on the local time of day and stop measuring the outside/inside brightnesses. It will then turn into manual mode where the user can select if the blinds should be open or closed. As a default case, once nighttime is detected, Intellux will keep the blinds fully open unless instructed otherwise by the user.

12. Undesired Event Handling

12.1. Application failure to send preferences

If the Intellux app fails to send the user preferences to the Intellux device, it would prompt the user to re-pair the device and allow the user to control the blinds by hand.

12.2. Intellux apparatus not responding

If the Intellux device is not responding to the signals sent by the application, then the app will inform the user to make sure the device is paired and that the user is within the Bluetooth range. Intellux will let the user control the blinds by hand until the issue is resolved.

12.3. Unable to find/pair application to the device

If the Intellux app fails to detect the device via Bluetooth, the user can instead scan the QR code on the side of the device to automatically pair the apparatus to the application.

12.4. Beads slip out of the actuator

If Intellux is not able to detect the beads passing through the stepper motor then the application automatically notifies the user to reinstall the beads by hand.

13. Requirements Likelihood to Change

13.1. Intellux App Functional Requirements

Table 8: Application functional requirements likelihood to change

Requirement	Likely/Unlikely to Change	Rationale
AFR1	Unlikely	It's a core component of the project.
AFR2	Likely	Depending on the range of the wireless communication system chosen.
AFR3	Unlikely	It's a core component of the project.
AFR4	Unlikely	Auto mode will not be operational at night time.

13.2. Intellux Apparatus Functional Requirements

Table 9: Intellux Apparatus functional requirements likelihood to change

Requirement	Likely/Unlikely to Change	Rationale
IFR1	Unlikely	It's a core component of the project.
IFR2	Unlikely	It's a core component of the project.
IFR3	Likely	Tolerance might change based on further research but the functionality will not.
IFR4	Likely	Tolerance and time constraints might change based on further research but the functionality will not.
IFR5	Unlikely	It's a core component of the project.
IFR6	Unlikely	It's a core component of the project.
IFR7	Likely	Angular speed constraints might change based on further research.
IFR8	Unlikely	It's needed to notify the user (AFR3).
IFR9	Unlikely	It's a core component of the project.
IFR10	Unlikely	It's a core component of the project.

13.3. Non-functional Requirements

Table 10: Intellux non-functional requirements likelihood to change

Requirement	Likely/Unlikely to Change	Rationale
NFR1	Unlikely	It's a core component of the project.
NFR2	Unlikely	Due to the safety of the user.
NFR3	Likely	Requires further research.
NFR4	Likely	Requires further research.
NFR5	Likely	Requires further research.
NFR6	Likely	Requires further research.