F-air

Dr. Andrew Rawicz

School of Engineering Science

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Burnaby, British Columbia

V5A1S6

Re: ENSC 405W Project requirements for the F-air Mira

Dear Dr. Rawicz,

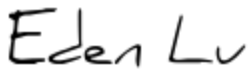
This document, “Project requirements for the F-air Mira” was prepared as a design requirements and specifications for our company product. This requirements is written for documenting the important design specifications on hardware, software, safety and sustainability for F-air Mira project. The purpose of this project is to build a smart mirror for allowing the user to try on online clothes or items through this mirror, which can give them a brand new online shopping experience.

In the attached requirements, the hardware and software specifications will be fully discussed. The safety and sustainability requirement needs to be specified for protecting user security and ecosystem friendly. At each stage of project, we will base on this documents to develop our product.

The team of F-air is comprised of three students with Computer and Electronics Engineering backgrounds. Our team members are Ninghui (Nick) Yu, Eden Lu and Xinwei (Alex) Zhang.

If you have any questions and concerns, please contact us at xinweiz@sfu.ca.

Sincerely,



Eden

F-air

Project Requirements
Virtual fitting mirror- Mira

PROJECT TEAM

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1. Introduction

1.1 Background

Online shopping has become an essential part of a plenty number of clothing brands and is taking a greater percentage of total retail. In 2018, online revenue of apparels and accessories in the US has reach 86.4 billion USD (Patricio Rivero; Zihan Zhu, 2018). Online shopping is convenient and has continually increase market.

However, unlike to ordinary shopping experience, online shopping lacking the procedure of "trying the product". This sometimes leads to dissatisfaction and returning of the product. According to research by University of California, Berkeley, 20-30% of the items ordered online will be returned, where 70% of the total returned apparels and accessories are related to the fitting issue. This problem causes additional transportation waste (for mailing back the product to retailer).

To solve the issue, F-air introduces its new product Mira. Mira is a tiny portable device that performs same functionality as a Mira but allows user to try online cloth on their own body. It is small, which makes it easy for installation and has relatively cheaper production cost comparing to other similar devices in the market. With these properties, F-air believes it can be more accessible to general population.

1.2 Scope and Functionality

The device constantly takes in input from the camera. Mira will analysis the image inputs and recognize user's body in the image. At the beginning of the process, the user will need to stand 1 meter away to let the processor analyzes user's body in a few seconds. After this step is done, user can move freely and choose the cloth they want to try-on. The cloth will appear on user's body and move according to user's movement. The output, which is the original image combining the cloth, will project from the projector light bulb onto the wall.

The rest of document will state detailed requirements of these features.

1.3 Requirement Classifications

For the easiness on prioritize the requirements, the following convention will be used through this document:

[REQ <Domain>-<Req#><Priority>-<Development Stage>]

Domain of requirement	Code
General	GE
Hardware	HW
Mechanical	ME
Safety/Sustainability	SS
Software	SW

Table 1. Requirement domain encoding

Prioity	Code
High	H
Medium	M
Low	L

Table 2. Requirement priority encoding

Development Stage	Code
Proof of Concept	POC

Prototype	POT
Production ready	POD

Table 3. Requirement development stage encoding

Example:

[REQ SW-19H-POC] The time used for body recognoization must have delay <= 0.1s

2. Hardware Overview

2.1 Hardware Design

Mira is a small square box. It is designed to be portable and easy for attaching to the wall. The front face of the Mira has a camera lens that captures user's body images. The input taken from the camera will be processed by a tiny computer along with powerful GPU, which recognizes human bodies and put on the cloth to right position. Then generate output by combining the original image with the cloth. The bottom of the box has a projector light bulb, which projects the output on the wall.

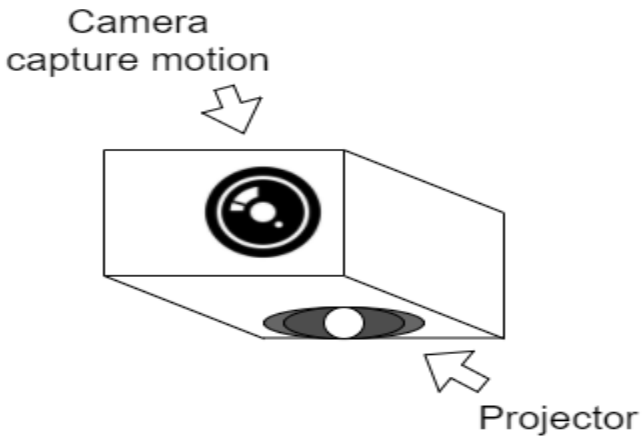

Figure 1. Hardware outlook

2.2 Hardware Requirements

The prototype hardware parts design block diagrams will be like the figure shown below. For the power supply, we will use two kinds of power adaptor. One is 110VAC for power up the projector, and another 5VDC power adaptor will be used to give power to raspberry pi. The camera will take the power from raspberry pi to capturing the video. If we have extra time for the project, we would combine two different power supply together. Also the raspberry pi is just used for prototype, the real product will be use low cost and high integrated chip as microcontroller. The camera and projector will be integrated in the same box, then the whole system will look like one complete unit.

2.3 Power management:

[REQ HW-9H-POC] The power go to projector should be 110VAC
[REQ HW-10H-POC] The power go to raspberry pi should be 5VDC

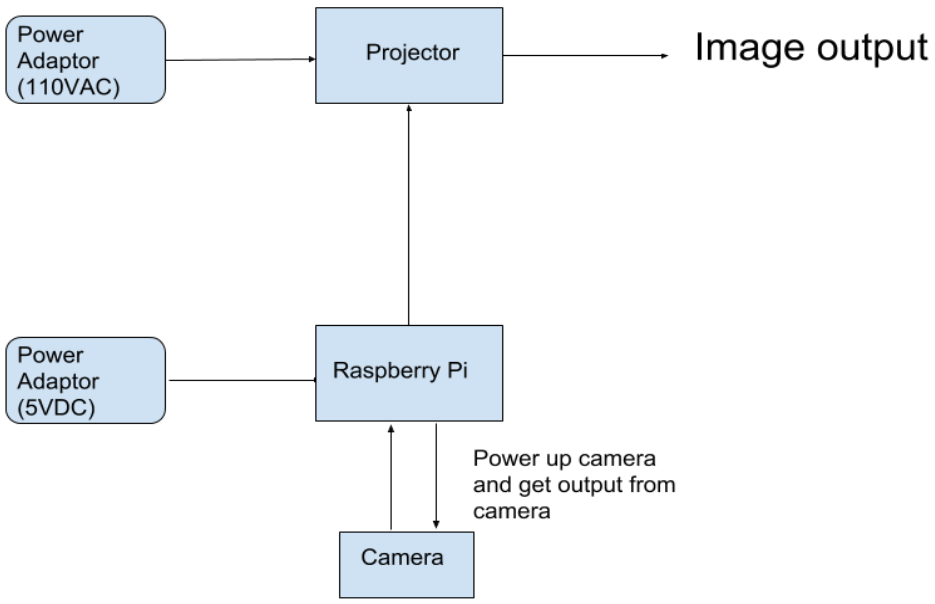

Figure 2. Power Management

2.4 Electronics requirements

2.4.1 Camera:

[REQ HW-1H-POC] Frame rate use 30fps standard
[REQ HW-2M-POC] 1080p for video recording
[REQ HW-3M-POC] The focus of lens will be fixed

[REQ HW-1H-POC]:

24fps is usually the standard for movie and TV shows, which creates a very cinematic look. 30fps is standard for television like sports, which need extra frames per second to capture more information. 60fps is used for video game and slow-motion videos.

Our project use 30fps to capture the body motion, because we need more detail motion information to recognize human body parts. However, 60fps has more frames than 30fps, which means the microcontroller needs process more image on recognition and 3D modelling. This may cause system delay and images will start to unnatural.

[REQ HW-2M-POC]:

1080P for 30fps frame rate is standard resolution for video camera.

[REQ HW-3M-POC]:

we will choose fixed focus lens, because it is cheaper and usually used on capturing image of human or object larger than one meter. From our design, the user need to stand in front of camera. There is a distance between camera and user.

2.4.2 Projector:

[REQ HW-4M-POC] At least 3000 lumens brightness for ambient light
[REQ HW-5M-POC] Screen size of output is approximate 2×2 meters

[REQ HW-4M-POC]:

For our design, the projector need to handle some stronger ambient light because the users are able to use it all day and night. Also, the camera needs some light to capture user's body, so Mira cannot be used in the dark environment all the time. The lumens of projector should be higher enough for image display. LED projectors has a lifespan of 20,000 hours. it deliveries the better color and low power consumption, low heat generates, which is power efficient for our design.

[REQ HW-5M-POC]:

The screen size is based on where the projector is mounted.
The longer the projector from the wall, the bigger the screen we can get. 2×2 meters screen size can fit for any human body. The actual size will be adjusted during the testing.

2.5 Mechanical requirements

[REQ HW-6M-POC] Projector should be mounted tightly on the wall to make sure the projector will not be destroyed by dropping off from the wall
[REQ HW-7M-POC] Camera needs to be mounted on a stable place, and make sure the camera would not have vibrations
[REQ HW-8M-POC]The angle between projector and camera is approximately 45 degrees
[REQ HW-9M-POC] Easy installation and operation for users

For the prototype, we might not design a projector to be mounted on the wall, we will use traditional projector, which need to put some distance away from the way. Also, we need to avoid camera vibrations during the using because the vibrations will affect the performance of taking video from camera. The angle and position of projector and camera needs to be confirmed during the testing. We need to make sure the projector and camera will display a natural and accurate human body image.

2.6 General Requirements

[REQ GE-1M-POC] Image processed video stream should have low latency
[REQ GE-2H-POC] User's image should have no distortion about their body size and height

[REQ GE-3M-POC] The video stream should be fluent and make user look at the 3D image feel comfortable
[REQ GE-4M-POC] The application should fit for different age groups

For the prototype, the big concern for us is system delay. Since the microcontroller needs to process video image through different recognition and algorithm, we need to use efficient algorithm and high frequency CPU to process it. Also, the body image should be no distortion on it, and we need let users can actually see themselves as in a real mirror. This will be an ideal case for our design.

3. Software overview

When the process begins, the user first need to stand 1 meter away to let the processor analyze user's body and generate a 3D body model in a few seconds. This model will be used to put on the 3D cloth and has physical interactions with the cloth. After this is done, the user can move freely. User's movement will be captured and used for controlling the body model, the cloth model will then follow body's movement and change the angle and position. The result of the cloth will then project to the wall from the projector.

Users are allowed to change different cloth through a mobile APP, the cloth models will be provided by the retailers.

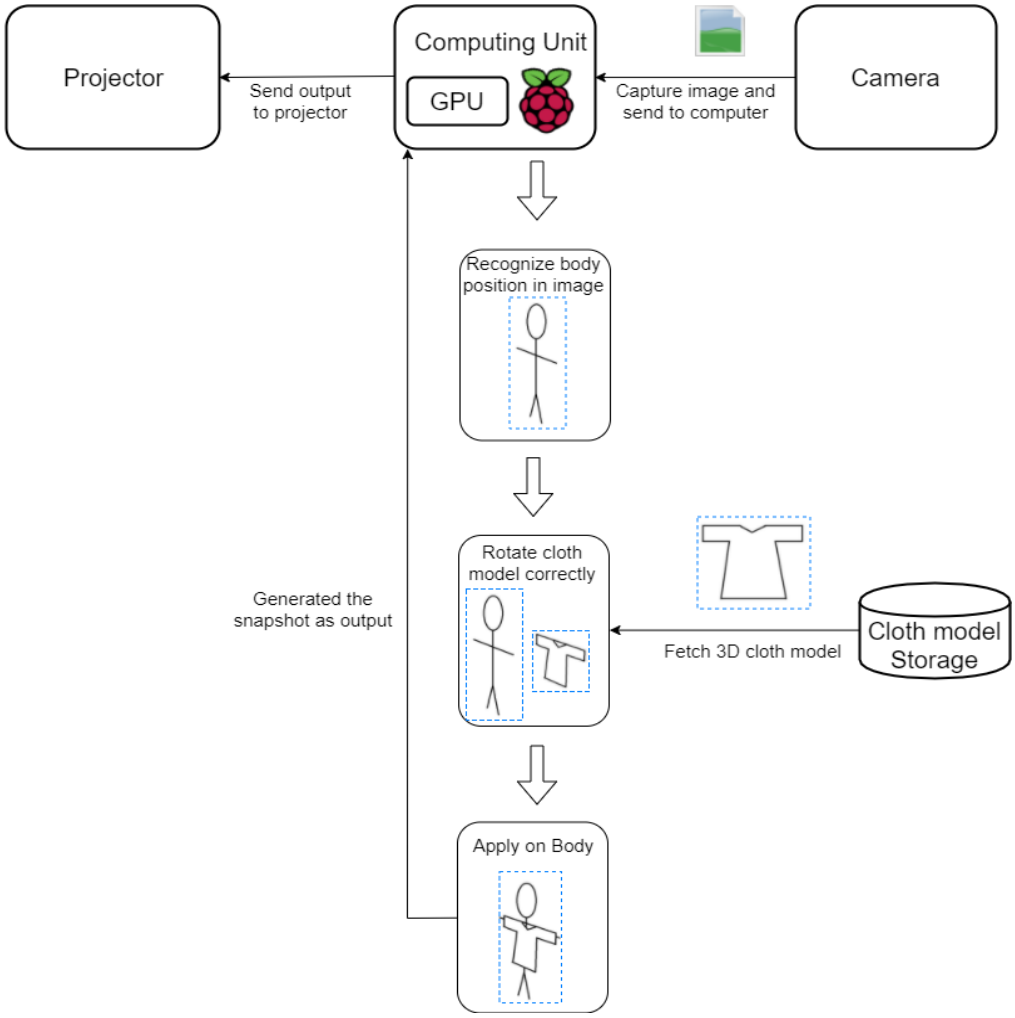

Figure 3. High level view of data flow inside Mira

The software is composed of 3 main tasks:

1. Body model formation
2. Cloth interactions
3. Body model controlling through camera

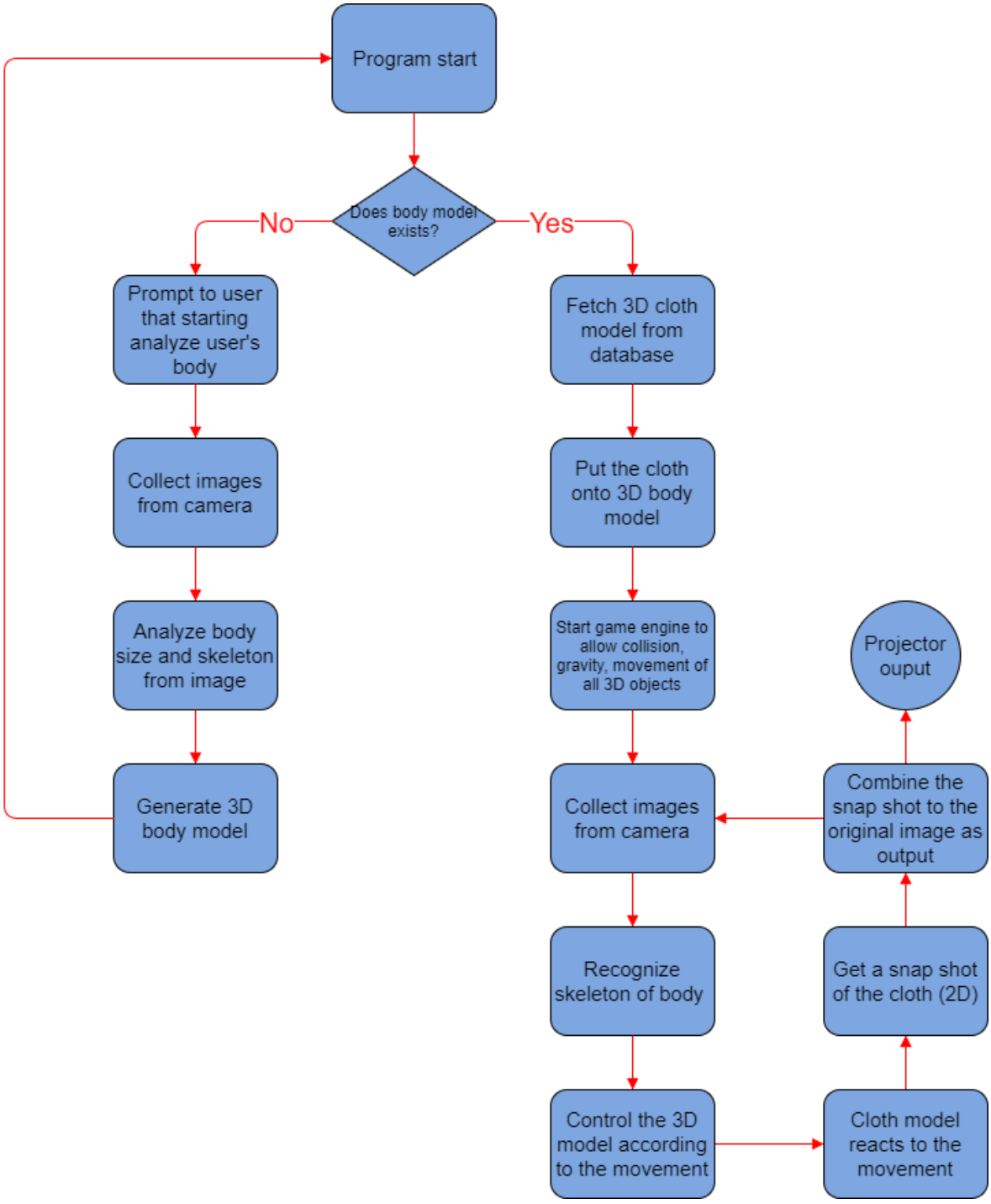

Figure 4. Software flow chart

3.1 Body model formation

In this stage, the software analyze the size of full body including the head and all fours. It requires to use a fed machine learning model to recognize the arms and legs in the image, and then apply edge detection (by analyzing the changes in image brightness) to obtain the shape and calculate the thickness. These information will be used to generated a 3D model. Since the accuracy of this stage will determine the quality of the fitting result, following requirements will act as the guideline for development.

[REQ SW-1H-POC] Application has machine learning feature to recognize skeleton of arms, legs, and body
[REQ SW-2H-POD] Application has machine learning feature to recognize face and eyes
[REQ SW-3H-POC] Application calculates distance between Mira and user
[REQ SW-4M-POC] Virtual cloth tights to user's body of accuracy within 2 cm

3.2 Cloth interaction

In this stage, the body model is already generated. The cloth model, which is provided by the retailer, is put onto the body model and registered with physics event handlers (will react to gravity and body movement).

[REQ SW-5H-POC] Virtual cloth moves and reacts according user's movement
[REQ SW-6M-POC] Virtual cloth reacts to gravity
[REQ SW-7L-POC] The 3D cloth model will store in a server and can be download to different Mira device
[REQ SW-8L-POC] Retailers should be able to upload their 3D model cloth to the server

3.3 Body model controlling through camera

In this stage, camera's input is constantly fed into the software. From the image, the skeletons of the body are detected (or approximated). Comparing the current skeleton of the image to the 3D body model skeleton. We calculate the positional difference between 2 skeletons and move the body model to the position. Since the cloth model already registered to the body model, it will react to the movement and produce realistic virtual fitting experience. This stage requires huge amount of computation, which may produce noticeable delay to user. Its development is gonna follow below requirements.

[REQ SW-9H-POC] Body skeleton recognization should be handled within 0.2 seconds
[REQ SW-10H-POC] The input is analyze in 10 FPS
[REQ SW-11H-POC] Cloth should reacts to the body movement within 0.1 s
[REQ SW-12H-POC] Total Delay between action and output should be <= 0.5 s

3.4 Software Control

The user should also able to switch cloth. Our current design is to use mobile app for switching cloth. The app should be first registered to the Mira device (through its unique QR code). The app also provides options to adjust project's setting.

[REQ SW-13H-POC] Users should be able to switch cloth through the mobile app
[REQ SW-14L-POC] Users should be able to switch lightness, resolution, and other setting through the mobile app
[REQ SW-15L-POC] Retailers should be able to upload their 3D model cloth to the server

4. Engineering Standards

4.1 OVERVIEW

The system of Mira includes technology with electronics and optics. Also, ergonomic standards are extremely important. For further development, we will introduce wireless functions for control Mira and share the image. Standard of wireless communication will also be considered

Since Mira is designed to be placed at home and in-store, there will be standards about materials safety and health that need to be considered during the design process.

4.2 Electronic Standards

The four fundamental parts of Mira include a camera, a project, a data storage and a processor. Each part involves consideration of electronic safety regulations. Also since Mira is related to audio and video processing, special requirement about safety will also be an important part. To project a reliable image with the quality that satisfies the purpose of design, Mira will have a relatively higher power consumption. 110V voltage supply will be used as the power source.

UL 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 1: General Requirements [1]
IEC 60065:2014	Audio, video and similar electronic apparatus — safety requirements [2]
IEEE Std 1	IEEE Recommended Practice - General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation [3]
IEEE Std 4	IEEE Standard for High-Voltage Testing Techniques [4]

4.3 Optics Standards

To decrease the heat generated during application and save energy, we will use the LED projector to produce the image. The standard for the design of devices with LED is listed below:

IEC 62471	LED Lighting Products [5]

IEEE Std 1789	IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers [6]

4.4 Wireless Standards

Two IEEE standards for devices that are using general and low-rate wireless network are list below:

IEEE Std 802.11	IEEE Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications[7]
IEEE Std 802.15.4	IEEE Standard for Low-Rate Wireless Networks[8]

4.5 Ergonomic Standards

Mira is a home servicing device. And for the fitting purpose, Mira need to measure the body shape of the users. ISO provides detailed standards which we will rely on during the design process.

ISO 6385	Ergonomics principles in the design of work systems[9]
ISO 7250-1	Basic human body measurements for technological design -- Part 1: Body measurement definitions and landmarks [10]
ISO 7250-3	Basic human body measurements for technological design -- Part 3: Worldwide and regional design ranges for use in product standards[11]
ISO 9241-303	Ergonomics of human-system interaction -- Part 303: Requirements for electronic visual displays [12]

4.6 Material Standards

Since Mira will generate heat during application, the material of the cover of Mira should be heatproof, and should not generate any toxic gas with the temperature rising.

ASTM F2931 - 17	Standard Guide for Analytical Testing of Substances of Very High Concern in Materials and Products [13]

5. Sustainability and Safety

As an electrical device designed to be used at home and in stores, Mira is aiming at providing an excellent shopping experience with guaranteed sustainability and safety.

5.1 Sustainability

During the “cradle to cradle” sustainability cycle, Mira goes through the following processes:

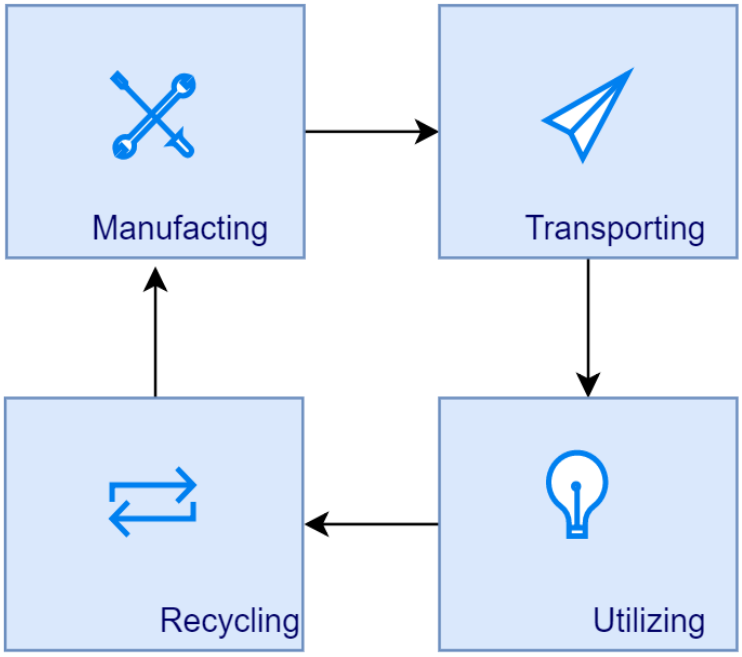

Figure 5. Sustainability Cycle

During each part of the four procedure, we will ensure that there is no toxic gas generated.

For manufacting, the usage of unrecyclable material will be minimized. The projector is designed to use LED, because it has less power consumption and a longer lifetime. It is also more robust and eco-friendly. Although we need to ensure the luminance is no higher than 10,000 cd/m², which will cause visual discomfort for indoor lighting. The shield of Mira will be made using aluminum alloy since it is light and heatproof.

For transporting, Mira will be packed in recyclable carton box stuffed with cushion inserts made of paper and corn instead of traditional plastic inserts.

For Utilizing, we will optimize the circuit of Mira to reduce the heat generated while application, therefore decrease the power consumption.

For recycling, we designed that we could cooperate with IT service brands (for example, geek square) to recycle unwanted or broken devices and use the remained electronic pieces for constructing or repairing Mira.

5.2 Safety

Mira is designed to capture the body shapes of users and project it on a surface. So usually users only contact Mira when they push the button to switch Mira on and off. We have the following requirement for safety:

[REQ SS-1H-POD] No toxic gas shall be generated during the entire lifecycle
[REQ SS-2H-POD] The entire device must be shielded to ensure no hazard of electric shock
[REQ SS-3L-POD] The edge of the shield will be round
[REQ SS-4M-POD] Alarm the user once the device temperature reaches 70°C
[REQ SS-5H-POD] Automatically shut-down once the device temperature reaches 80°C

6. Conclusion

In this document, requirements and specifications are discussed to get a clear cut idea about Mira. Real world problem is defined, and the solution we proposed is explained. A list of engineering standards is given, followed by each requirement explained in detail. In order to acquire the proposed quality of Mira, the requirement engineer may experience a number of stages. These stages include mechanical design, circuit heating, performance improvement, and safety with sustainability qualification. Software requirements is also identified

These requirements will ensure Mira to act as smoothly as a normal mirror we used daily, with extended functionality of virtual fitting.

References

[1] Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use
https://standardscatalog.ul.com/standards/en/standard_61010-1_3
[2] Audio, video and similar electronic apparatus - Safety requirements
https://webstore.iec.ch/publication/494
[3] IEEE Std 1-2000 - IEEE Recommended Practice - General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation
http://standards.ieee.org/findstds/standard/1-2000.html
[4] IEEE Std 4-2013 (Revision of IEEE Std 4-1995) - IEEE Standard for High-Voltage Testing Techniques
http://standards.ieee.org/findstds/standard/4-2013.html
[5] Photobiological safety of lamps and lamp systems
https://webstore.iec.ch/publication/7076
[6] IEEE Std 1789-2015 - IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers
https://standards.ieee.org/findstds/standard/1789-2015.html
[7] IEEE Std 802.11-2016 (Revision of IEEE Std 802.11-2012) - IEEE Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
http://standards.ieee.org/findstds/standard/802.11-2016.html
[8] IEEE Std 802.15.4-2015 (Revision of IEEE Std 802.15.4-2011) - IEEE Standard for Low-Rate Wireless Networks
https://standards.ieee.org/findstds/standard/802.15.4-2015.html
[9] Ergonomics principles in the design of work systems
https://www.iso.org/standard/63785.html
[10] Basic human body measurements for technological design -- Part 1: Body measurement definitions and landmarks
https://www.iso.org/standard/65246.html
[11] Basic human body measurements for technological design -- Part 3: Worldwide and regional design ranges for use in product standards
https://www.iso.org/standard/64237.html
[12] Ergonomics of human-system interaction -- Part 303: Requirements for electronic visual displays
https://www.iso.org/standard/57992.html
[13] Standard Guide for Analytical Testing of Substances of Very High Concern in Materials and Products
https://www.astm.org/Standards/F2931.htm

Appendices

i. Acceptance Test Plan

To provide an acceptable performance of Mira, the camera should have at least 30fps. Since Mira is projecting the clear image of a human body, we need to ensure the camera is capable for capturing video with 1080p. Also the projector shall show image with required size and luminance.

Since Mira is a device used at home, the power supply will be 110V AC. And the power supply to the Raspberry Pi is 5V DC.

There are some requirements for installation for the customers to ensure the safety.

For the software part, we will ensure that both the body reorganization and the garment model is well functioning. Then the delay will be limited in an acceptable range. Also, the controlling method will be considered.

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Test sheet

Hardware Parts	
Camera:	Comments
1: 30 fps frame rate is capatiable and fluent with image processing: ☐ Yes ☐ No	
2: 1080p video streaming is capatiable and fluent with image processing: ☐ Yes ☐ No	
3. human body can be showed clearly in the image with fixed focal length ☐ Yes ☐ No	
Projector:	
1: 3000 lumens ambient light is capatiable for using in a normal fitting environment ☐ Yes ☐ No	
2: Screen size 2×2 m can show the whole human body with good image quality ☐ Yes ☐ No	
Power management:	
1: Projector power: 110VAC ☐ Yes ☐ No	
2: Raspberry pi power: 5VDC ☐ Yes ☐ No	
Installation:	
1: Porjector is tightly mounted on the wall ☐ Yes ☐ No	
2: No vabiration around camera durng the normal use ☐ Yes ☐ No	
3: The angle and postion between projector and camera is good for displaying the user body ☐ Yes ☐ No	

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Test sheet

Software Parts	
Body model formation:	Comments
1.Can recognize skeleton of arms, legs, and body ☐ Yes ☐ No	
2. Can recognize face and eyes: ☐ Yes ☐ No	
3.clothes tights to user's body of accuracy with in 2cm: ☐ Yes ☐ No	
Cloth interaction:	
1.Virtual cloth moves and reacts according user's movements: ☐ Yes ☐ No	
2. Cloth reacts to gravity: ☐ Yes ☐ No	
3. 3D cloth will can be store in a server and dowload to different Mira device ☐ Yes ☐ No	
Body model controlling through camera:	
1. The delay between action and output should be <= 0.5s ☐ Yes ☐ No	
2. Cloth should reacts to the body movement within 0.1s ☐ Yes ☐ No	
Software Control:	
1. Users should be able to switch colth throught the mobile app ☐ Yes ☐ No	
2: Users can swithc lightness, resolution, and other setting through app ☐ Yes ☐ No	
3: Retailers can upload their 3D model cloth to the server ☐ Yes ☐ No	

Ii. Glossary

LED	A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable current is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.
Ergonomics	The application of psychological and physiological principles to the (engineering and) design of products, processes, and systems.
Iuminance	A photometric measure of the luminous intensity per unit area of light travelling in a given direction. It describes the amount of light that passes through, is emitted or reflected from a particular area, and falls within a given solid angle. The SI unit for luminance is candela per square metre (cd/m^2).
FPS	Frames per second
Lumens	A measure of the total quantity of visible light emitted by a source, like brightness