Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A1S6

Re: ENSC 405W Design Specifications for the F-air Mira

Dear Dr. Rawicz,

This document, “Project requirements for the F-air Mira” was prepared as a design specification for our company product. This requirement 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 documents, the hardware and software high level design specifications will be fully discussed. The different stages of our project need to be specified for distinguishing the different design level. At each stage of this project, we will base on this document 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 Lu

Eden Lu

Design Specifications

Virtual fitting mirror - Mira

F-air

Project team

Alex Zhang
Eden Lu
Nick Yu

Contact Person

Alex Zhang
xinweiz@sfu.ca

Submitted to

Dr. Andrew Rawicz – ENSC 440 Steve Whitmore – ENSC 405w School of Engineering Science
Simon Fraser University

Issue Date

July 29, 2018
Version: 1.1

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Introduction

Since online shopping are accessible to general population, there is a very big market for online apparel shopping. From the 2016 statistic report of Canada Post states, around 80% of Canadians shops online, and more than 45% of them purchase apparel (Growing E-commerce in Canada, 2016). However, the issues about returning unfit apparels to retailer never get resolved. This problem could lead to limiting the market and increase the transportation waste.

To solve this issue, Mira strives to solves this problem by providing functionality of try on online product at home. It is a tiny square-shaped device who can combine the cloth with user's shape and projects the appearance on the wall, where users can see how the cloth will actually look like when wear on their body.

According to the design principle that a computer shall not waste your time or require you to do more work than is strictly necessary (Raskin, 2000), we will keep the procedure for using Mira as simple as possible. We want to achieve the goal that each user could easily operating Mira with minimum instructions.

This document contains information about design specifications of our design. Details about how we make decisions on choosing the components, implement the software, and some basics about the techniques we used will be covered in the rest of paper.

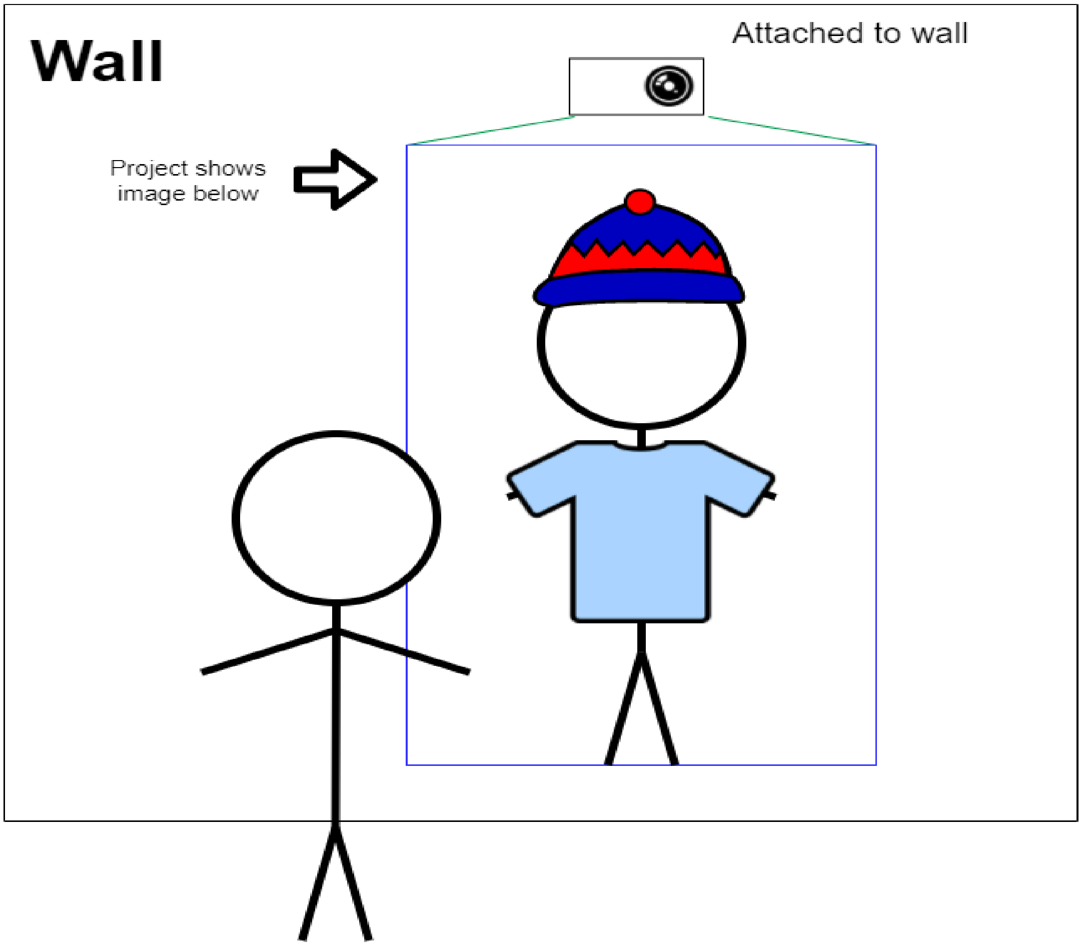


Figure 1 Mira form a virtual fitting room with a wall

Camera Liveview Design

The camera is used to record the live streaming of a person body. The idea image quality for product Mira should be as clear as possible and low noise.

Proof of concept

In the proof of concept, we will use webcam to verify our design. At the beginning of design, we just need to process the image of people's body, so the quality or the pixel of the camera is not necessary for the image process. The webcam is efficient and the fast way to proof our design.

Prototype

Considering using raspberry pi as microcontroller, the image recorded from camera should not be too high resolution and quality. Otherwise the raspberry pi would not be able to handle image recognition and complicated 3D model process. The requirements of camera is specified at **[REQ HW-1H-POC], [REQ HW-2M-POC], and [REQ HW-3M-POC].** Based on these requirements, the camera used in prototype is Raspberry pi camera module V2 (Figure 2), which can capture video at 1080p30, 720p60, featuring a fixed focus lens, and high performance (high sensitivity, low crosstalk, low noise).

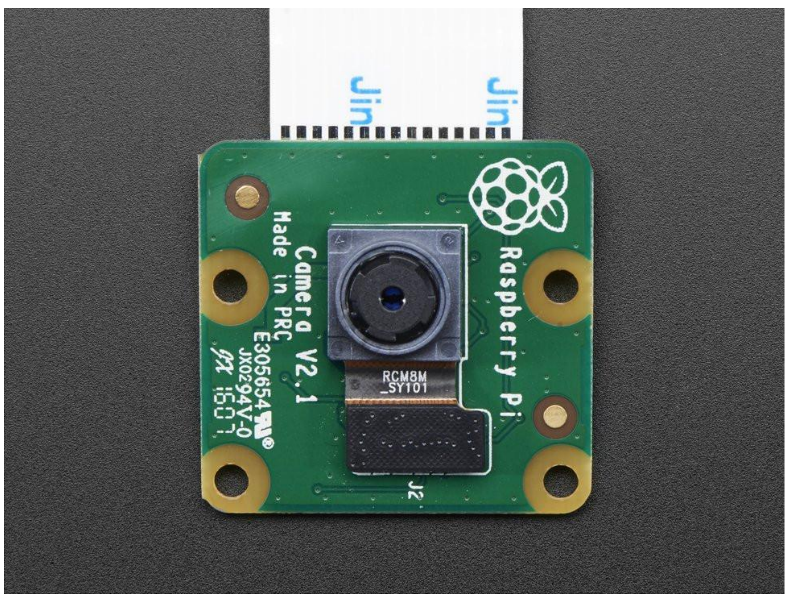


Figure 2 Raspberry pi camera module V2

Another reason we choose pi camera is directly connected to main chip of raspberry pi, which does not need to communicate through USB and load to CPU. The speed would be much faster than other non-pi cameras.

The camera attaches to Raspberry Pi via a ribbon cable to CSI interface. The CSI bus is capable of high data rates and pixel data, which was designed especially for interfacing to cameras. The connection of the camera and pi is shown in figure 3.

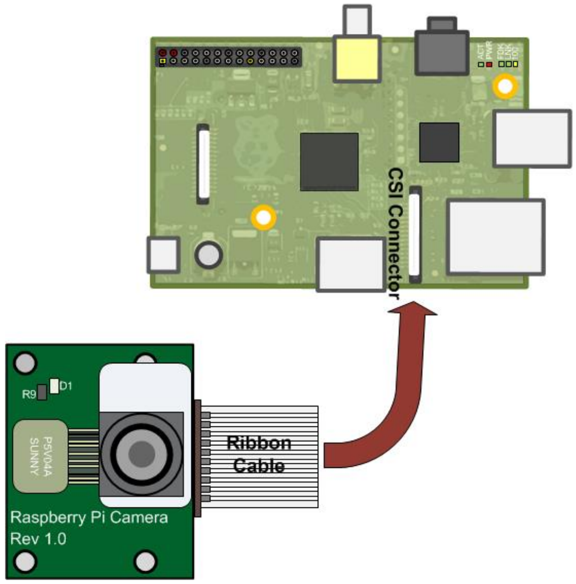


Figure 3 Connect camera to board

Product

The camera used in real product should have much higher image quality as possible, because we should let people feel like looking themselves in the real mirror. The camera needs featured with autofocus and 4k Video as well. The autofocus sensors built in camera can recognize and identify objects in the frame, which can help people to select which part they can see more detail.

Projector Design

The projector is used to display live streaming of human activity in front of camera, which simulates as a real mirror. For our prototype, it would be more efficient to use an existing projector from the market. The requirements of projector in the design is described in **[REQ HW-4M-POC]** and **[REQ HW-5M-POC]**.

Prototype

The projector we used is XGIMI Z4X (Figure 4), which is a used projector from team members. The specification of the projector is shown in the table below:

Projector type	LED Projector
Brightness	2200 LED brightness*700 ANIS lumens
Lens type	F=185mm lens
Power consumption	48-90W
AC power supply	AC 100-240V. 1.2A 50/60 Hz
DC power inside	12V DC

Table 1: XGIMI Z4X specification

Figure 4 XGIMI Z4X

From the projector specification, the projector's power consumption and model size can meet prototype design requirements. The connection between the projector and Raspberry Pi is through an HDMI cable. Another communication method is using wifi to transmit data between two devices, but for the low latency purpose, we choose HDMI cable transmission first.

Product

In the future, the real product will be designed as one unit, the projector, camera , and microcontroller will be integrated on one completed PCB board. It will benefit for the performance and power consumption of the product. For the prototype, we would like to make all function unit to be separated, which can be easier for testing and reworking the schematic design.

Power supply design

Proof of concept

The prototype hardware parts design block diagrams will be like the figure 5 shown below.

For the camera and projector, there will be 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. we would combine two different power supplies together to simplify the wire connection and system.

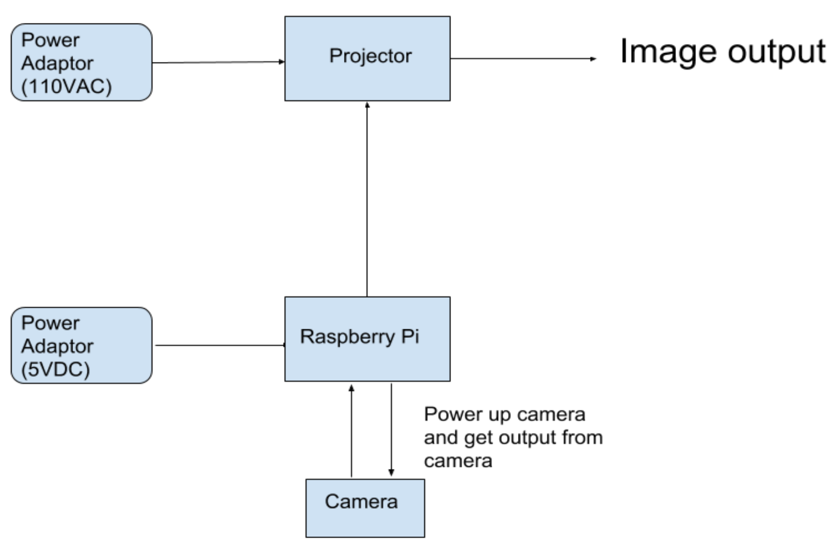


Figure 5 Hardware design block diagram

The projector has a 12V dc power inside the circuit power rail, so the system can be simplified by using a voltage converter to convert that 12V DC to 5v DC power. This 5V dc power can be used to power up the raspberry pi. Then the design only need one wall plug to power up the whole system. The raspberry pi does not need to connect to the power adaptor anymore. The heart of this voltage converter is the voltage regulator chip, LM2576. The information about LM2576 chip is shown in figure below.

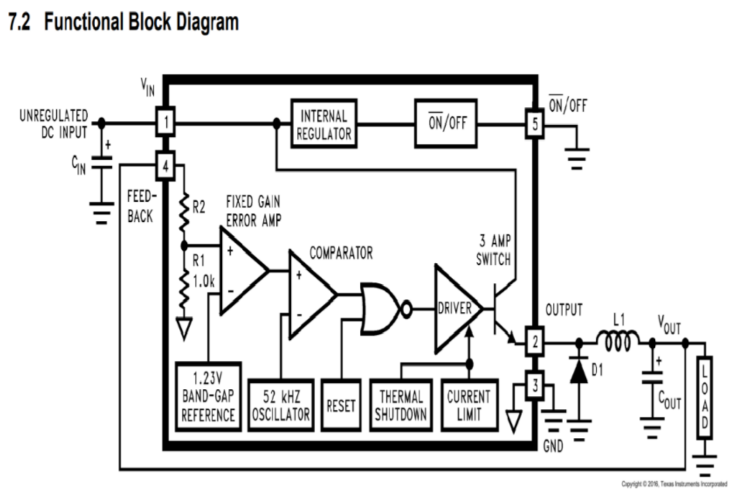


Figure 6 LM2576 block diagram

From the LM2576 datasheet and block diagram, one advantage of LM2576 regulator is more energy efficient than 3 pins regulator such as LM7805. Because LM7805 convert 12V to 5V by changing 70 percent of energy to the heat, and the maximal current load for LM7805 is only 1A compared with 3A for LM2567. Another advantage of using LM2576 is its build in current limit circuit, which can prevent switch current from exceeding safe values (3A) during an accident overload on the output. As the official power adaptor for raspberry pi is 5V with 2.5A, so 5V/3A power can also be used for Pi. (LM2576 Simlpe Swicher 3A, 2016) Since the power supply with a higher amperage will not harm the Pi, and the Pi only draw as much current it needs.

Prototype

The schematic circuit was created on Eagle, and it is shown in figure 2. Each component was selected from standard library or online components library. Another method to get footprint of components is measuring the size of components and searching for the similar model in that standard library, and the list of electronics components of voltage converter show in BOM table 1. The USB female connector can provide power to USB devices. In this project, it is connected with 5V output voltage in the schematic.

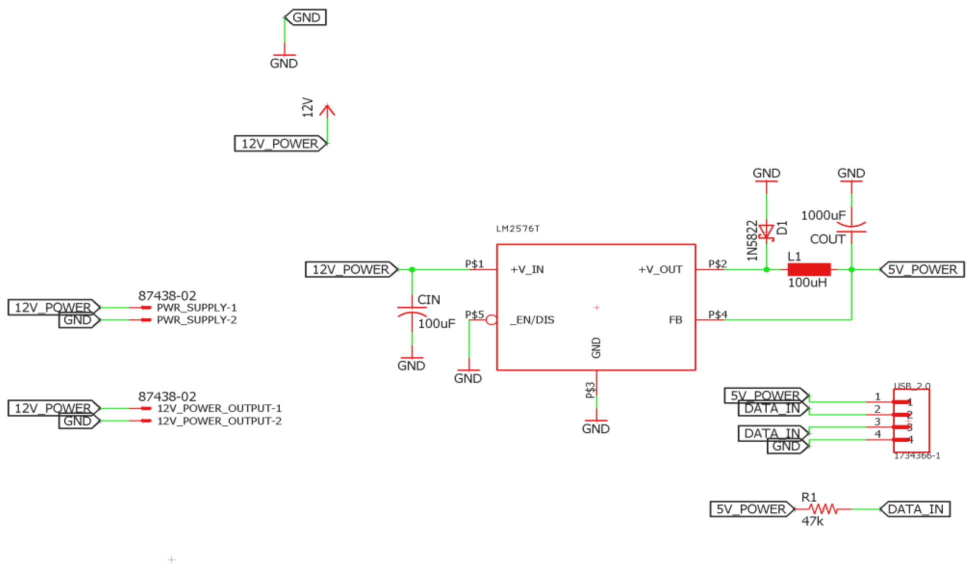


Figure 7 Schematic circuit of voltage converter

Components	Qty	Distributor	Part No.
Buck regulator 5V 3A	1	Digikey	LM2576T-5.0/NOPB-ND
Diode Schottky 40V 3A	1	Digikey	1N5822-TPMSCT-ND
1000 uF capacitors	1	Digikey	493-1467-ND
100 uF capacitors	1	Digikey	1189-1300-ND
100 uH inductor	1	Digikey	RLB9012-101KL-ND
USB 2.0 Type A female connector	1	Digikey	1175-1265-ND

Table 2: The BOM file of voltage converter

Product

For the product version, the whole unit will only use only one AC power supply. It should power up all the components including microcontroller, camera, and projector. Also, we need to consider power consumption and power safety as well. The power consumption should meet the requirement standard and testing the different user case to verify the safety of power supply.

Software

Design details

In this section, the design detail of software will be introduced in separated parts:

Body Recognition

At the beginning of our project, we were intended to use Kinect to recognize body shape in 3D. Unfortunately, Microsoft has terminated the product line of Kinect 1 year ago and can rarely find in the market. We are constrained to use another approach – use neural networks and deep learning to perform the recognition. We research about the algorithm and found a reliable open source library called OpenPose. It is a library that built upon neural network that can detect human key points. This library is fed with COCO or MPII datasets, where COCO is a large-scale object detection dataset and MPII is a human pose dataset that uses for evaluating body joints.

Preprocessing

Before start processing, the image is first convert from RGB scales to grayscale for easiness of computation. And convert from range [0, 255] to [0, 1] to fit into the neural network

```
img = cv2.cvtColor(img ) / 255.0
```

Neural network

Neural network is composed of connected **neurons** that contains the evaluated values from previous layers. Where **layer** is a group of connected neurons that represents a single operation. The last layers of the network are the results of whole network.

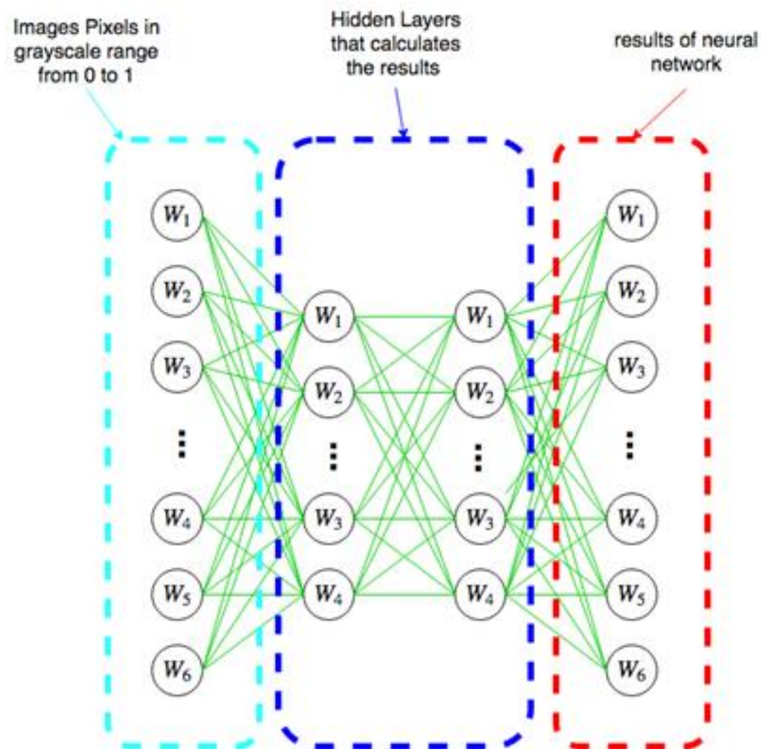


Figure 8 Overview of neural network

Think about how humans recognize a human using our eyes? Our brain may use following operation:

1. Find head, arms, legs in the image.
2. Do head at top, arms at middle, and legs at lower part of body?
3. From above observation to guess whether it is a human.

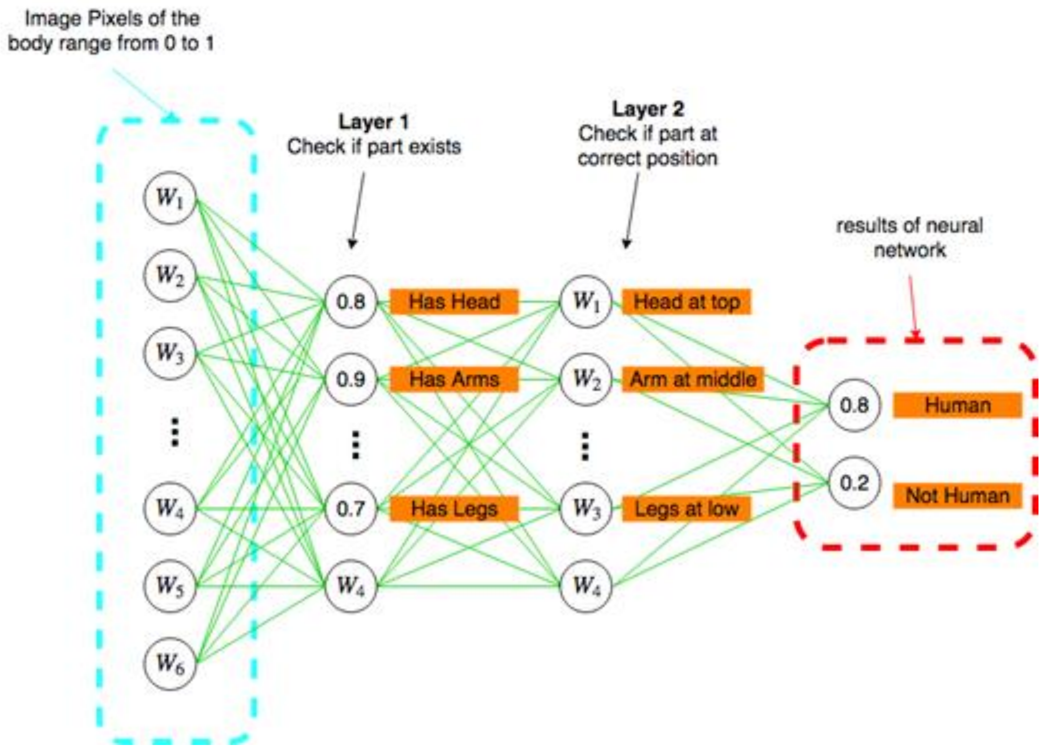


Figure 9 Simple example of examine whether there is human in image

The layers are trained with datasets (from COCO and MPII) to recognize parts. The above model demonstrates an very basic idea how neural network operates. The model of OpenPose is much more complicated and has 57 layers to find the key points of body. Two kinds of matrices are generated from last layer: **heatmaps** and **PAFs (Part Affinity Fields)**.

Heatmap is a matrix of images that states which pixels from the image may contains a body part (range from 0 to 1), which we can use to extract the location of body parts.

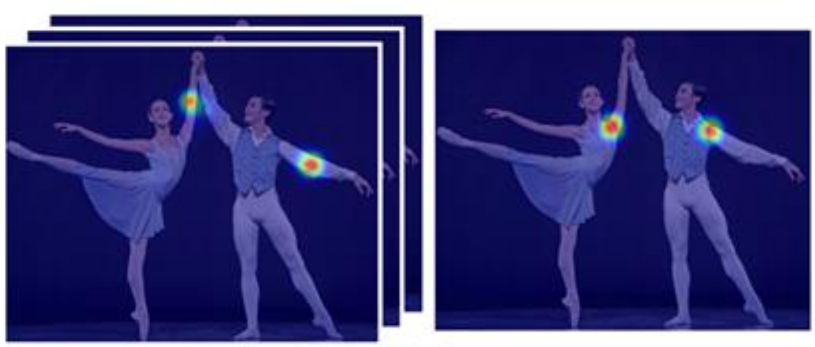


Figure 10 Heatmap

PAFs (Part Affinity Fields) are matrices that contains information about the position and orientation of different parts, which we will use to connect the parts correctly not randomly.

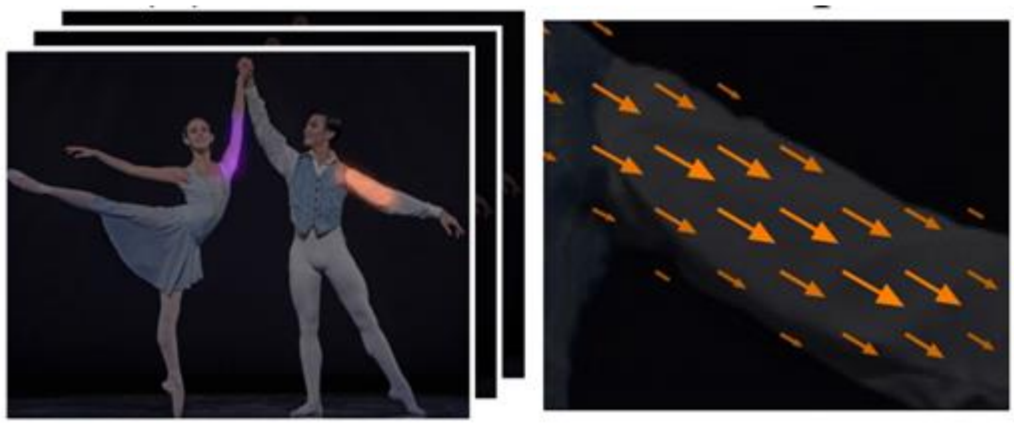


Figure 11 PAFs (Part Affinity Fields)

The heatmap is a cloud of pixels that state the position of joint, by finding the center pixel of the cloud using average algorithm will gives the position of the joint in certain. Using this position with the PAFs, the next joints can be found. After running this algorithm all the joints will be connected and the skeleton of the body is determined.

Figure 12 Skeleton of body is determined

The result of OpenPose are 18 skeleton key points in 2D image.

Convert the skeleton into 3D

To control the 3D cloth according to user's motion, it is essential to recognize the body in 3D rather than 2D. We found a convolutional 3D Pose Estimation algorithm (Denis Tome; Chris Russel; Lourdes Agapito) to estimate the skeleton in 3D with given 2D key points determined in from the image. We will use the result we generate from OpenPose alone with this algorithm to get the actual pose of human body.

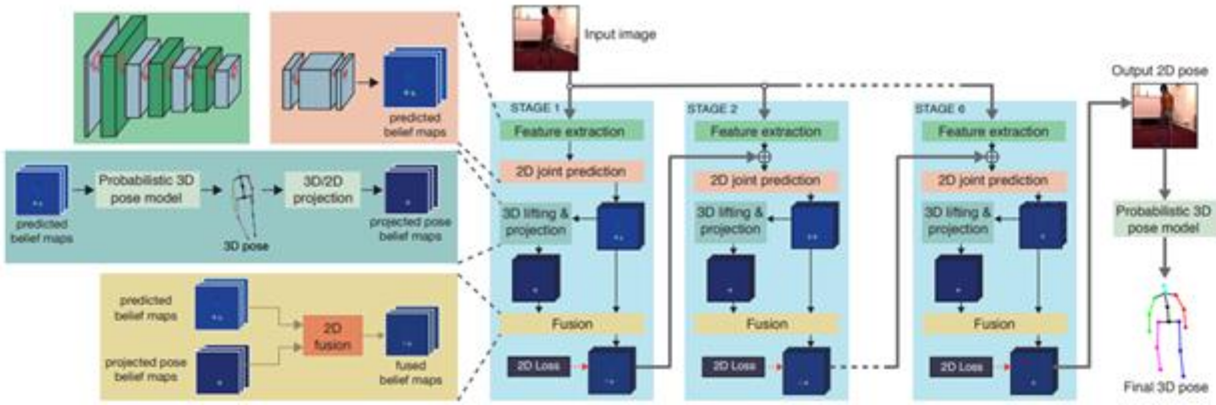


Figure 13 Algorithm of 3D lifting (Denis Tome; Chris Russel; Lourdes Agapito)

This algorithm is also implemented in convolution neural network by Denis Tome', Chris Russell, and Lourdes Agapito. Given a 2D joint prediction, this algorithm will estimate the 3D pose from a pretrained probabilistic 3D pose model. From this estimated 3D pose will redefine the 2D pose. The algorithm now will repeat this process for **6 times**, will generate a relatively accurate 3D pose result.

Control 3D model using pose

We use Python alone with TensorFlow module to combine these two libraries to generate the 3D pose estimation.

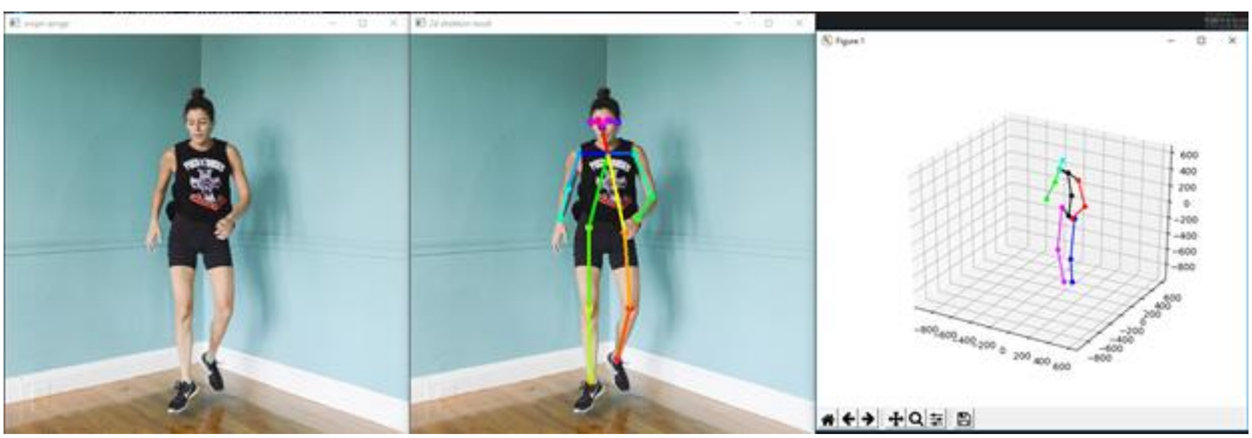


Figure 14 3D and 2D estimation generated from combining OpenPose and 3D Lifting algorithm

Having the result of 3D estimation, we are capable to generate the body model and control it. The 3D modeling software we use is Blender 3D, which is open source and allow using Python script to access all functionalities of modeling.

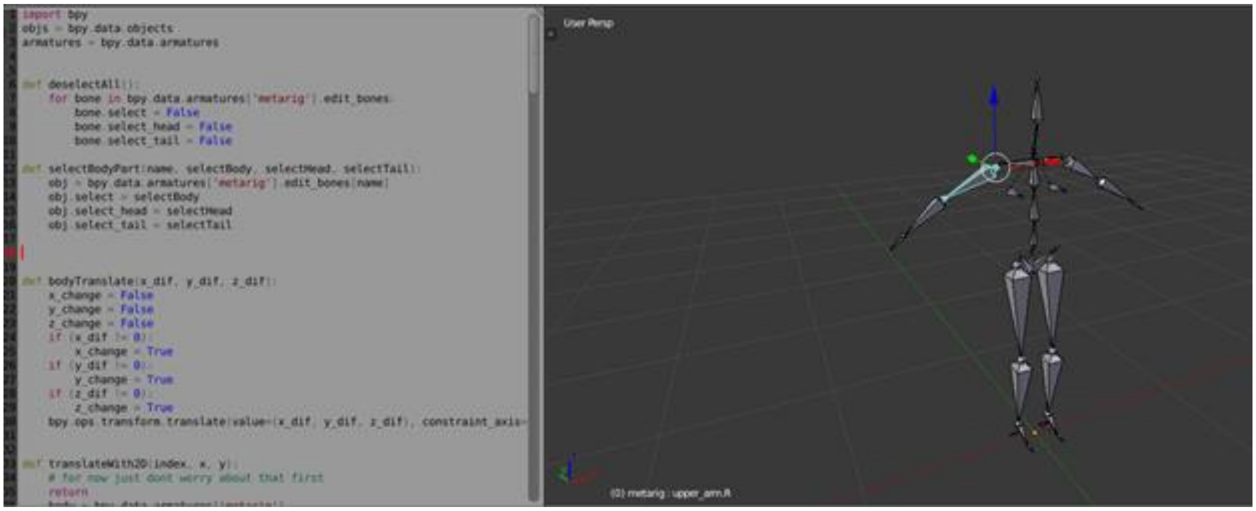


Figure 15 Model generated using our python script

Through the camera, user's pose and position will be estimated and use to control the model.

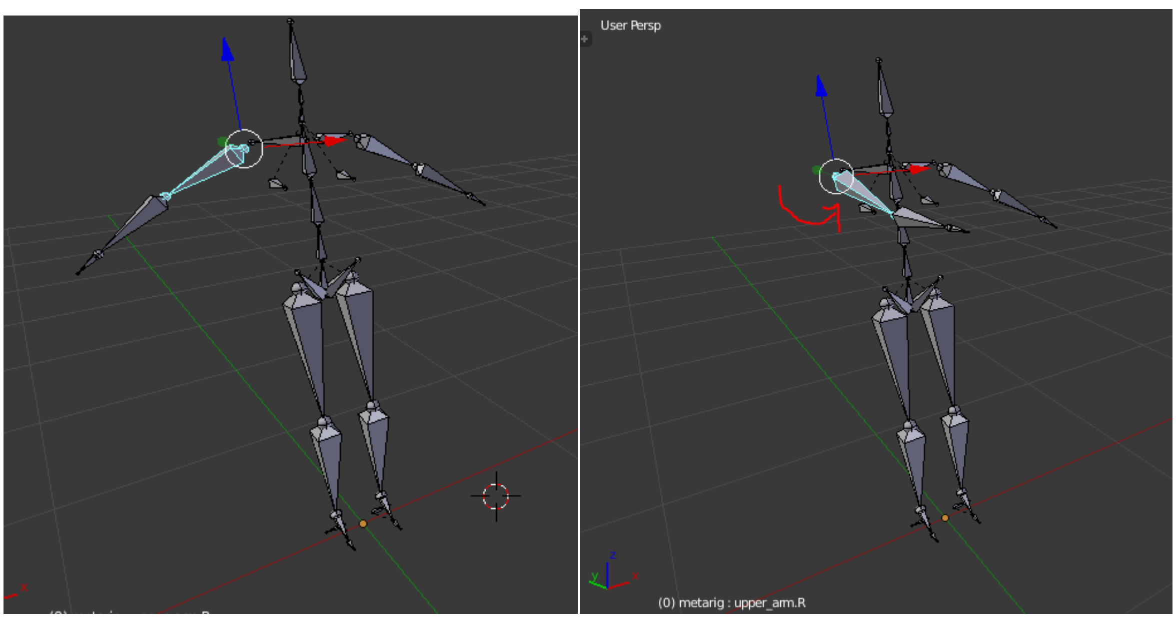


Figure 16 Control the model

Proof of concept

In proof of concept version, Mira should be able to recognize human 2D skeleton **[REQ SW-1H-POC]** **[REQ SW-2H-POC]** through the camera and convert it into 3 dimensional space that meets **[REQ SW-5H-POC]**. The existing code is using OpenPose and Lifting Library which employed convolutional neural network techniques to achieve the minimal acceptable accuracy. The software is still experimenting on PC, where it constantly fed by default camera with 720p images in 60FPS. The 3D cloth model and cloth interaction with the body model are not supported. Also, the pose estimation speed are not considered at this stage.

Prototype

In prototype stage, the cloth model has to be created and use Blender's game engine to create interactions between the body model and cloth with general physics like collision and gravity. This should give the user more realistic experience to meet **[REQ SW-5H-POC] [REQ SW-6M-POC]**. The pose estimation speed should be fast enough to meet **[REQ SW-9H-POC] [REQ SW-10H-POC] [REQ SW-11H-POC] [REQ SW-12H-POC]**. Which can be achieved by getting a better GPU to train the neural network. We have to measure the users' body shape in good precision. We will use another open source library DensePose researched by Facebook to estimate mapping all human pixels of RGB image to 3D surface (DensePose). This library may be able to help us to meet the requirement **[REQ SW-4M-POC]**. Also, the skeleton estimation can be improved by change number of cycle for 3D Lifting algorithm (currently use 6 times, increase the number should theoretically improve the accuracy), which we will investigate more in this stage.

Test Plan Appendix

Camera Test Plan

Team FAIR

F-air

Camera Test Plan Sheet

Test#	Test cases	Outcome(Pass/Fail)	Comment
1	Camera can turn on/off with control		
2	Can capture the whole body of human clearly in a fixed distance		
3	Can capture the whole body of human clearly in a dark environment		
4	Capture the human body without any distortion or noise		
5	Camera can support 1080P video streaming		
6	Camera can show clearly the human's face		
7	Camera is capitable with raspberry pi		

Projector Test Plan

Team FAIR

F-air

Projector Test Plan Sheet

Test#	Test cases	Outcome(Pass/Fail)	Comment
1	Projector can turn on/off with control		
2	3000 lumens light capatiable for using in a fitting environment		
3	Can display the whole human body without distortion and noise		
4	Capatiable with Raspberry pi through the HDMI cable		
5	Can show clearly humam's face		
6	Screen size should be at least 2m×2m		
7	The colour and quality of the displaying should be real and natural		

Voltage Converter Test Plan

Team FAIR

F-air

Voltage Converter Test Plan Sheet

Test#	Test cases	Outcome(Pass/Fail)	Comment
1	When input voltage is 12V, output will be 5V		
2	The maximal load current can be 3A		
3	The output is stable 5V when changing the load current frequently		
4	The ripple voltage(noise) should be lower than 5% of the output voltage		
5	Can power up the Raspberry pi through the output voltage		
6	Power consumption should be same as official Raspberry power adaptor		
7	The power efficiency of voltage converter should above 80%		

Image Processing Test Plan

Image Processing Test Plan Sheet

Test#	Test cases	Outcome(Pass/Fail)	Comment
1	Able to recorgnize human body in the video stream		
2	Able to recorgnize human skeleton in 2D		
3	Able to convert skeleton into 3D model		
4	The 3D model can follow human body's movement		
5	30 fps frame rate is capatiable and fluent with image processing		
6	1080P videol streaming is capatiable and fluent with image processing		
7	The 3D cloth can attach to human body's 3D model		

Conclusion

Benefits from Mira's nature of using machine learning to achieve virtual fitting, it turns out to be a "evolvable" product. It doesn't have much dependency on the hardware parts. That means we can improve the product (in accuracy or functionalities) by enhance only the software parts like neural network model and 3D modeling script. Customers won't need to waste money to buy next generation of device when improvement have been released; they will just need to download the upgrade from internet. Additionally, cloud computation has been hot these days, we also look into to put its computing units (CPU and GPU) onto the cloud, where we can further shrink the product size to make it a more portable product. Mira has good natures to allow it adapts different kinds of technology. Due to its potential of improvement and demand from the market, we believe Mira will be a unique, useful, and lovable product for most of the online shoppers.

User Interface Appendix

Introduction

Mira is aiming at providing excellent online fitting experiment to all customers with different backgrounds. The user interface should be simple and user-friendly with minimum instruction. Furthermore, the user interface should also have a modern and elegant design to attract the users.

The user interface contains 2 main parts: the phone app interface for user to browse and select the outfits, the projected interface to display the image of the user with selected outfit model.

Figure 17 GUI of APP

User Analysis

Mira is designed for both the clothing retailers and the customers of online clothing shopping. Since it is very likely that both retailers and customers do not have background with electronics, Mira should keep the setup and debug process as simple as possible. Also considering the fact that the users of Mira may use different language, the operation instructions should be clear and obvious. Instructions by word should be replaced by graphs and animation as much as possible.

Most retailers will require Mira to maintain in use for more than 8 hours. That brings the consideration of heat radiation. And retailers usually have bright condition. Mira need to ensure the image quality is acceptable with this condition. For the retailers who already have their own APPs for online shopping, we can offer APIs to them to directly connect to Mira from their own APPs.

Customers may have more complex environment. The power supply wiring should be simple to avoid potential danger.

Technical Analysis

1. Discoverability

After turning on Mira and connected the phone with Mira via Bluetooth, the user will be able to select the outfits and casting the image using Mira. On the GUI shown in above, after tab on "CONNECT MIRA" (bottom right), the loading page will be shown. If an error occurs during or the connection is overtime, the breakdown page will be shown to let the users retry or get help.

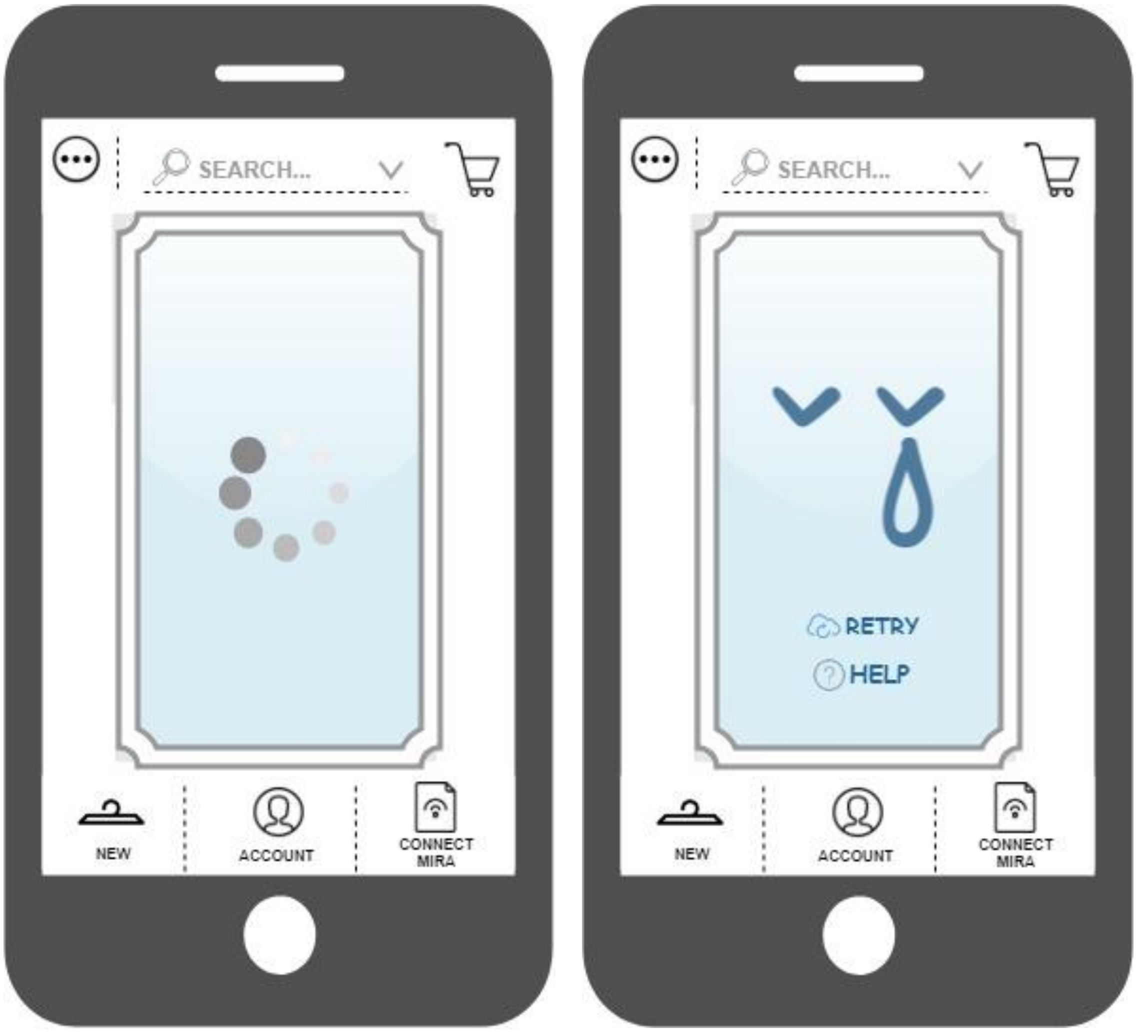


Figure 18 Loading and Breakdown Page of GUI

2. Feedback

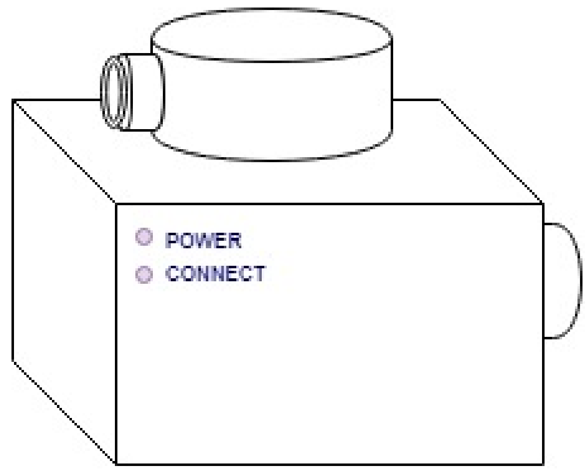


Figure 19 Mira Feedback Lights

Once Mira is plugged in, the power light will be on as a breath light. After pressing the power button, the power light will keep be on. In this condition, the users could start to connect Mira with the APP via Bluetooth.

Once the Bluetooth connection between Mira and the smart device, the connect light will be on as a breath light. After the user tab connect Mirror button (button right) on the GUI of the APP, the connect light on Mira will keep be on. And a succeed page will be shown on the APP.

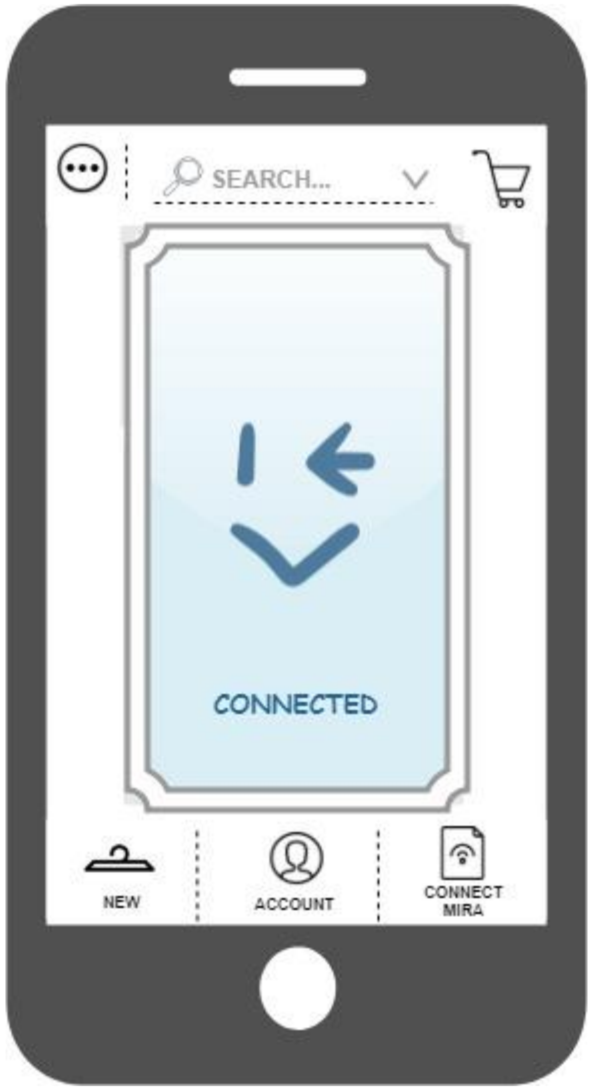


Figure 20 Succeed Page

3. Conceptual models

Mira and the GUI of APP are two separate parts which functions together. The main purpose for the GUI is offering a convenient method for the user to control Mira. Mira will analyses the movement and the body shape of the users, and display it using projector.

4. Affordances

As introduced in discoverability and feedback, after turning on the power, Mira is controlled by the smart device APP. The affordance of the hardware part of Mira is to display according to the instruction sent by the APP via Bluetooth. The hardware part of Mira need to be placed in a proper position to capture the shape and movement of the users and project the image.

The software part of Mira (APP) allow the users to overview all the outfits they want to try, and select the outfit they want to try on. Also, with further development, the APP will allow users to directly purchase items and check orders.

5. Signifiers

To get the correct angle to capture the image of users and project the image, users need to adjust the angle of camera and projector manually. There is supposed to be a friction of the junction between the camera and the projector to hold the camera stable. However, if the friction is too strong, the users may twist it hard and accidentally break Mira. So during the design we will adjust the proper friction. So it will be easy for the users to adjust the camera, and insure the friction is still large enough to keep the camera stable.

6. Mappings

As shown in Figure 3, all the instruction lights on the hardware is labeled. It is simple for the user to understand what each light is representing.

As shown in Figure 1, the GUI frame of the APP is designed to be user-friendly for most users base on majority online shopping APPS. Users could easily find the features they want without educated.

7. Constraints

The camera allows the users to adjust the angle within 180 degree instead of 360 degree because of wiring issue. We will add nodes to block users for over turning.

Engineering Standards

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.

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 (UL 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements, 2016)
IEC 60065:2014	Audio, video and similar electronic apparatus — safety requirements (IEC 60065:2014 Audio, video and similar electronic apparatus - Safety requirements, 2014)
IEEE Std 1	IEEE Recommended Practice - General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation (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, 2011)
IEEE Std 4	IEEE Standard for High-Voltage Testing Techniques (IEEE Std 4-2013 (Revision of IEEE Std 4-1995) - IEEE Standard for High-Voltage Testing Techniques, 2015)

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 (IEC 62471:2006 Photobiological safety of lamps and lamp systems, 2006)
IEEE Std 1789	IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers (IEEE Std 1789-2015 - IEEE

	Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers, 2016)

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 (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, 2016)
IEEE Std 802.15.4	IEEE Standard for Low-Rate Wireless Networks (IEEE Std 802.15.4-2015 (Revision of IEEE Std 802.15.4-2011) - IEEE Standard for Low-Rate Wireless Networks, 2017)

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 (ISO 6385:2016 Ergonomics principles in the design of work systems, 2016)
ISO 7250-1	Basic human body measurements for technological design -- Part 1: Body measurement definitions and landmarks (ISO 7250-1:2017 Basic human body measurements for technological design -- Part 1: Body measurement definitions and landmarks, 2017)

ISO 7250-3	Basic human body measurements for technological design -- Part 3: Worldwide and regional design ranges for use in product standards (Basic human body measurements for technological design -- Part 3: Worldwide and regional design ranges for use in product standards, 2017)
ISO 9241-303	Ergonomics of human-system interaction -- Part 303: Requirements for electronic visual displays (Ergonomics of human-system interaction -- Part 303: Requirements for electronic visual displays, 2017)

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 (Standard Guide for Analytical Testing of Substances of Very High Concern in Materials and Products, 2017)

Analytical Usability Testing

1. Structure Detect

The first step of analytical usability testing is to test if Mira can determine different body parts. This part is tested using different photos as inputs. Mira is able to determine 14 human body points of images captured with different angle include front, back and different sides.

2. Processing Speed

Mira need reliable processing speed to achieve a smooth display. To increase the processing speed, we need to test the performance of different GPU and optimize the code to find a balance with acceptable processing speed and affordable cost.

3. Movement Capture

With the proper structure detect and processing speed, it will be easy to ensure the movement of users will be understand by Mira. Therefore, the clothes will also move according to the body movement.

4. 3D Model

We choose to use 3D blender to build the models for outfits and accessories. During the analytical usability testing we will ensure the 3D model revert the texture and detail of the outfits. Also we will test the models to avoid corrupt.

Empirical Usability Testing

Currently we haven't made the device ready for empirical usability testing. The test plan is instructed below:

1. Power

Once Mira is plugged in the 110V power supply, the power light should be on as breathing light which indicate that Mira is powered properly. Once the power button is pressed, the power light should keep on indicating Mira has successfully started. Also the connect light will be on as a breathing light to represent that Mira is ready to be connected with a smart device via Bluetooth.

2. Connection

To connect APP with Mira, first the user should connect Mira with their smart device using Bluetooth. After successfully connect, the connect light will keep be on. The user could tab "connect" button in the APP for display. If the connection is built, the user should be able to see a page indicating the device is connected.

3. Choosing Outfits

After successfully connected, the user could start trying on the outfit the want to choose. All the recommend outfit will be listed in the "new" tab. The user could also search for a outfit or find all of the outfits using the search bar on the top. There will also be a filter feature on the right of the search bar.

4. Display

Once Mira is turned on, the projector will instruct the user to stand on a point which is about 1m away from the camera. This step is for Mira to recognize the proportion of the body parts.

The user could try on the outfits by tapping the outfits they like. Then they will be able to see the image of themselves with selected outfits. They can also change outfits by clicking other outfits.

Conclusion

So far, we have already decided the frame for both hardware and software UI. We will use those figures to do a survey to potential users about their opinions. After adjusting and developing we are going to prototype our device and let the users to test on it again.

440 Planning Appendix

Introduction

Mira is a tiny portable device that performs same functionality as a Mira but allows user to try online cloth on their own body. During the first four months of prototype project research and development, our team spent most of time working on image processing, human body reorganization algorithm and voltage converter circuit design. The system so far mainly using laptop and webcam to verify the proof of concept. The webcam is used to capture the video stream of human body and movements, and the laptop as main microcontroller for image processing. The software part is able to detect the human skeleton of a image or video streaming, and converting the 2D skeleton image to 3D model. The voltage converter is designed to converter 12V input voltage from projector to 5V output, which can simplify the power adaptor and make system to one complete unit. During the 4 months, our team created a human body detection algorithm, a schematic circuit of voltage converter, and an outline of UI design. For the result, the smooth of human detection and the frame rate of image processing can meet standard requirements, and it remains to be determined whether Mira will be efficient and reliable after attaching with 3D model clothes which will be verified in next four months. For the next semester, we will work on designing 3D clothes and combining with human detection together. Also, we will replace the laptop with raspberry pi camera, projector, and raspberry pi. The speed of system will be optimized by optimizing the algorithm and updating the hardware platform.

Background

Online shopping has became 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 of 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).

Scope

The goal of next semester is to complete the hardware and software development of the system, and build a completed system to demonstrate our project. The original scope of our project has been expanded through the team discussions.

For the hardware part, we will add a voltage converter in inside the main board of Projector. That voltage converter is designed for simplifying the circuit and power adaptor. The whole system will use only one power supply to power up the both projector and microcontroller. Also, another significant part need

For the software part, the layout of the UI and appearance has been designed, and this change would to be more clear and easier for users to use. Users could select the the clothes or items through their phone, and Mira would receive the signal through the wireless to turn on the fitting mode.

The core part of our project design is image processing, so our team would keep learning and doing the research on tensorflow and bender tools. An efficient algorithm and neural network would increase the speed and performance of the system, and a fast speed allows the system to have more headroom for uploading high quality image and 3D models.

Benefits

The benefits of project can also be increased by the new scope of design. Mira will benefit for both online shopping customers and retailer store. Mira can offer customers the ability to try on different products and combinations in their home, and many more than they would be able to try on in retailer store. This lets the customers be able to quickly compare numerous clothes and decide which outfit they like most. With the comparison of different kinds clothes, customers would rarely buy something they do not like, or the wrong size of clothes. This can help the customers reduce the cost of returns and unworthy expenses on items that they do not like.

For the clothing retailers, let customers go into a fitting room is an important factor to make sales. Statistics show that 76 percent of customer who tries something in the fitting room will purchase something at the end. Mira can help retailers or online producer bring customers back to the fitting room, and the more things customers try, the more things they would buy. Also, for some expensive items such as jewelry and luxury bags, which are easily becoming the target of theft crime since they are easy to be hidden when the criminals pretend to be fitting. The Mira would keep jewelry stores safe when customers are making a decision about what they want to wear.

Compared to other similar product in the market, Mira does not like other smart mirrors which need a big monitor and a large mirror. Instead of using big monitor, Mira uses projector to display the images, which is cheaper and more portable. The user can also interface with the Mira through their phone. Mira's UI is convenient and efficient for users to select their favorite items.

Risks

The technologies we found feasible for our project are tensorflow and blender 3D. We will combine these 2 technologies with image processing to build up the software part of our project. But we may has some learning curve when we investigate into these tools, which may eventually delay our deadlines.

The latency between human actions and the image people watching would reduce the performance of the image processing. The Mira system has the risk in providing real-time information of the human body and allow it interface with virtual 3D models, but we will keep optimizing the algorithm and minimize the delay as much as possible.

The power safety of the whole system and circuit protection can also be a risk for our team. In the future, we will build a voltage converter circuit to simplify the system. The most struggling issues are the connection of wires inside projector and power supply modules. Hardware testing does not like software debugging which can be permitted to make many mistakes without burning in the system, but hardware need to be tested it mistakes free unless you want it to be burned. Same as wires connection, the wires need to be connected exactly showed in electrical wiring diagram.

It is very unlikely for this category of risk to occur but it is worth mentioning. There is a possibility of a team member being ill right before deadlines which causes progress cannot be finished on time. The mitigation strategy would be to split up the leftover work among healthy team members and finish it as soon as possible. A team member might also suddenly drop out of the course. This reduces the size of the group and can lead to lower project quality. The rest of the group will have to work harder. Communication is another important factor among team members as this may lead to failure of the final project. important for everyone in the group to understand the project and each other's work thoroughly. Conflicts with team members need to be solved before it extends.

Market

The online clothing shopping is significantly increased globally by 2018, so the biggest market for our company is to cooperate with online shopping stores like Alibaba or Amazon. Our strategies are to let Mira replace the traditional mirror, which Mira can become new smart home device. Another market is physical store, we can also cooperate with retail stores, and installing the Mira in the physical store, which can help them save space of store thus saving the rental fees.

Competition

Since online shopping will be big market in the future, there are some companies already designed similar products as Mira. However, there still has much difference between our competitors' product. There are major competitors for online shopping fitting mirror:

Fitting Charts and Fitting APPS

Fitting tools including fitting charts and fitting APPs are the most widely used solutions. They have the lowest cost for maintenance. However, fitting charts only provide the most basic information. Customers do not believe fitting charts are reliable. Fitting APPs, for instance, Fits.me and TrueFit, are developed based on fitting charts. They require the users to input parameters including height, B/W/H measurements, age, and other details. It is complained by the users that it is too complex to use. And still, they fail to provide a direct view for the users to see how the garments look like on their own body type.

Advanced Returning Program

To eliminate the hassle of returning, some fashion retailers have provided advanced returning program to allow their customers to try the garments and accessories before purchasing. Amazon recently released a new returning program called Prime Wardrobe. The items with a box and a preprinted shipping label will be delivered to the customers without purchasing. After trying on the clothes, the customers could pay for the items they want and return the rest using the box with the label. This is a convenient method for the customers, but it will cost Amazon on average $7 to handle with each returned item. The huge cost will result in the increase in price which will be paid by customers, and therefore the retailer will be less competitive.

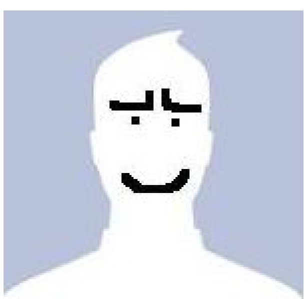
Other Virtual Fitting Hardware

Virtual fitting is becoming a fresh tendency in the real world for online shopping instead of a sci-fi movie idea. Smart devices, for instance, FXmirror, has been designed to capture the body shape and movement and show the appearance of the user with the selected garment on a large screen. This is the most efficient and cutting-edge solution that has ever occurred. There is no waste cost on shipping. And the customers could still enjoy the shopping experience without actually spend time and cost going to stores in person. Virtual fitting devices are not only easy to use, but also provide a direct appearance.

However, the virtual fitting devices currently exist are only designed for retailers to display in stores. They are large and unaffordable for typical families and individuals. This is a waste of the core advantage of virtual fitting because it is still necessary for customers to be in the nearby stores in person.

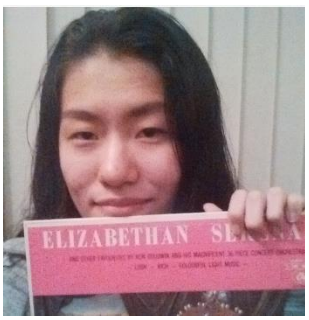
Additionally, it is huge product with height 75 inches height [11] and use the techniques of Kinect camera to implement the features. These properties make the product not as portable as our tiny-sized Mira and also added additional production cost due from using the expensive Kinect camera. We believe our product has better selling points in terms of size and price.

Personal Management



Eden Lu - CEO (Chief Executive Officer)
In charge of researching about the body recognition and 3D modeling control methods. Provide helps on the software development stage. Assisting making decisions on pick reliable algorithm that fits the need.

Nick Yu - CTO (Chief Technology Officer)
Responsible for interfacing camera and projector with Raspberry Pi. Schematic circuit design and PCB board layout. Set up the hardware testing cases based on our test plan. Support software team member to do the software debug and image processing research.



Alex Zhang - CKO (Chief Knowledge Officer)
Responsible for 3D model adjust and project performance. Research and develop in UI design. Design the market plan and optimizing plan based on the research of current market and our product.

Time Management

To make full use of time, we try our best to divide the jobs into sub-jobs so everyone in the team can work in parallel. However, in order to ensure the quality of our product, we have to put all our force to investigate into software core before we start investigating on the hardware implementation. Where the software core includes some fresh and difficult topics that we can research about to make Mira more precise, reliable, and fast. Luckily, during ENSC 405 we have almost completed our goals for body estimation and model controlling. Therefore, the rest of software work (cloth interaction and body shaping) should be able to complete in two weeks and the hardware implementation can start afterward. We have already researched about the camera, projector and other hardware parts that may fits our needs and will start purchasing them from shops. At the last stage of hardware integration, we will work together in careful manner to ensure our product in perfect shape.

Schedule of 405				
	Start Date	End Date	Timeline	Status
Project Mira	07-05-2018	5-8-2018		
Experiment Facial Detection	14-05-2018	20-05-2018		Compele
2D Virtual fitting experiment	14-05-2018	27-05-2018		Compele
2D Model motion experiment	27-05-2018	03-06-2018		Compele
Experiment with body detection	03-06-2018	10-06-2018		Compele
Experiment on body pose recognition	10-06-2018	24-06-2018		Compele
3D virtual fitting	24-06-2018	08-07-2018		Active
3D Motion detection	08-07-2018	29-07-2018		Compele
Deciding the hardware design	14-05-2018	27-05-2018		Compele
Angle of Camera	08-07-2018	15-07-2018		Upcoming
Power and resolution analysis	08-07-2018	15-07-2018		Compele
Brightness Adjustment	24-05-2018	22-07-2018		Upcoming
Material purchaes	08-07-2018	29-07-2018		Upcoming
Circuit setup & compression	29-07-2018	30-07-2018		Upcoming
Size Ooptimization	30-07-2018	05-08-2018		Upcoming

Complete
Active
Upcoming

Figure 21 ENSC 405 schedule, green is complete and red is upcoming

Schedule of 440				
	Start Date	End Date	Timeline	Status
Project Mira	04-09-2018	3-12-2018		
3D virtual fitting	04-09-2018	07-09-2018		Active
Body shape modeling improvement	08-09-2018	14-09-2018		Active
Accuracy Improvement	15-09-2018	28-09-2018		Upcoming
Material purchaes	04-09-2018	28-09-2018		Upcoming
Integration of software and hardware	29-09-2018	12-10-2018		Upcoming
Camera Resolution adjustment	13-10-2018	19-10-2018		Upcoming
Angle of Camera	20-10-2018	31-10-2018		Upcoming
Projector Adjustment	01-11-2018	09-11-2018		Upcoming
Circuit setup & compression	10-11-2018	23-11-2018		Upcoming
Size Ooptimization	24-11-2018	03-12-2018		Upcoming

Active
Upcoming

Figure 22 ENSC 440 schedule

Budgetary Management

Compare to the project proposal, our device actually requires an additional component - Graphic Processing Unit. All components require are listed below.

Item	Prototype	Final Product	Cost
Camera	√	√	$40
Laptop	√		$0 (already owned)

Raspberry Pi 3		√	$50
Projector	√	√	$200
GPU (GTX 1060)		√	$300

	Prototype	Final Product
Subtotal	$240	$590
tax (12%)	$28.8	$70.8
Contingency (25%)	$60	$147.5
Total	$328.8	$808.3

Conclusion

In this semester, our team have verified the human body and skeleton reorganization on the laptop and have designed new features of our UI outline. Now we have a beginning stage prototype design of the Mira, which built a strong foundation for further development of Mira. Our team is confident for future work in next semester, which includes continue learning TensorFlow and blender 3D tools, optimizing the neural network, combining the power source of projector and microcontroller together, interfacing the software with camera and projector through the Raspberry pi. We have confidence to successfully release our prototype product in the end of next semester.

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