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## Department of Electronic Engineering

### FINAL YEAR PROJECT REPORT

**BENGU2-INFE-2017/18-YTC-01**

**Automatically Copy Drawing Machine using  
an Android / IOS**

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Bachelor of Engineering (Honours) in  
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## Student Final Year Project Declaration

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Project Title : Automatically      Copy  
Drawing Machine using an Android /  
IOS

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DEPARTMENT OF ELECTRONIC ENGINEERING FINAL YEAR PROJECT 2017/2018  
YTC-01 Automatically Copy Drawing Machine using an Android / IOS

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## Abstract

To makes a persistent human-readable representation of graphics or text on paper, human invented different machine to do it. Printing is an efficiency way to present individual's mind to the public. Public can read the printing material, such as a book, poster, letter, to know a individual's mind and his feeling. Printing can record the individual's mind in printing material, so their mind and think can be reproduced. It allowed the rapid transmission of these new ideas. Therefore, in Renaissance period, the success of printing press technology is a mainly reason to push the human civilization to a higher place. Invention of printing democratized learning and allowed a faster propagation of more widely distributed ideas.

Before 220 AD, in China, there has woodblock printing technology to print graphics or text on textiles and later paper. Later, movable type is invented. In 19th century, there has the first computer printer. Nowadays, people use Digital printing in work and some industry use 3D printing to show their demonstration.

The system uses Makeblock XY-plotter Version 2.0 to redraw the people writing and drawing can present a more reality and smooth image. It is because a new method of duplication is used in this project, which is using high technology chip (PHPoC Blue, a wireless LAN programmable IoT board) and high speed stepper motors(42BYG Stepper Motor).

Beside the modern dot matrix printing machine, using XY plotter system can perform a smoother drawing. Because dot matrix printing requires high pixel or dot matrix when it needed to print high-quality image. In the meantime, XY plotter system using the vector instead of matrix to draw the image. No matter how big the image it is, it won't be blurry. Especially drawing the oblique line.

Since the system is using pen drawing, it calculated the best movement. So that the system is draw as fast as human speed and as accurate as human drawing.

Record and replay function are introduced in the system, so that the user can keep redraw unlimited number of his graphics or text throughout the time.

## Chapter 1: Introduction

The ideas of system are coming from imitating human drawing and writing. This system is different from the traditional dot matrix printer.

The traditional do matrix printer is using a print head to print the drawing moves back-and-forth. So that, images are drawn out of a dot matrix. As result, the fonts and graphics will be blurry when the pixel and resolution of the image is low.

The system in this project is rebuild the drawing of human drawing. It is because that the system will record the XY coordination every fixed second. Then, it will instantly draw the image following the pen movement.

The system is consisted of a few parts. The end device client interface, server side and the connection between the client side and the server side. The detail of these parts will be discussed in middle of the report.

### 1.1: The Plotter and Dot-matrix Printer

#### 1.1.1 Dot-matrix Printer

Dot-matrix Printer is striking pins against an ink ribbon to print closely spaced dots in the appropriate shape. Dot-matrix Printer is different to plotter. Dot-matrix Printer is printing the image base on a digital image. It is because printer need to the dot base on the matrix. Therefore, the quality of the image always determined by the number of pins and dots per inch. The number of pins can vary from 9 to 24. Moreover, dot-matrix printer requires the digital image to do the drawing. The digital image usually use bitmap to store the image data.

However, even the best dot-matrix printers, which has 24 pins, there still a bit blurry and you can see the different, if you look closely.

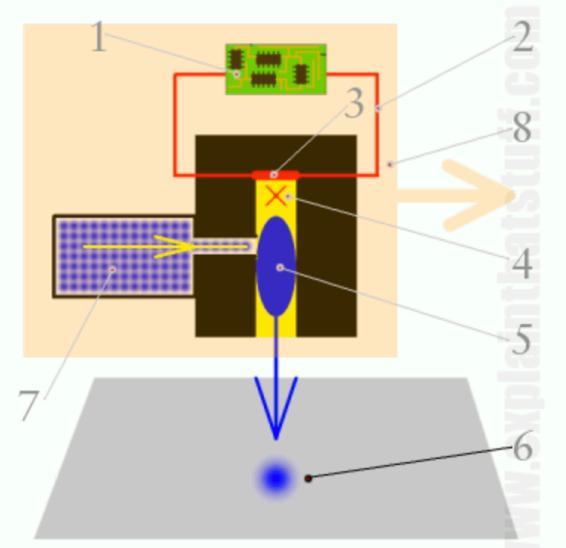


Figure 1 Dot matrix Printer Head

### 1.1.2 Plotter

Plotter is mainly used in printing vector graphics. It is because it draws pictures on the surface of a piece of paper by using a pen or other instrument. Because plotter can clearly show line representation.

Plotters are used to print the blueprint of ships, machines, buildings and so on. The plotter nowadays normally uses XY coordination to plot the graphic. However, there is also a plotter used in printing 3D artwork. Since plotter drawing is more natural and smoother, especially in drawing the line. It has always been used in printing the design paper. Plotter always plots the graphic based on the vector calculation.

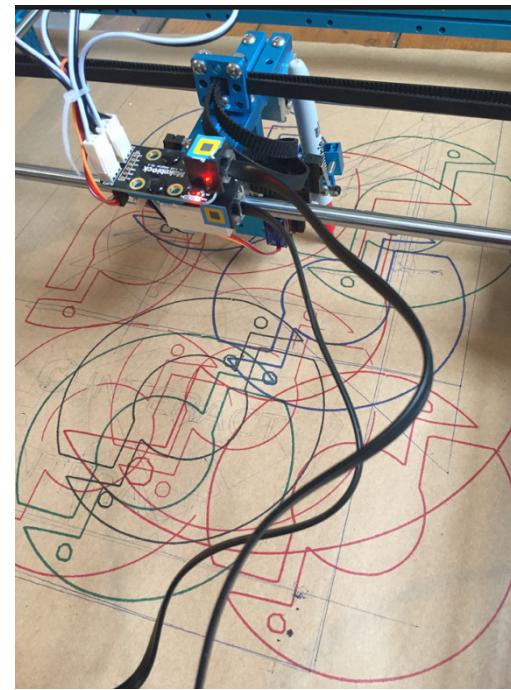


Figure 2 XY Plotter Drawing Blueprint

### 1.1.3 Comparing the Dot matrix printer and the XY plotter

After comparing the dot matrix printer and the XY plotter.

There are a few differences.

	Dot-matrix Printer	XY plotter
Graphics	Vector graphics	Raster graphics
Speed	From 50 to over 500 cps <sub>2</sub> .	Determined by the stepper motor
Quality	Quality controlled by the number of dots per inch	Quality controlled by the algorithm of the analog image to vector convertor
Size	High	Low
Printing	discrete set of points (dot matrix)	Continuous line

Table 1 Comparing dot matrix printer and XY plotter

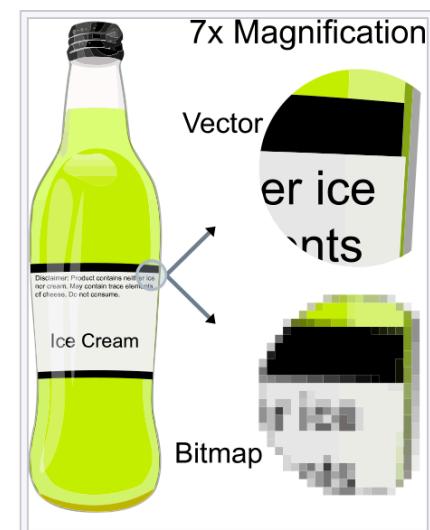


Figure 3 Example showing effect of vector graphics versus raster graphics under 7x Magnification

## 1.2: The theory of XY plotter

XY plotter is a plotter that uses two motors to control two axes of motion. By controlling the X axes and the Y axes to draw continuous vector graphics. Since the line is represented by the vector, even enlarge the scale of the graphic, the line is still clear to see.

### 1.2.1 The flow of printing image by using XY plotter

Since the XY plotter is printing image in vector graphic. In order to draw the image by using the plotter, it needs to do the conversion before it prints.

Normally, XY plotter prints the file in .SVG format (Scalable Vector Graphics) or 2D dimensional CAD format (Computer-aided design). These design formats are in linear and vector graphic. XY plotter can easily draw just follow the vector provided by the graphic.

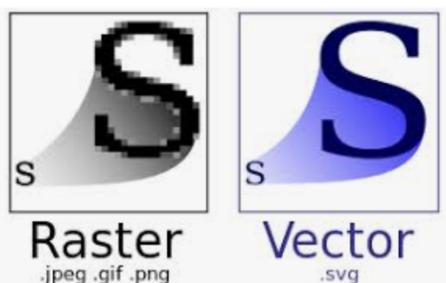


Figure 5 The common file format of raster graphic and vector graphic

If the image, such as .jpg (Joint Photographic Experts Group) or .bmp (bitmap image file), is not in SVG or CAD format, it is needed to transform the file to vector graphic. The plotter cannot draw the raster graphic but vector graphic. It needs to use the draw programs to analyze the image discrete

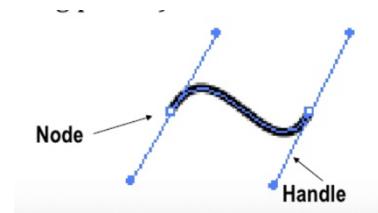


Figure 4 The concept of raster image to vector image conversion

set of points, then connect these points together. After sampling, these dots form a line, mathematical formulas will be used to define the lines, shapes and curves to build a vector graphic. The shapes of vector graphic can be edited by moving points called node.

### 1.2.2 SVG file

The SVG format is a famous format in XY plotter. It is because that the file has recorded the vector function. The vector function is stored in XML file. Although it can only draw two-dimensional graphics, it can draw dynamic and interactive graphics. Its file size is quite small too. As a result, it is famous for people used in logo design because its size and scalability

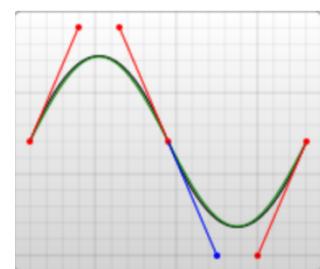


Figure 6 Draw Curve by two control points

To transform .jpg or another image to .svg, it needs to do the sampling, and change them into mathematical formulas, then save them in the path, which located in XML file.

SVG predive a set of mathematical formulas for user do the conversion.

M = moveto

L = lineto

H = horizontal lineto

V = vertical lineto

C = curveto

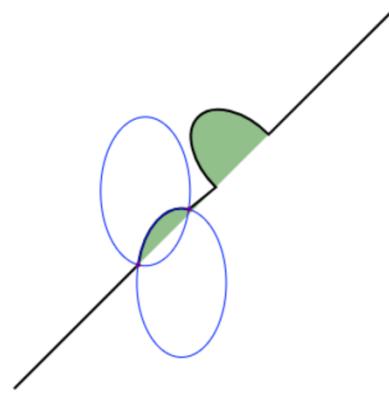
S = smooth curveto

Q = quadratic Bézier curve

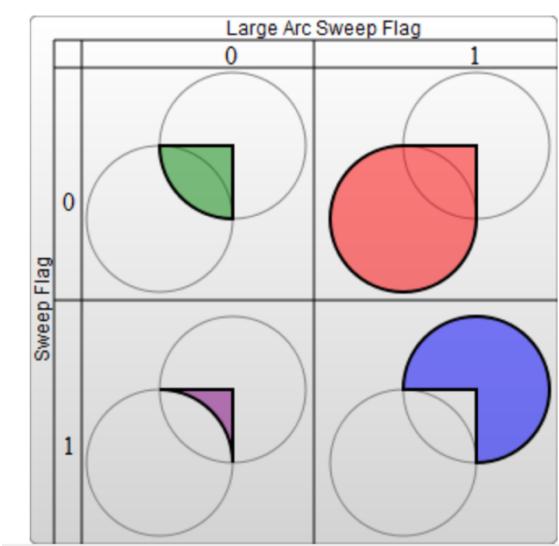
T = smooth quadratic Bézier curveto

A = elliptical Arc

Z = closepath

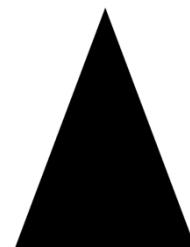


*Figure 7 An example with two ellipses formed by four different arcs.*



*Figure 9 SVG with colour*

The most common <path> element used is horizontal lineto, vertical lineto, quadratic Bézier curve and curveto. According to the above path elements, user can know where the line started, how the line moving, and where the line ended. Although there are 7 elements for drawing path, it is enough to draw the curve, circle and elliptical Arc etc. Moreover, SVG can be colorful.



*Figure 8 An simple example code of drawing an triangle*

There is a simple example code of drawing an triangle in SVG format

```
<svg height="210" width="400">
<path d="M150 0 L75 200 L225 200 Z" /></svg>
```

### 1.3: Marketing Research

After doing the research, in Hong Kong market, most of the office is using laser printer or inkjet printer as their printing method. The reason is price and the speed of the printer.

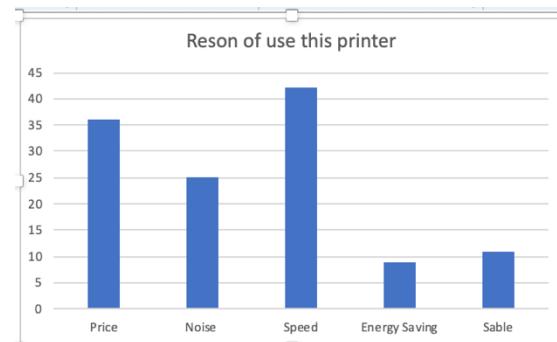


Figure 10 Reason of use this printer

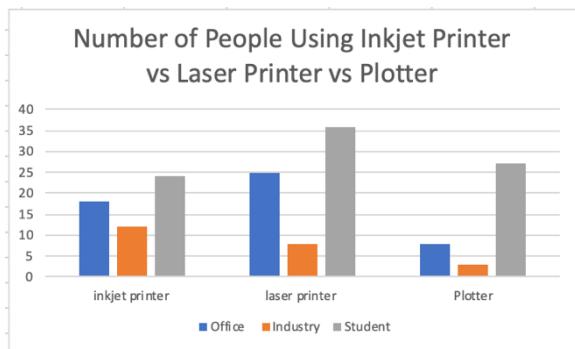


Figure 11 Number of People Using Inkjet Printer vs Laser Printer vs Plotter

Comparing the Inkjet Printer, Laser Printer and Plotter. Most of people is using Laser Printer, and then inkjet printer and the last is plotter. However, there is also has market potential as there's still has demand in plotter.

For people who using plotter are most come from the education industry. Most of them are student or teacher. Using plotter in education usage, especially in STEM (Science, Technology, Engineering and Mathematics) teaching and learning. Moreover, there also some designer and people from measuring industry using plotter for working purpose. For most of people from education industry. They require the plotter to be wireless and easier to coding. For other industry, they want the price can be cheaper.

### 1.4: Target User Group

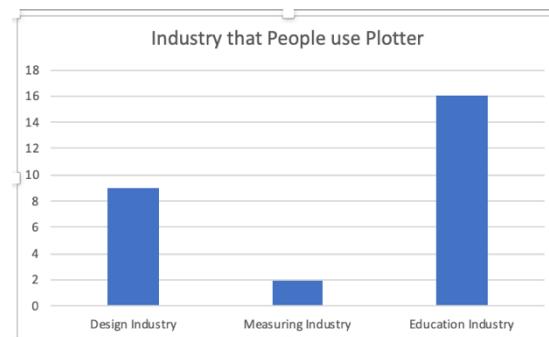


Figure 13 Industry that People use Plotter

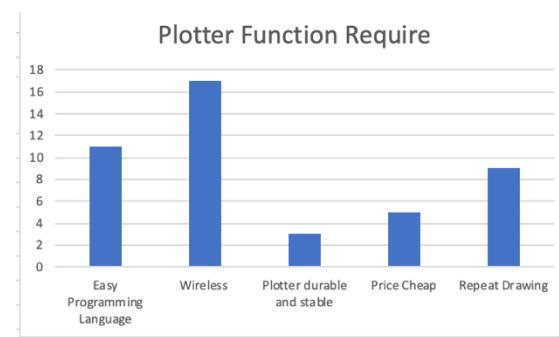


Figure 12 Plotter Function Required

According to my research in above study, we found out there are lots of people who use XY plotter are come from the education industry. Therefore, there has a high potential customer from school and college. The reason related to the government encourage the STEM activities.

To fulfill the need of these potential customer. A Plotter should be mainly focus on wireless, can redraw and easier to code. My drawing system in this project will archive these requirements. So that the need of the market can be met.

Since student and apart of teacher are the beginner in Programming or STEM aspect, the system has to be simple and clear to understand. The above target user groups need a simple app which give help to them for learning rather than a complex, professional app. Hence, we will keep our app interface and Instruction clear and easy to fit our target user needs. Therefore, a simpler and more user-friendly is needed.

## Chapter 2: Concept of the Automatically Copy Drawing System by using Android / IOS

The concept of the Automatically Copy Drawing System by using Android / IOS in this project is simplified into two parts. One part is client side and one part is the server side. For the client it will handle the data that user input, then the data will be sent from the end device to the server through the wireless medium.

Architectural Design of Drawing System :

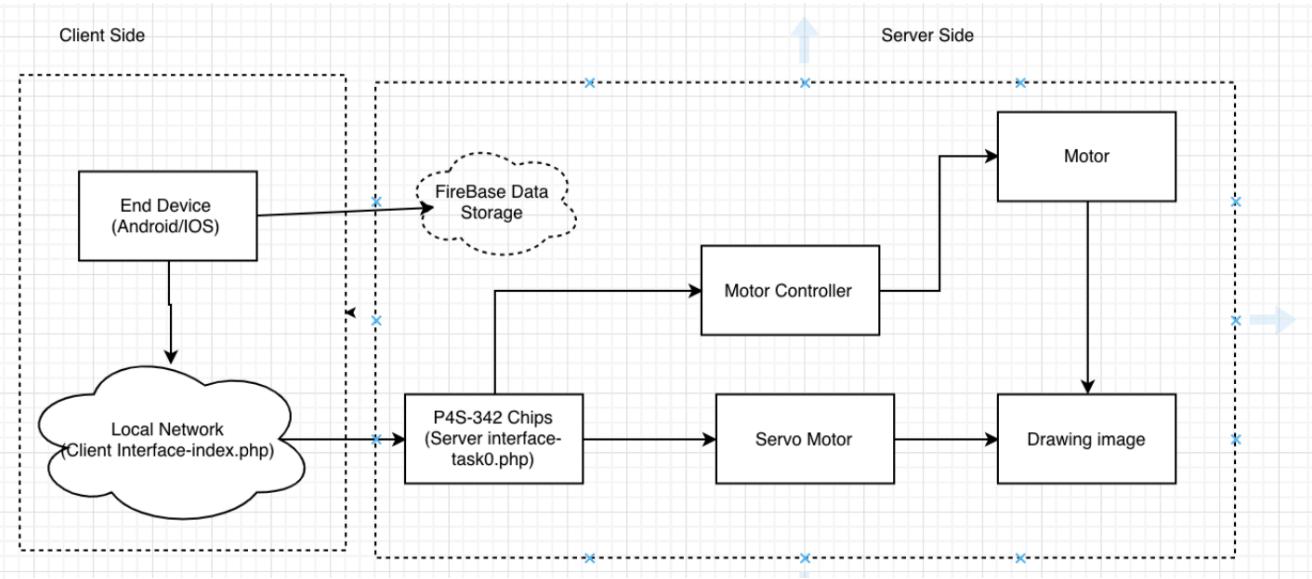


Figure 14 Architectural Design of Drawing System

As Figure 14 shown, when the user sends the input data to the end device, the data will be sent to either the cloud server or local network before getting into the server. The server in this project is using P4S-342 Chip. This chip can build a small web server and do the data handling. The data after sent to the server client web page first, then the server received the data. It will do the filtering and data checking. And then send to the motor controller and the servo motor. The motor controller will send the signal to the motor. The servo motor will do the pen up and pen down control. And the motor will control the pen movement. So that the XY plotter can draw the image instantly.

### Chapter 2.2: The special feature of Automatically Copy Drawing System

The Automatically Copy Drawing System has the following features.

- Use XY plotter draw the image by using IOS instantly.
- Use XY plotter draw the image by using Android instantly.
- Use XY plotter draw the image by using Web interface instantly.

- Android / IOS control the plotter by using wireless connection instead of wired connection.
- The speed of the plotter needed as fast as human drawing speed.
- A recorded function allow user to record the drew image.
- A redraw function allow user to redraw their image.
- Cloud Storage Service for storing the image recorded data and user login information.
- A login function required for the Mobile App.

According to the above feature and the flow chart. We will discuss the one by one start from the user interface, P4S-342 Chip and last the servo motor and stepper motor movement. So that the drawing can be completed.

### **Chapter 3: Mobile App Summary (Android / IOS)**

To develop this Mobile App is main to allow user easier to control the XY plotter. We hope that after this application has released, user can enjoy a more convenient and comfortable environment for drawing image using the XY plotter.

The Mobile App included the Android Version and the IOS Version. So that, these two kinds of mobile operation system users can also use their mobile phone to access this drawing system.

#### **3.1.1 Target Platforms and Device Configurations (Android)**

##### **3.1.1.1 Targeted Platform**

minimum API 17 : Android 4.2 (Jelly Bean) mobile phone / tablet

##### **3.1.1.2 Device Configurations**

Network :	Wifi / Mobile data network
Memory :	min 1GB
Storage :	min 40MB free space
Screen Resolution :	min 1080x1920p
Screen Orientations :	Portrait only
Touch Screen :	Enable
Keyboard :	User device configuration
Sound / Notification:	User custom setting
Language :	English / Chinese (Traditional)
Location(GPS) :	Not applicable

#### **3.1.2 Target Platforms and Device Configurations (IOS)**

##### **Information**

Seller	N/A
Size	44.3 MB
Category	P      Productivity
Compatibility	Requires iOS 9.0 or later. Compatible with iPhone, iPad and iPod touch.
Languages	English,
Age Rating	Rated 4+
Copyright	© 2018 City University of Hong Kong
Price	Free

## Chapter 4: Android App Design and Analysis

### 4.1.1 User Scenarios

Before getting start to use the functions of the app, there would be five pages show up first, which are Login Page, Registration Page, Profile Page, Cloud Storage System Page and Show Updated File Page.

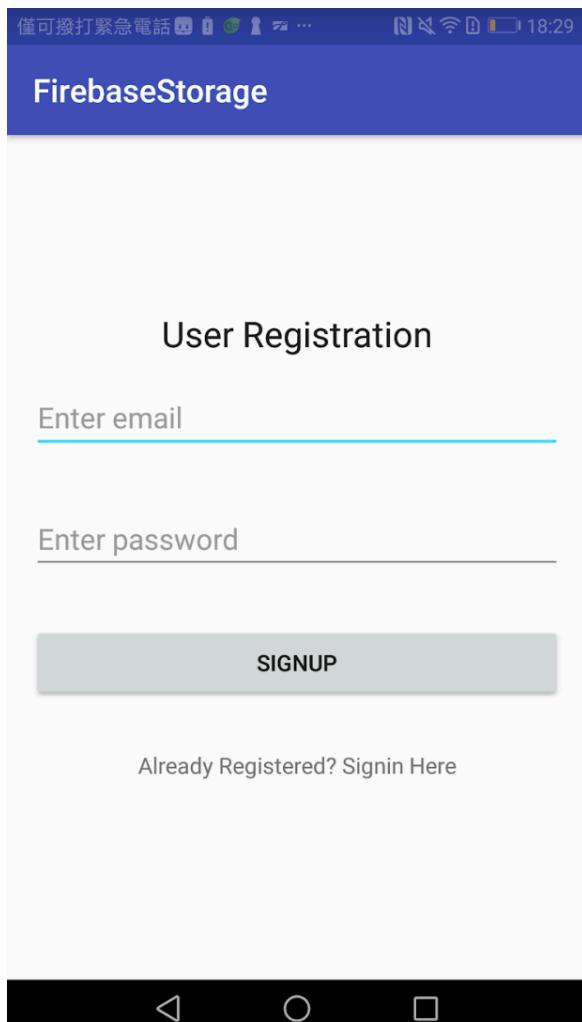


Figure 16 User Registration Page

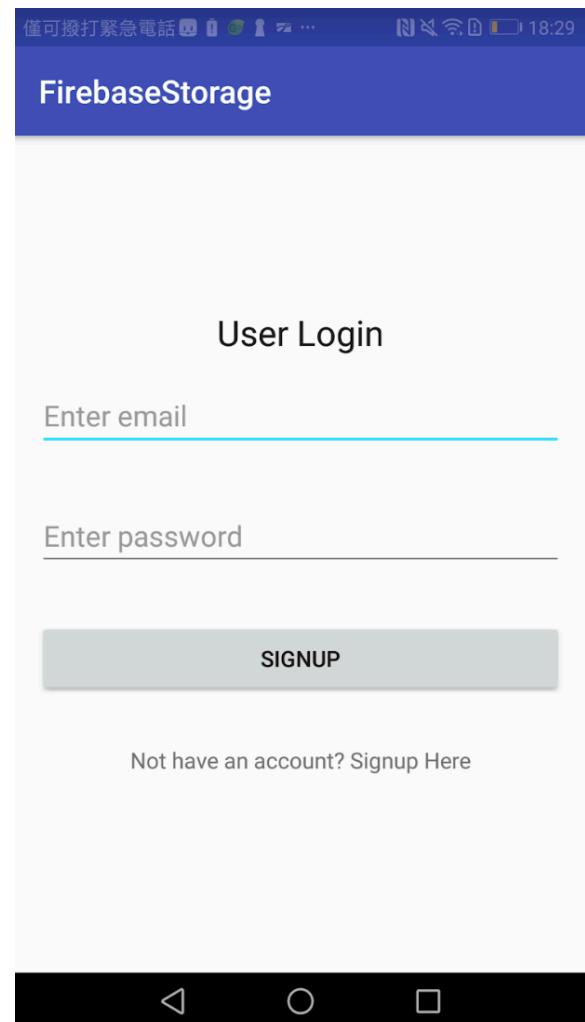


Figure 15 Login Page(Start Page)

The first one is Login Page, which act as a cover of the app, showing the Entrance for the user. User was needed use their own account to login the system before access the right to control the XY plotter. This page would get the login email and password of the user, and do the matching and saving to the firebase (a cloud database).

The second is the Registration page, this page is related to the registration of new user, including set up the login email and password. These data of new user will send to the

database, and create an entry to record the data of the new account for the user. As the email is used for login, so the same email account cannot be used for registration twice.

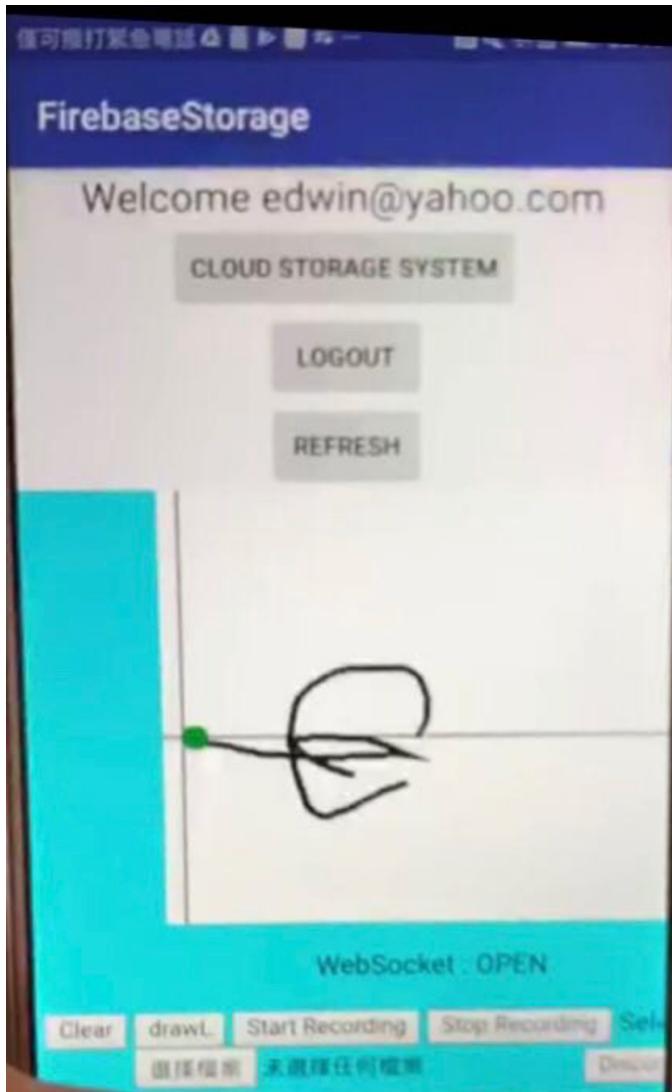


Figure 18 Profile Page with Five buttons in Canvas

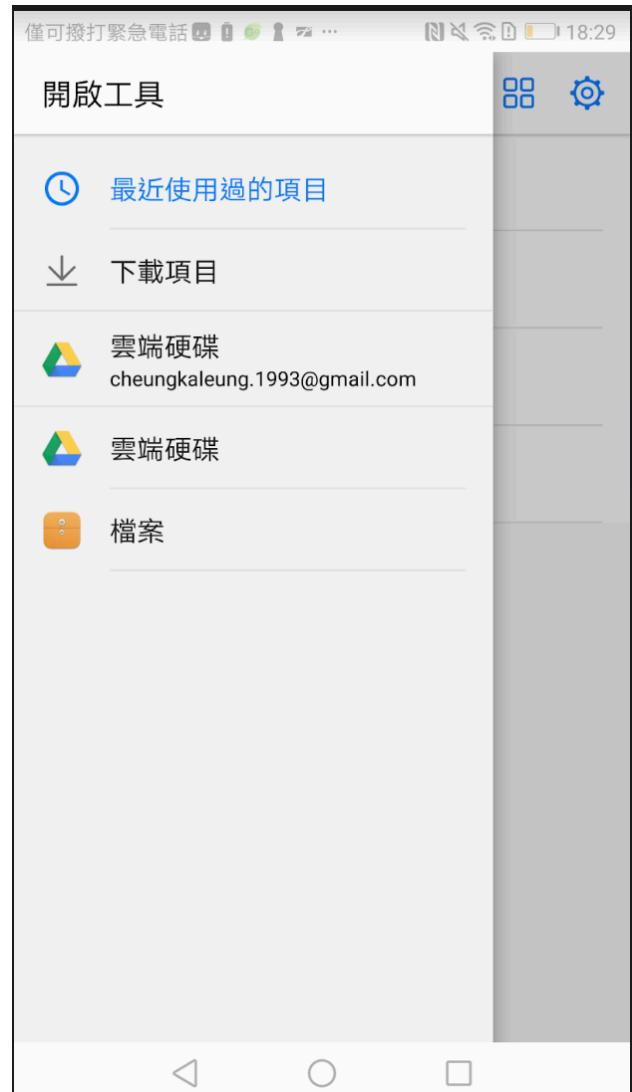


Figure 17 After clicking Open image recorded file, the app will auto popup a page to allow user to upload the file

The third is the Profile Page, this page is mainly for drawing image by using the plotter. In this page will show the username, canvas and three buttons. The canvas in this page is for user drawing. For that three buttons, one is cloud storage system button, one is logout button and other is refresh button. The cloud storage system button will lead user to the Cloud Storage System Page, logout button will log user out and refresh button is use for refresh the canvas connection.

In the Canvas, there has five more buttons. Start from left to right. They are Clear button, Start Recording button, Stop Recording button, Open Recorded file button and Connect/Disconnect to the Plotter button. Since there are two mode of drawing. One is

directly drawing the image by using the Plotter, one is recording function. The recording function will record the drawing movement when user drawing the image.

When user use the directly drawing mode, first they need to switch to Wi-Fi network to local Wi-Fi network. User then need to click the “Connect” button, if the WebSocket is successfully connected to the chip. It will show a “Web Socket Connected” on the canvas. Then user can press the white board that provided inside the canvas. When the user presses the screen, the app will detect a press and send the “PEN\_DOWN” command to the chips. Then the chips will trigger the servo motor, then the pen head will touch the paper or desk. When user drag the screen or move their finger while pressing, the command will be sent to the chip, the chip will control the motor movement. Then, the motor will control the pen. The pen will follow the user finger movement instantly. When user finger leave the screen, a “PEN\_UP” command will to chips, the servo motor then lift the pen head. The pen head leave the paper and drawing is stopped.

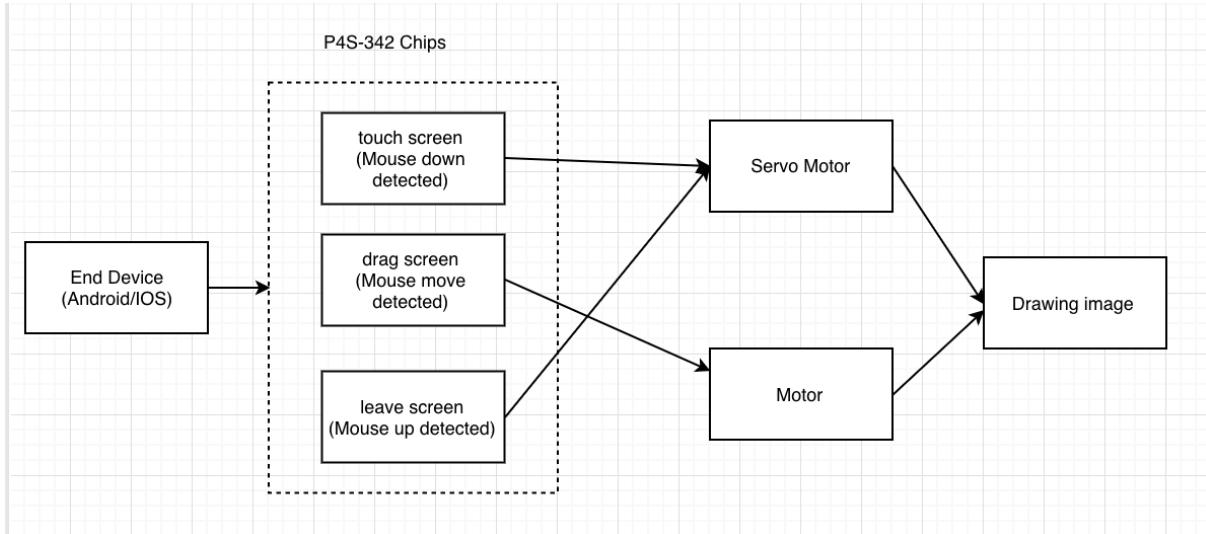


Figure 19 Drawing flow chart

When user use the recording mode, it basically same as the directly drawing mode. User only need to click the “Start Recording” Button after clicking the “Connect” Button. Then, in canvas session. User can draw by pressing the screen, dragging on the screen and

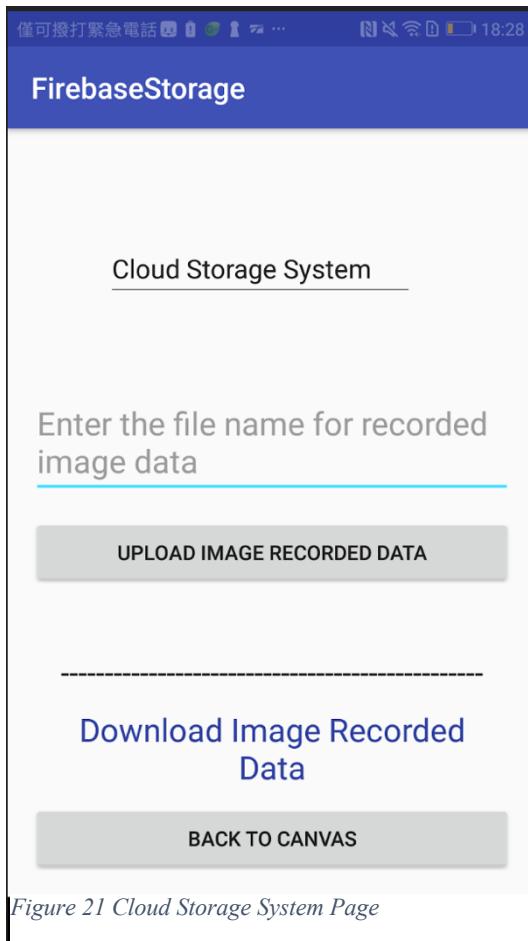


Figure 21 Cloud Storage System Page

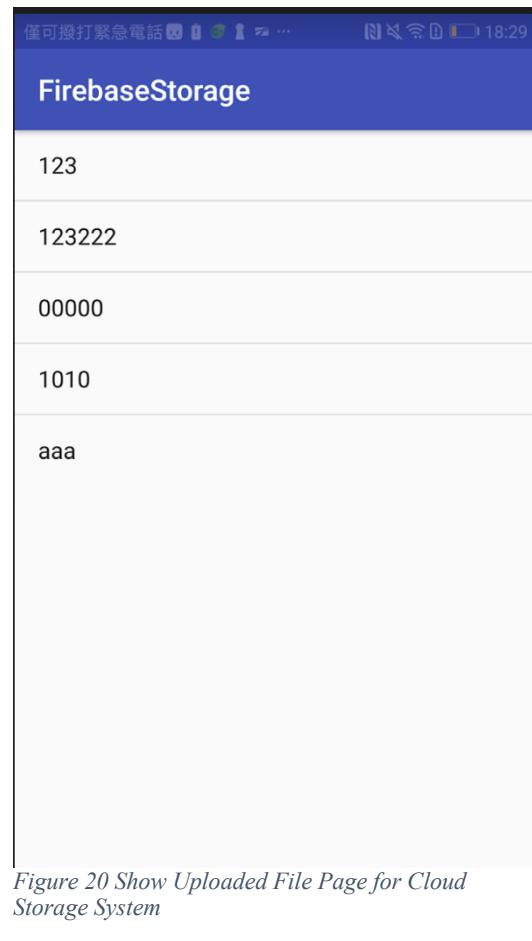


Figure 20 Show Uploaded File Page for Cloud Storage System

release their finger. After completed their drawing, user just need to click the “Stop Recording” button. Then an image recorded file will automatically download to the local phone memory storage. In image recorded file, every command sent from mobile phone to the server will be recorded and saved in this file. It included the time, command code and XY coordination. User can redraw their artwork by clicking the “Open Recorded file” button. After clicking the button, the app will pop up a dialog box allow user select which file to open. After clicked open button, canvas will automatically start to redraw the image base the data in image recorded file.

The fourth is Cloud Storage System Page. This page is mainly use for do the cloud storage. User can upload and download the file to the cloud database here. In this page there are three buttons. Start from top to bottom, they are “Upload file” button, “Download File” button and “Back to Canvas” button.

When user want to upload the file, they need ensure their have the internet connection. They can use their mobile data or public Wi-Fi. Then user need to enter the file name they want, and then click the “Upload file” button. After click the “Upload file” button, the app will browse a page for user select the file to upload. Here the app limited the user only can upload the .txt format file to the database server. Another format type is prohibited, such as .pdf or .jpg etc. After selected the file, it will automatically back to Cloud Storage System Page and user can see the uploading status in this page.

When user want to download back their file from the cloud storage. They need to click the “Download” Button. Them the app will lead the user to “Show Upload File” Page.

The fifth is Show Uploaded file Page. In this page, user can see what file he uploaded before. Also, user can download their recorded image file back to the mobile, and redraw it by sending it to the XY plotter. After clicked the file that shown in this page, the app will download the selected file to the local memory storage for user use this file to redraw the artwork in Canvas of Profile Page.

#### 4.1.2 Screen and Interactivity Design (Draft)

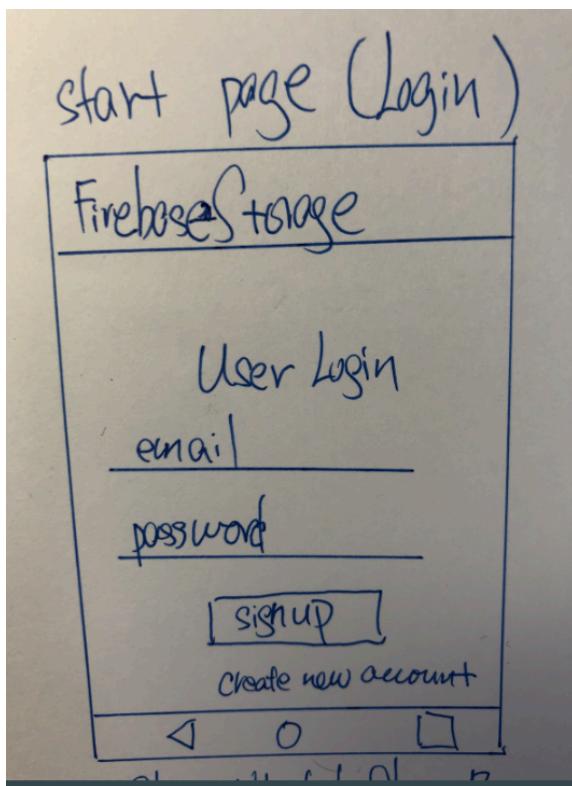


Figure 22 Drafted Start Login Page

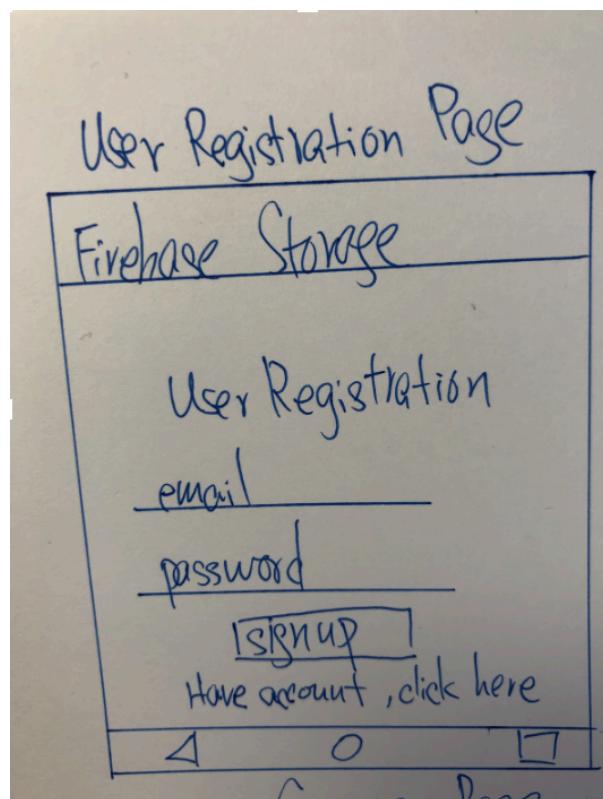


Figure 23 Drafted User Registration Page

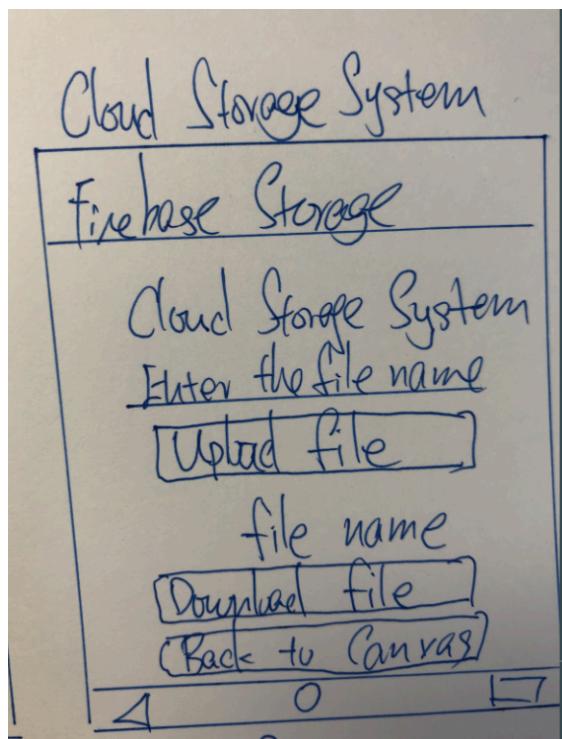


Figure 27 Drafted Cloud Storage System Page

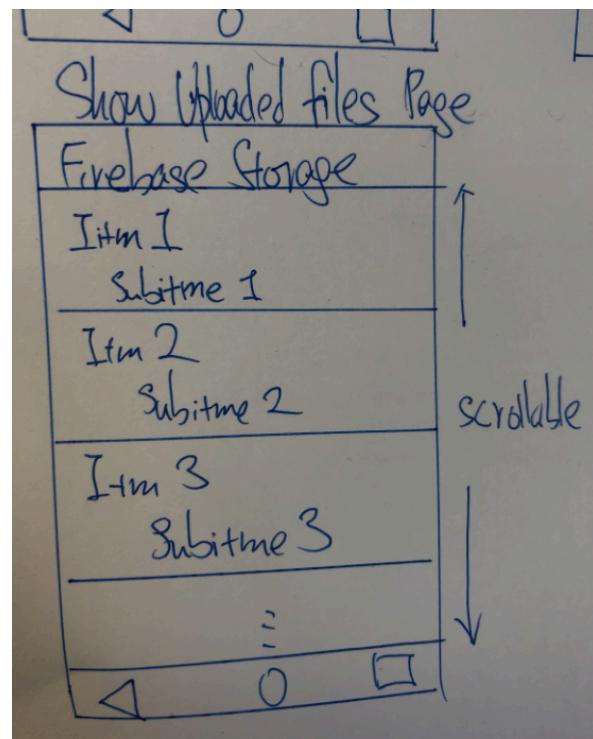


Figure 26 Drafted Show Uploaded file Page

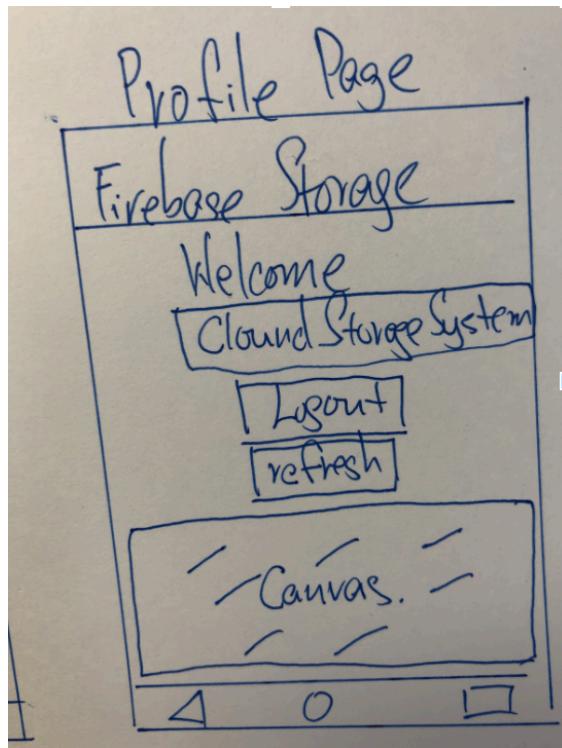


Figure 25 Drafted Profile Page

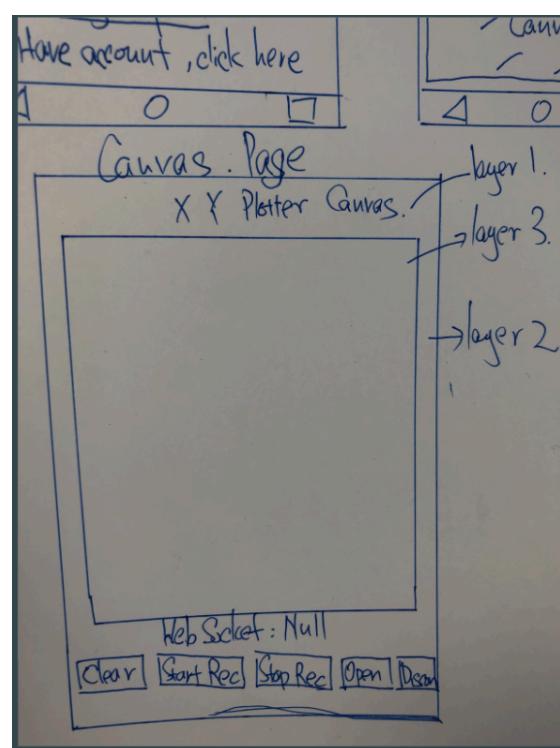


Figure 24 Drafted Canvas Page With 3 Layer setting

#### 4.1.3 Architectural Design of Android Mobile App

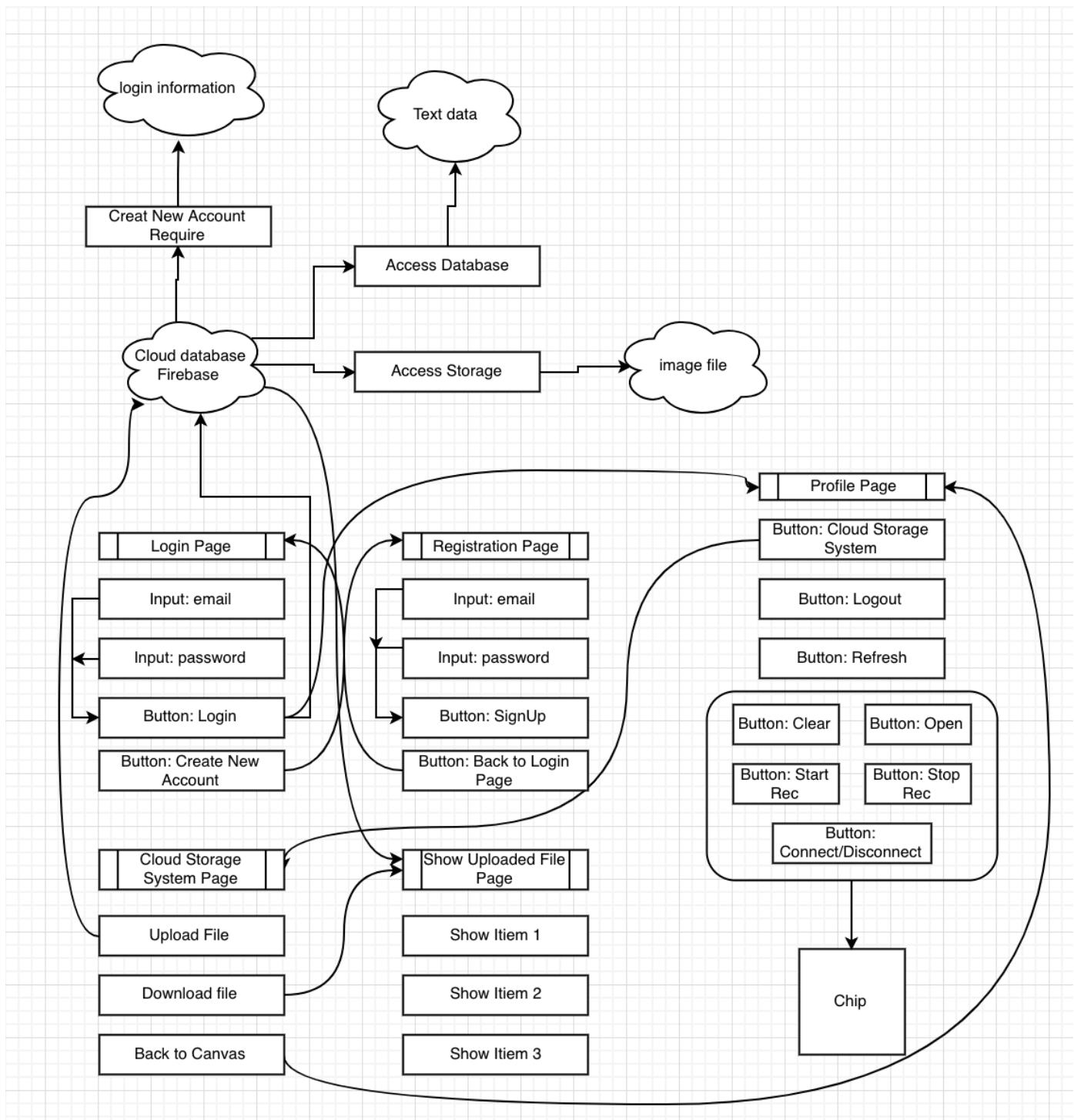
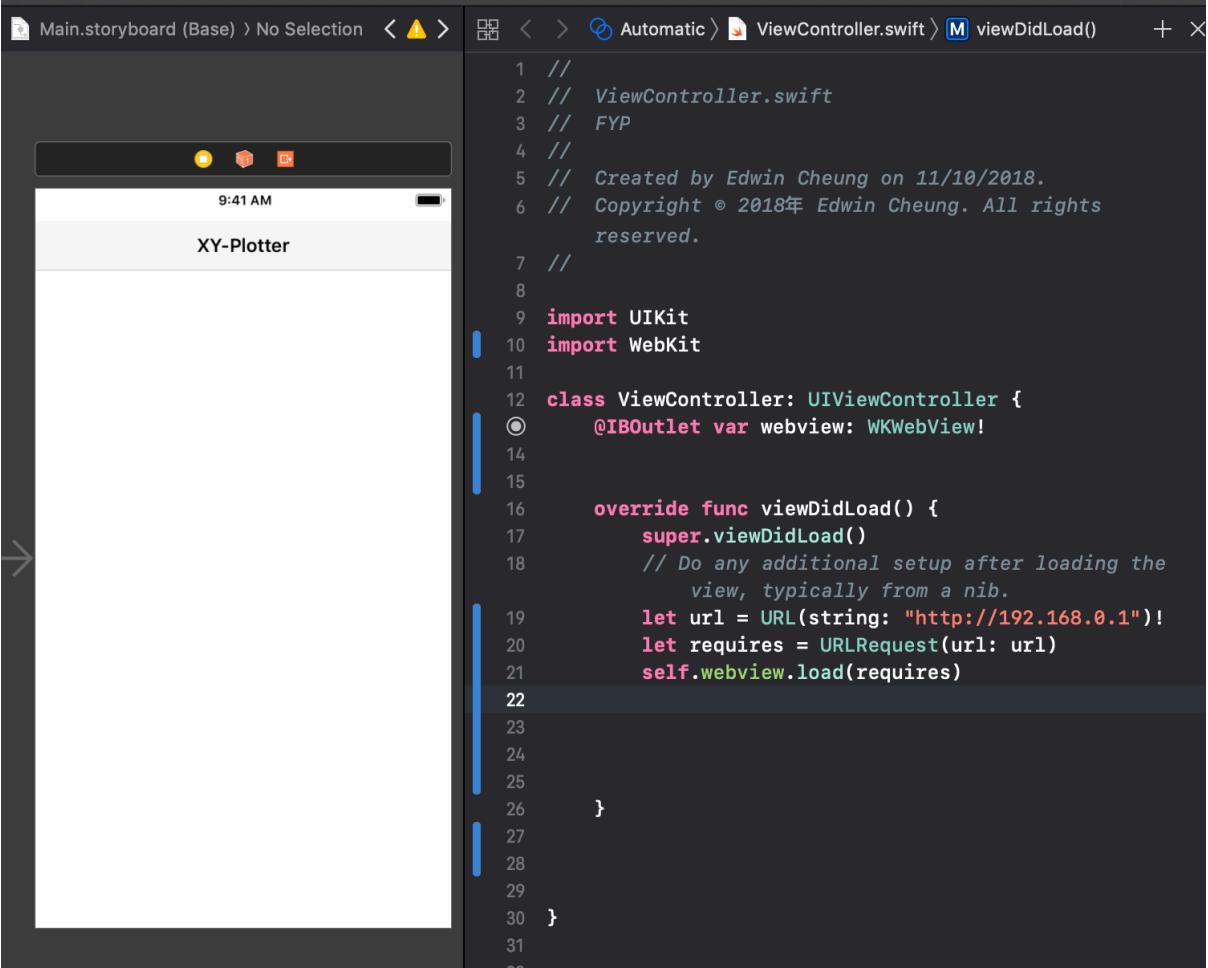


Figure 28 Architectural Design of Android Mobile App and a part of Firebase

Above graphic has shown the Architectural Design of Android Mobile App. According to the graphic, you can clear see the connection inside the App.

#### 4.2 IOS app design and Web interface

The Web interface is similar to the Canvas that represented in above android app. And the IOS app design is simple. It only linked to the web interface by using the WebKit to browse the web interface of the web client, IP 192.168.0.1.



The image shows a split-screen view of Xcode. On the left is the storyboard editor titled "Main.storyboard (Base) > No Selection". It displays a single view controller with a title bar showing "9:41 AM" and a navigation bar with three icons. The view itself is labeled "XY-Plotter". On the right is the code editor titled "Automatic > ViewController.swift > viewDidLoad()". The code is as follows:

```
1 //  
2 //  ViewController.swift  
3 //  FYP  
4 //  
5 //  Created by Edwin Cheung on 11/10/2018.  
6 //  Copyright © 2018年 Edwin Cheung. All rights  
7 // reserved.  
8  
9 import UIKit  
10 import WebKit  
11  
12 class ViewController: UIViewController {  
13     @IBOutlet var webView: WKWebView!  
14  
15  
16     override func viewDidLoad() {  
17         super.viewDidLoad()  
18         // Do any additional setup after loading the  
19         // view, typically from a nib.  
20         let url = URL(string: "http://192.168.0.1")!  
21         let requires = URLRequest(url: url)  
22         self.webView.load(requires)  
23  
24  
25     }  
26  
27  
28  
29 }  
30  
31  
32 }
```

Figure 29 IOS app design

## Chapter 5: Web Client and Web Server

### 5.1.1 Web Client Architectural Design

The web client has used the IEEE 802.11b/g to do the communication between the server and web client. Using the WebSocket to do the communication between the end device to web client.

#### 5.1.1.1 Bluetooth VS IEEE 802.11b/g

This system is using IEEE 802.11b/g to communicate between the end device and the web server. The reason of not using Bluetooth is because the range of the signal. The Bluetooth technology can only detect 5-10m diameter. However, IEEE 802.11b/g provide the range of around 100m diameter. In addition, Bluetooth need to install a device before using Bluetooth protocols.

The operating of IEEE 802.11b/g is using 2.4 GHz band, and the data rate can be 11 Mbit/s. It allows user setup the network ID and password for the security need. Therefore IEEE 802.11b/g is more security, higher data rate and larger range

As result, using IEEE 802.11b/g is much more convenient and easier to access.

	Bluetooth	IEEE 802.11b/g
Frequency	2.4Ghz	2.4Ghz
Range	10 meters	100 meter
Primary Application	WPAN	WLAN
Data transfer rate	800 Kbps	11 Mbps
Primary device	Mobile	Mobile, Notebook

Table 2 Bluetooth VS Wi-Fi

#### 5.1.1.2 Apply IEEE 802.11b/g in connecting end device and web server

To start the connect between the mobile device and the server client. The chip (P4S-342) will setup a private local network. This similar to the personal hotspot. The protocol it used here's is IEEE 802.11b/g.

After the chip setup wireless LAN, the nearby device can access into that local network. Then the end device can access the website that the chip provided. In this project, the IP address of the website is 192.168.0.1 and the port is 80, which is using http to access.

### 5.1.1.3 The flow of access from end device to the server:

1. Start connection
2. Chip establish local network, AP:MyFYP
3. Get in local network, IEEE 802.11 (Physical / Data Link Layer),
4. Enter the PC, IP:192.168.0.1 (Network Layer)
1. Get the webpage, TCP/Port:80 (Transport Layer)
2. After three-way handshake
3. Establish WebSocket keep the connection alive (Application Layer)

After the connection between end device to the server. All the command, such as received the screen press, drag and release action from the mobile device, will be send to 192.168.0.1. The web client will keep receiving the data from the end device.

After the web client receive the data, it will pass to web server to do the calculation and delivery different command to different device.

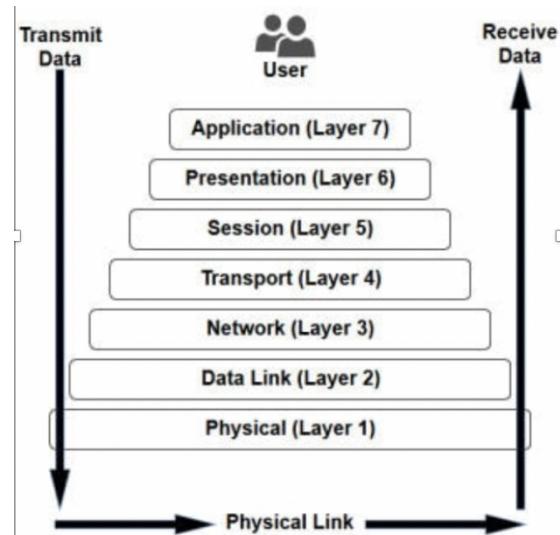


Figure 30 7 Layers of Open Systems Interconnection Model

### 5.1.1.4 Web Socket VS HTTP

Web Socket is similar to HTTP protocol. However, they usually used in different way. For HTTP protocol, the connection needed to establish each time. At the same time, Web socket protocol only need to establish once after the TCP connected. If the client side need to keep a long-time connection, it is recommended to use web socket protocol for the connection. It's because this can reduce the overhead problem.

	HTTP	WebSocket
Duplex	Half	Full
Messaging Pattern	Request response	Bi-directional
Overhead	100s of bytes	2-6 bytes
Latency	New Connection each time	None (Because it use exiting connection)

Table 3 Web Socket VS HTTP

### 5.1.1.5 Web Socket Application

In this project, it used web socket to keep the connection alive between the server and the end device.

This project chooses to use web socket to connect between the client and server, mainly because it only needs to do the three-way handshake once, after then it can maintain a long and high quality of duplex connection. Moreover, the size of its header is small.

To establish the WebSocket, it needed to do the three-way handshake first. After the TCP/IP connection completed, then the web socket will start its connection.

```
function wc_onclick()
{
    if(ws == null)
    {
        ws = new WebSocket("ws://<?echo _SERVER("HTTP_HOST")?>/xy_plotter", "csv.phpoc");
        document.getElementById("ws_state").innerHTML = "CONNECTING";

        ws.onopen = ws_onopen;
        ws.onclose = ws_onclose;
        ws.onmessage = ws_onmessage;
    }
    else
        ws.close();
}
```

Figure 31 Web Socket Application in client side

## Chapter 6: The Canvas design

The canvas here has three main function. one is setup the connection by using WebSocket (talked in Chapter 5), one is building a canvas for user drawing, the other is the recording pen movement function (This will talk the later chapter).

### 6.1.1 The Programming Language

The Canvas Layout is writing by using the PHP and JavaScript. It's because in client-server connection, it needs the script to handling the data. Using PHP can handle the server-side scripting language. And JavaScript can handle the client-side scripting language. Comparing to other programming language such as pythons. PHP and JavaScript can better handling data between the backend server and frontend client interface.

### 6.2.1 The Canvas Layout

In web design, the Canvas is formed by 3 layers. Layer 1 is the canvas that for user drawing. Layer 1 will detect the X-axes press, drag and release action that send from the phone. Layer 2 will detect the Y-axes press, drag and release action that send from the phone. So that canvas can follow the XY-axes drawing movement. Layer 3 is background image.

```
layer_1 = document.getElementById("layer_1");
layer_2 = document.getElementById("layer_2");
layer_3 = document.getElementById("layer_3");

var body = document.getElementsByTagName("BODY")[0]
body.addEventListener("touchstart", disable_zoom);
body.addEventListener("touchend", disable_zoom);
body.addEventListener("touchmove", disable_zoom);
body.addEventListener("mousedown", disable_zoom);
body.addEventListener("mouseup", disable_zoom);

layer_1.addEventListener("touchstart", mouse_down);
layer_1.addEventListener("touchend", mouse_up);
layer_1.addEventListener("touchmove", mouse_move);
layer_1.addEventListener("mousedown", mouse_down);
layer_1.addEventListener("mouseup", mouse_up);
layer_1.addEventListener("mousemove", mouse_move);

ctx1 = layer_1.getContext("2d");
ctx1.translate(0, canvas_height);

ctx2 = layer_2.getContext("2d");
ctx2.translate(0, canvas_height);

ctx3 = layer_3.getContext("2d");
ctx3.translate(0, canvas_height);
```

Figure 32 The Canvas Layout

### 6.1.3 The Pen command in Canvas

#### 6.1.3.1 Pen Down algorithm

In above canvas, it will detect press, drag and release action. For press action detected, a pen down command will be send to the web server by using the WebSocket protocol.

```
ws.send(CMD_PEN_DOWN + " " + x +
" " + y + "\r\n");
```

```
function mouse_down()
{
    if(isReplaying)
        return;

    if(event.targetTouches)
    {
        event.preventDefault();
        if(event.targetTouches.length > 1)
            return;
    }

    event_handler(event, "DOWN");

    if(ws == null || ws.readyState != 1)
        return;

    ws.send(CMD_PEN_DOWN + " " + x + " " + y + "\r\n");
    record(CMD_PEN_DOWN, x, y);
```

Figure 33 Mouse Down when detected screen press -client side scripting

And then, after the server received the ws command, it will control the servo motor change the gear clockwise to 180 degree. So that the pen head touch the desk or paper.

```
function pen_down()
{
    $angle = 180;

    $width = WIDTH_MIN + (int)round((WIDTH_MAX - WIDTH_MIN) * $angle / 180.0);

    if(($width >= WIDTH_MIN) && ($width <= WIDTH_MAX))
        ht_pwm_width(2, $width, PWM_PERIOD);
}
```

Figure 34 Pen Down -Server side scripting

### 6.1.3.2 Pen Up algorithm

The Pen Up algorithm very similar to Pen Down that mentioned above. They are also using the ws to send the command to the server. But the different is when server received the Pen Up command. It controls the servo motor change the gear clockwise to 110 degree. So that the pen head cannot touch the desk or paper.

```
function pen_up()
{
    $angle = 110;

    $width = WIDTH_MIN + (int)round((WIDTH_MAX - WIDTH_MIN) * $angle / 180.0);

    if(($width >= WIDTH_MIN) && ($width <= WIDTH_MAX))
        ht_pwm_width(2, $width, PWM_PERIOD);
}
```

Figure 35 Pen Up command

```
110
111 function xy_goto($x, $y)
112 {
113     global $mode;
114
115     if($x < TOUCH_OFFSET)
116         $x = TOUCH_OFFSET;
117     if($x > (MAX_X - TOUCH_OFFSET))
118         $x = MAX_X - TOUCH_OFFSET;
119
120     if($y < TOUCH_OFFSET)
121         $y = TOUCH_OFFSET;
122     if($y > (MAX_Y - TOUCH_OFFSET))
123         $y = MAX_Y - TOUCH_OFFSET;
124
125     $x0 = (int)step_cmd(SID_X, "get pos") / $mode;
126     $y0 = (int)step_cmd(SID_Y, "get pos") / $mode;
127
128     $delta_x = $x - $x0;
129     $delta_y = $y - $y0;
130
```

Figure 36 Pen movement using XY/goto command

### 6.1.3.3.2 The Sampling Rate

When canvas (client interface) detected a drag action, the canvas will continuously record the XY coordination every millisecond.

Since the high sampling rate will increase the size and memory usage. The low sampling rate will lower the quality of image. After the optimization, the Sampling Rate here is using 20Hz. Which mean that 1sample take around 0.046575342465753 sec and 1sec take 21.470588235294118 samples.

1542253410692	1	22	2118
,1542253411096	2	22	2097
,1542253411146	2	22	2071
,1542253411180	2	22	2036
,1542253411212	2	22	1997
,1542253411230	2	22	1971
,1542253411246	2	26	1945
,1542253411263	2	30	1924
,1542253411297	2	35	1881
,1542253411313	2	39	1859
,1542253411330	2	43	1837
,1542253411347	2	48	1816
,1542253411363	2	52	1785
,1542253411397	2	56	1742
,1542253411429	2	65	1716
,1542253411463	2	65	1686
,1542253411480	2	65	1664
,1542253411497	2	65	1634
,1542253411513	2	65	1608
,1542253411530	2	65	1578
,1542253411546	2	65	1543
,1542253411563	2	65	1509
,1542253411580	2	65	1470
,1542253411597	2	65	1440

Figure 37 The number of sample has been taken every second.  
Sampling rate optimization= 20Hz

#### **6.1.3.3.3 The Server side data handling**

The canvas will record the XY coordination every 5ms. Then it will send the ws command to the server side. After the data received from web client side, P4S chip will calculate the speed, acceleration and coordination. After calculate the best movement, it will form two set of data, one is X coordination data, the other is Y coordination data. They will send to two different stepper motor controller, one is controlling X stepper motor and other is control Y stepper motor. Last, these two motor will move instantly and complete the drawing.

## **Chapter 7 Hardware Component**

### 7.1.1 P4S-342 Chip

P4S-342 Chip is Core Component in this project. It is used to setup the AP, wireless local network, setup a web server, connecting end device and the motor and do lots of data handling and processing.

## The function of the P4S-342:

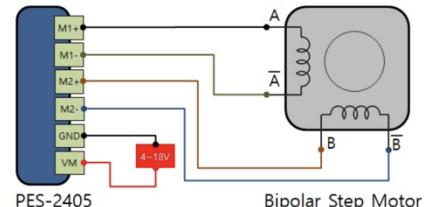
- Provides IEEE802.11b/g Wireless LAN
  - Provides 2 UART ports
  - Provides 4 hardware timer
  - Provides I2C and SPI interfaces
  - Provides TCP/IP stacks
  - Provides a Web Server
  - Support Websocket, Telnet, SSH, SSL
  - Provides the various libraries such as  
Email, DNS, MySQL

The diagram illustrates the layout of the PAS-342 RS microcontroller board. It features a central ATmega328P microcontroller with various pins labeled. Key components include a USB port (J3), a power section with a 5V regulator (U2001/U2003), and several connectors (J1, J2, J4) for interfacing with external modules like a GPS or WiFi module. Dimensions are provided for the board's overall size (56.0 x 34.9 mm) and internal components. A central text area on the board reads "PHP RAKHS MADE IN KOREA".

*Figure 38 Figure 37 The blue print of P4S-342 Chip*

### **7.1.2 Stepper Motor Controller**

The Stepper Motor Controller is used for power supply, motor identification, control the speed, angle and acceleration of the stepper motor.



*Figure 39 Stepper Motor Controller*

The Motor used in this project is Stepper Motor. It is different to the DC motor. The stepper motor can control the angel movement. Therefore, it can accurately draw the image without error. The power of the stepper motor need 5V to run it.

## The 42BYG Stepper Motor Specifications :

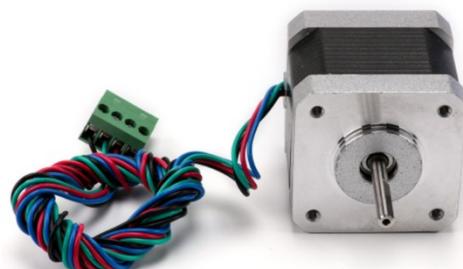
## PHASE · 2PHASE STEP

ANGLE : 1.8+-5%°/STEP

RATED VOLTAGE · 12V

CURRENT : 1.7A/PHASE

RESISTANCE :  $1.5 \pm 10\%$ /PHASE



*Figure 40 The 42BYG Stepper Motor*

INDUCTION : 2.8+-20%mH/PHASE

HOLDING TORQUE : 40N.cm Min

DETENT TORQUE : 2.2N.cm

Max INSULATION CLASS : B

LEAD STYLE : AWG26 UL1007

#### 7.1.4 Servo Motor

The servo motor in this system mainly used to control the pen up and pen down action. The servo motor controls the pen up and pen down by turning the angle of the gear. Since the power consumption is very low. It is not needed a controller chip to connect the servo motor. The right graphic shows the theory of the servo motor controlling the pen up and pen down.

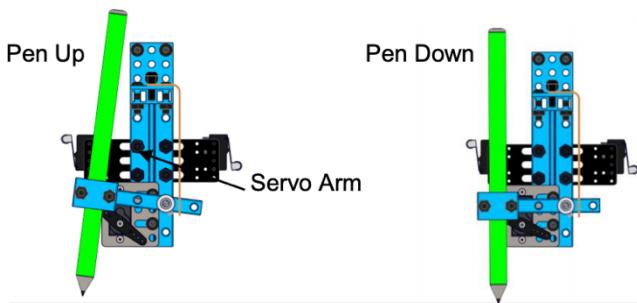


Figure 42 Servo motor Control the pen up and pen down

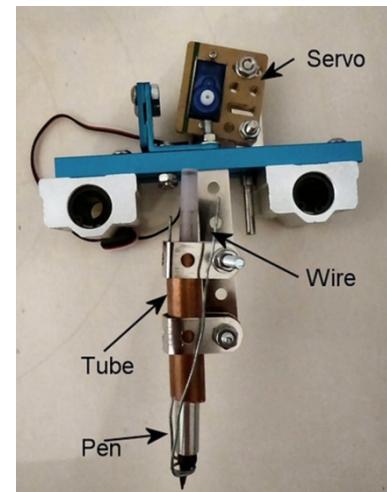


Figure 41 The theory of the servo motor controlling the pen up and pen down.

## Chapter 8: The Recording Mode

As the above chapter mentioned, there has two mode of drawing. One is directly draw the image, and other is recording mode. This mode will the drawing data coordination while user drawing the image.

### 8.1.1 Record the Pen Movement Algorithm

Above chapter has mentioned that the sampling rate of the pen movement is 20Hz. To record the pen movement, it is needed to record all the ws commands that send from the client side to the server side. If it successfully records all the ws commands, it can redraw the image again according to those ws commands.

The algorithm is to keep track the ws command sending from client to server.

The graphic on the right is an function to record the ws function.

Since we have known that the ws command will be sent when there has “PEN\_UP”, “PEN\_DOWN”

and ”PEN\_MOVE”. Therefore, the record function will be placed in pen up, pen down and pen move function. Then, all the ws command can be recorded.

```

223 - function record(command, x , y){
224 -     if(isRecordMode){
225 -         if((command == CMD_PEN_UP || command == CMD_MOVE)
226 -             && !hasFirstPenDown){
227 -             return;
228 -         }
229 -
230 -         if(command == CMD_PEN_DOWN && !hasFirstPenDown)
231 -             hasFirstPenDown = true;
232 -
233 -         if(prevCmd == CMD_PEN_UP && command == CMD_MOVE)
234 -             return;
235 -
236 -         var currentTime = new Date().getTime();
237 -
238 -         var cmdStr = currentTime + " " + command;
239 -         if(command != CMD_PEN_UP){
240 -             cmdStr += " " + x + " " + y;
241 -         }
242 -         console.log("Recording : " + cmdStr);
243 -         cmdStr += "\n";
244 -         recorded_commands.push(cmdStr);
245 -         prevCmd = command;
246 -     }
247 - }
```

Figure 43 Record the Pen Movement Algorithm

### 8.1.1 I/O function of Record the Pen Movement Algorithm

#### 8.1.1.1 Write Record function

When user press the strat recording button in canvas, the function will be active.

After recorded the ws command, it needs to place them in the local memory address.

After user press the Stop recording button in canvas. The recording will be stop and the file will generate and download the user mobile phone automatically.

```

265 - function download(data, filename, type) {
266 -     var file = new Blob([data], {type: type});
267 -     if (window.navigator.msSaveOrOpenBlob) // IE10+
268 -         window.navigator.msSaveOrOpenBlob(file, filename);
269 -     else { // Others
270 -         var a = document.createElement("a"),
271 -             url = URL.createObjectURL(file);
272 -         a.href = url;
273 -         a.download = filename;
274 -         document.body.appendChild(a);
275 -         a.click();
276 -         setTimeout(function() {
277 -             document.body.removeChild(a);
278 -             window.URL.revokeObjectURL(url);
279 -         }, 0);
280 -     }
281 - }
```

Figure 44 Write Record function

### 8.1.1.2 Read Record function

The Read Record function will read the .txt file that user uploaded in canvas. The Read Record function will read each line of the .txt file. There will be a loop to keep looking the ws command in file. In the file the first column is the time, the second is command code. 1 is pen down, 2 is pen move and 3 is pen up.

```

283 function execute_commands(){
284     isReplaying = true;
285
286     var firstTime = 0; // new Date().getTime();
287
288     for(var i = 0 ; i < recorded_commands.length ; i++){
289         var cmdStr;
290         if(i > 0)
291             cmdStr = recorded_commands[i].substring(1);
292         else
293             cmdStr = recorded_commands[i];
294
295         // console.log(i + ":" + cmdStr);
296         var args = cmdStr.split(' ');
297         // time CMD ( x y )
298
299         if(firstTime == 0){
300             // 1st command , MUST be PEN_DOWN
301             ws.send(args[1] + ' ' + args[2] + ' ' + args[3] + "\r\n");
302             firstTime = args[0];
303             console.log("1st command : " + args[1] + ' ' + args[2] + ' ' + args[3]);
304         } else {
305
306             var delta = args[0] - firstTime;
307
308             if(delta < 0 )
309                 return;

```

Figure 45 Figure 43 Read Record function

```

1542253410692 1 22 2118
,1542253411096 2 22 2097
,1542253411146 2 22 2071
,1542253411180 2 22 2036
,1542253411212 2 22 1997
,1542253411230 2 22 1971
,1542253411246 2 26 1945
,1542253411263 2 30 1924
,1542253411297 2 35 1881
,1542253411313 2 39 1859
,1542253411330 2 43 1837
,1542253411347 2 48 1816
,1542253411363 2 52 1785
,1542253411397 2 56 1742
,1542253411429 2 65 1716
,1542253411463 2 65 1686
,1542253411480 2 65 1664
,1542253411497 2 65 1634
,1542253411513 2 65 1608
,1542253411530 2 65 1578
,1542253411546 2 65 1543
,1542253411563 2 65 1509
,1542253411580 2 65 1470
,1542253411597 2 65 1440
-----
```

Figure 46 data in recorded file

### 8.2.1 Complete the Drawing

After the Stepper motor or servo motor receive the command from P4S-342 and stepper motor controller. They will start drawing the image. Since the 42BYG motor has a high speed. The Pen movement as fast as human finger movement. And there has no time delay in this system.

## Chapter 9 The Cloud Storage System

### 9.1.1 Firebase

It is a mobile platform from Google. It provides many different cloud services features, allowing users to save and retrieve data to be accessed from any device or browser. Firebase handles the backend online element for app. And it is free of charge.

### 9.2.1 Firebase feature

In this project, we use Firebase as web, real-time database and storage server.

The firebase here mainly handles the following things:

user authentication

login account information storage

data storage

### 9.3.1 Firebase setup

Before getting started, it needs to make an account in order to gain the permission to access to the console, provide the project name (FYP\_2018) this will be used to integrate with Firebase, after that, a google-services.json file will be downloaded, paste this file in the “app” folder. In our project dashboard. In this json file, it included the authentication and identification. So that the app can use the resource through the Firebase’s API

### 9.2.2 Configuration Firebase for User Authentication

we enabled “email and password” for user authentication. Users are required to login or to register a new account.

In the AndroidManifest.xml file add:

```
<uses-permission  
    android:name="android.permission.INTERNET" />
```

登入供應商	
供應商	狀態
電子郵件/密碼	已啟用
電信業者	已停用
Google	已停用
Play 遊戲	已停用
Facebook	已停用

Figure 47 Enabled authentication methods

This line will grant the internet permission

for our app since Firebase is a public cloud, inter connection is always required. Then we need to add the following 2 dependencies in the “build.gradle”

build.gradle

```
dependencies {  
    classpath 'com.android.tools.build:gradle:2.1.2'  
    classpath 'com.google.gms:google-services:3.0.0'  
}
```

In order to use other Google APIs and Firebase, this 2 lines will grant the permission of google-services.

```
We need to add one more dependency and one apply plug-in in app/build.gradle  
compile "com.google.firebaseio:firebase-auth:9.0.2"  
apply plugin: 'com.google.gms.google-services'
```

The first line will be used for “Authentication” utility and the second line is for activate the google-services plug-in.

Also, in the Login Page, the onCreate function, we need to add:

```
firebaseAuth = FirebaseAuth.getInstance();  
FirebaseUser user = firebaseAuth.getCurrentUser();
```

firebaseAuth is a abstract class extends, by calling the getInstance() method, we can get obtain an instance of this class, the getCurrentUser() method is called to get a FirebaseUser object, this object contains information about the log-in user, then the validated method will be called:

```
firebaseAuth.signInWithEmailAndPassword(userName,  
userPassword).addOnCompleteListener(new OnCompleteListener<AuthResult>(){...})
```

This is used to validate user information according to the authentication record on Firebase, it takes 2 arguments, “userName” and “userPassword” for verification.

If users don't have login account, they will be guided by RegistrationActivity, this activity contains the following elements to be filled by users:

```
editTextEmail = (EditText) findViewById(R.id.editTextEmail);  
editTextPassword = (EditText) findViewById(R.id.editTextPassword);
```

```
buttonSignIn = (Button) findViewById(R.id.buttonSignin);
textViewSignup = (TextView) findViewById(R.id.textViewSignUp);
```

All these input data will be checked for validation and then to be sent by the method:

```
private void sendData(){...}
```

```
FirebaseDatabase firebaseDatabase = FirebaseDatabase.getInstance();
DatabaseReference myRef = firebaseDatabase.getReference(firebaseAuth.getUid());
myRef.setValue(userProfile);
```

The first object was created for accessing the firebase database, and the second object is to retrieve a location in the firebase database to read/write data, in this case, we will need to

call the `getUid()` method to generate a user-id for this newly created user, this Uid is unique in project. Finally, the `.set(userProfile)` method is called to send the above data to firebase database.

識別碼	提供者	建立時間	登入時間	使用者 UID ↑
cheung.1993@yahoo.com.hk	✉	2018年11月14..	2018年11月14..	JTsugheA09QFfiEDYf8OacjWncG2
edwin@yahoo.com	✉	2018年11月15..	2018年11月15..	NaWuIcnE41WE1SHBB1b1b4i4EI83
test@yahoo.com	✉	2018年11月14..	2018年11月15..	RHuYuQbjQSS5PUJbDKNTpczml3..
cheung@gmail.com	✉	2018年11月14..	2018年11月14..	XqWduKe8P9Oy9EQ8l7YssBIE8H1
cheunh.1993@yahoo.com.hk	✉	2018年11月14..	2018年11月14..	cSgp8sNDCfT2kOwnkjjk8lE5iqj2
cheung.2008@yahoo.com.hk	✉	2018年11月15..	2018年11月15..	ftJRFQlbxBhUUgAVlyk9uKw8RsY2

Figure 48 Account created with UID



### 9.2.3 JSON Tree Limited Structure.

Firebase is using JSON Tree Structure to saving data. Usually in another database software, such as Microsoft SQL Server, MySQL, Oracle Database etc. They can store more than one data in a row for different attributes. For example, to save a user basic data in a customer table. There will be a row recorded the user email, password.

Figure 49 User Password Encryption with JSON tree structure

However, for the JSON tree structure, there are only two columns can save the data. If one was set as primary key the left ones must have to set the data. It's unfriendly and inflexible. There is the common example of JSON tree structure

### 9.3.1 Configuration Storage

- Firebase also can act as a storage server. This storage server will store the data that user upload from their mobile. It provided 5G GB storage.
- Before using the storage function, it needs to set the permission. To allow the public user to get in the storage system.

```
1  service firebase.storage {
2      match /b/{bucket}/o {
3          match /{allPaths=**} {
4              allow read, write;
5          }
6      }
7  }
```

Figure 50 Permission setting for Storage Service

### 9.3.2 Get the pdf from the mobile storage

Since the app need to grant the right of storage permission before upload the file. The app will go to the screen to allow storage permission if the permission is not available. After granted the permission, the files is ready send to firebase.

### 9.3.2 firebase upload and download

To upload the file to firebase. First, it needs to use StorageReference library to set the upload platform. After the platform created, the data will place to "data" variable and immediately pass it to firebase.

```
StorageReference sRef = mStorageReference.child(Constants.STORAGE_PATH_UPLOADS + System.currentTimeMillis());
sRef.putFile(data)
    .addOnSuccessListener(new OnSuccessListener<UploadTask.TaskSnapshot>() {
        @Override
        public void onSuccess(UploadTask.TaskSnapshot taskSnapshot) {
            progressBar.setVisibility(View.GONE);
            textViewStatus.setText("File Uploaded Successfully");

            Upload upload = new Upload(editTextFilename.getText().toString(), taskSnapshot.getDownloadUrl
                .toString());
            mDatabaseReference.child(mDatabaseReference.push().getKey()).setValue(upload);
        }
    })
    .addOnFailureListener(new OnFailureListener() {
        @Override
        public void onFailure(@NonNull Exception exception) {
            // Handle unsuccessful uploads
        }
    });
}
```

Figure 51 Code for Upload file to internet

To download file from firebase, first it needs to retrieve upload data from firebase database by getting the database reference. After retrieve the data, user can click the item. Then the app will open the browser, the file will automatically download to local storage.

```
//adding a clicklistener on listview
listView.setOnItemClickListener(new AdapterView.OnItemClickListener() {
    @Override
    public void onItemClick(AdapterView<?> adapterView, View view, int i, long l) {
        //getting the upload
        Upload upload = uploadList.get(i);

        //Opening the upload file in browser using the upload url
        Intent intent = new Intent(Intent.ACTION_VIEW);
        intent.setData(Uri.parse(upload.getUrl()));
        startActivity(intent);
    }
});
```

Figure 52 Code for Download files from internet

## **Chapter 10: Conclusion**

The drawing system can redraw the human writing through the wireless network. It is believed that there has a market demand of wireless automatically drawing machine, especially in education industry.

The feature of the system is using pen drawing, it calculated the best movement. So that the system is draw as fast as human speed and as accurate as human drawing.

The other feature Record and replay function are introduced in the system, so that the user can keep redraw unlimited number of his graphics or text throughout the time.

In future, it can be improving the algorithm of find the pattern of human writing, or analysis the chirography of human writing. It will be having a great impact and help in human society.

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**Appendix A**

**Appendix B**

**Appendix C**