<table>
<thead>
<tr>
<th>Title</th>
<th>Smart palm reading app with auto pattern recognition (iOS platform)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author(s)</td>
<td>Cheung, Shirley (張卓慧)</td>
</tr>
<tr>
<td>Citation</td>
<td>Cheung, S. (2014). Smart palm reading app with auto pattern recognition (iOS platform) (Outstanding Academic Papers by Students (OAPS)). Retrieved from City University of Hong Kong, CityU Institutional Repository.</td>
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<td>Issue Date</td>
<td>2014</td>
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<tr>
<td>URL</td>
<td><a href="http://hdl.handle.net/2031/7383">http://hdl.handle.net/2031/7383</a></td>
</tr>
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</tr>
</tbody>
</table>
Department of Electronic Engineering

FINAL YEAR PROJECT REPORT

BENG3-INFE-2013/14- LMP-04-BENG3-INFE

Smart Palm Reading App with Auto Pattern Recognition (iOS Platform)

Student Name: Cheung Shirley
Student ID:
Supervisor: Dr. Po, L. M.
Assessor: Dr. Chan, Sammy C. H.

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

I have read the student handbook and I understand the meaning of academic dishonesty, in particular plagiarism and collusion. I declare that the work submitted for the final year project does not involve academic dishonesty. I give permission for my final year project work to be electronically scanned and if found to involve academic dishonesty, I am aware of the consequences as stated in the Student Handbook.

Project Title:
Smart Palm Reading App with Auto Pattern Recognition (iOS Platform)

Student Name: Cheung Shirley
Student ID:

Signature
Date: 20 April, 14
Abstract

It is believed that palm reading can predict future and identify personal characteristic by making use of palm lines, hand shapes and other palm features. In this paper, an algorithm was proposed to extract principle palm lines, hand shapes and fingertip positions from a photo on smartphones. The algorithm applies computer vision methods such as noise filtering, edge detection and directional detectors to accomplish the purpose. An image database was built and OpenCV was used to test the algorithm. It is found that principle palm lines can be extracted under acceptable conditions. Furthermore, a mathematical method was proposed to analyse the extracted lines. It makes use of slope and derivations to conclude prediction based on palm reading theories. Besides, mobile development approaches were researched to increase the efficiency of mobile application development. It is found that cross-platform library and web approach can be adopted in many scenarios such as e-book applications. To demonstrate the finding, three iOS mobile applications have been developed accordingly. In addition to these research areas, database and social network integration were involved to implement them as usable mobile applications. The findings may be useful for other applications such as biometric verification and health estimation.
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Part I  Project Details

1. Introduction and Objectives

Palm Reading is a traditional Chinese practice for people to know more about their personality and their future. Its theory can be modeled as a computational analysis. Owing to the popularity of mobile devices, there is a need to produce a mobile application for palm reading. This project is going to integrate the computation techniques with palm reading theories into a mobile application.

It is believed that palm reading can predict future and identify personal characteristic. Palm reading theories are based on features of palms and fingers, and most of these theories can be applied algorithms to identify and compute.

Past students has developed a simple palm reading iOS app based on theories proposed by a master, Peter So, that only requires users to draw three principle lines on their palm photo for analysis. However, there can be much more aspects for the app to discover and analyze palm features, such as palm shape, palm color, hand mount, finger size and finger position. Hence, a basic version, that is a slightly improved and bug-free version of the original app, and an advance version are going to be developed. Besides, social network is going to be integrated into the app to promote the palm reading culture. An e-book app, which aims to teach basic concepts of palm line, is going to be developed too. There are 3 applications in total are going to be developed.

Despite the fact that this is a continuous project that has already been under progress for over one year, it is expected to finish the project in this year. There are 4 objectives for this project in this year listed below:

- To develop and implement an algorithm to recognize principal palm lines
- To revise and develop new features for the Smart Palm Reading App
- To develop an iOS palm reading e-book app
- To ensure stable running of all these apps in different iOS devices
2. **Background Study**

This section outlines the background study done on the market research of existing application, palm reading theory and social media integration. It is found that some features can be added into the applications.

(a) **Market Research**

<table>
<thead>
<tr>
<th>Applications Name (Language version)</th>
<th>Share result</th>
<th>Pro / Lite</th>
<th>E-book</th>
<th>Downloads (Thousand)</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmistry. Palm Reading (English)</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>14</td>
<td>Analyze life, health, love, intelligence, sex, fortune, money, marriage and children, travel, frame and fate lines.</td>
<td>• Explanation on many palm lines • Simple and clear pictures in analysis</td>
<td>• Too much text • Troublesome for matching line patterns</td>
</tr>
<tr>
<td>Palm Reader Scan - Your destiny, reading horoscope and astrology for your hand (English)</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>68</td>
<td>Analyze palm photo on lines, line intersections, thumbs and hand shapes.</td>
<td>• Auto recognition of lines</td>
<td>• No highlight in colors for analysis</td>
</tr>
<tr>
<td>Palm Reading HD (English)</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>39</td>
<td>Analyze palm photo on life, heart, head, and Saturne lines, and also hand shapes.</td>
<td>• Detailed explanations • Auto recognition of line patterns</td>
<td>• Poor palm recognition • Taking too long time for recognition</td>
</tr>
<tr>
<td>Palm Reading Booth Pro (English)</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>32</td>
<td>Analyze palm photo on lines, fingers, space between fingers and palm shape.</td>
<td>• Simple and convenient</td>
<td>• Captured photo not in scale • High frequency and number of advertisement</td>
</tr>
</tbody>
</table>

From the above analysis, it is preferable that the apps in this project provide basic and advanced versions with no annoying advertisement. Furthermore, the e-book can be separated from the Smart Palm Reading app as another app while keeping a linkage between the apps. As the majority of palm reading apps use English, using Chinese explanations in the app in this project may attract more users in Chinese market. To provide convenient and comprehensive analysis, palm line, finger size, finger position and hand mount with an auto-recognition on hand shape and theoretical-based
analyses shall be included in the apps. Besides, saving, reviewing and sharing palm results to social media can also be included in the products.
(b) Palm-Reading Research
Peter So, a famous feng shui master, published many books on palm reading. So (Chinese Palmistry, 2007) stated that characteristics could be determined by palm reading. The following shows the palm reading features that are going to be implemented in the app.

(i) Palm Line
Each type of lines represents a specialized aspect.

<table>
<thead>
<tr>
<th>Line</th>
<th>About</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life line</td>
<td>Health</td>
</tr>
<tr>
<td>Intelligence line</td>
<td>Intelligence</td>
</tr>
<tr>
<td>Love line</td>
<td>Emotion and heart health</td>
</tr>
<tr>
<td>Marriage</td>
<td>Marriage</td>
</tr>
<tr>
<td>Mercury line</td>
<td>Intuition</td>
</tr>
<tr>
<td>Success line</td>
<td>Success and luck</td>
</tr>
<tr>
<td>Fate line</td>
<td>Destiny</td>
</tr>
</tbody>
</table>

(So, Chinese Palmistry, 2005) (So, Chinese Palmistry, 2006)

Line features such as starting-point position, curve shape and length may have different effects on the above listed aspects.

<table>
<thead>
<tr>
<th>Line name</th>
<th>Features and Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life line</td>
<td>Position</td>
</tr>
<tr>
<td></td>
<td>• High starting point – Enjoy controlling and interested in power</td>
</tr>
<tr>
<td></td>
<td>• Low starting point – Easy to argue and give up</td>
</tr>
<tr>
<td></td>
<td>• Ending point at middle – Always make impartial judgments</td>
</tr>
<tr>
<td></td>
<td>• Ending point at opposite side – like to migrate</td>
</tr>
<tr>
<td></td>
<td>Curve</td>
</tr>
<tr>
<td></td>
<td>• Narrow curve – selfish and do not care others</td>
</tr>
<tr>
<td></td>
<td>• Broader curve – active and nice to others</td>
</tr>
<tr>
<td></td>
<td>Length</td>
</tr>
<tr>
<td></td>
<td>• Long – Healthy and strong</td>
</tr>
<tr>
<td></td>
<td>• Short – Unhealthy and weak</td>
</tr>
<tr>
<td>Intelligence line</td>
<td>Length</td>
</tr>
<tr>
<td></td>
<td>• Short – not enjoy learning</td>
</tr>
<tr>
<td>Line</td>
<td>Position</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Normal       | • Normal – normal intelligence  
               • Long – enjoy thinking Curve  
               • Straight – highly analyzing brain with highly mathematic mind  
               • Non-straight with ending point lower than starting point – have balanced thinking on imaginative and factual thinking | |
| Long         | • Starting point above life line starting point – confident  
               • Starting point below life line starting point – rude and easy to argue with others | |
| Heart line   | • Ending point on position below index finger – brave to devote for love and easy to forgive others  
               • Ending point on position between middle finger and index finger – high requirement on partner and like to show off  
               • Ending point reach the other side edge – easy to be jealous  
               • Ending point on position below middle finger – only want sex and not want to devote  
               • Ending point on position before reach position below middle finger – totally do not want to devote for love | |
| Marriage     | **Number of Lines** • One – one and only one with sure for marriage  
               • Two with close – sure and clear marriage  
               • Two with far or more – much confuse on love | |
| Mercury      | • Starting point at bottom middle of palm – having a good and accurate intuition  
               • Starting point at bottom of palm near to thumb – having a better sensing ability than normal people | |
| Success      | • Ending point below intelligence line – success when young but not at elderly time  
               • Ending point between intelligence line and heart line – success in work but fail in love | |
| Fate     | • Starting point in center of palm – finish finding one’s objective and directions at around 30 year-old  
               • Starting point on the intelligence line – career starts to develop since middle-age using own intelligence  
               • Starting point on love line – having an unstable life until elderly  
               • Starting point on the bottom middle of palm – succeed in career on one’s own | |

*(So, 掌紋續篇, 2006) (So, 掌紋掌紋篇, 2005)*
(ii) **Hand Shape**  
Each hand shape represents a specific characteristic.

<table>
<thead>
<tr>
<th>Hand</th>
<th>Description</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fingers</td>
<td>• Hardworking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Friendly</td>
</tr>
<tr>
<td></td>
<td>• Straight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rectangle in shape</td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rectangle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fingers</td>
<td>• Helpful</td>
</tr>
<tr>
<td></td>
<td>• Long</td>
<td>• Enjoy thinking</td>
</tr>
<tr>
<td></td>
<td>• Bony</td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Thin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Narrow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fingers</td>
<td>• Smart</td>
</tr>
<tr>
<td></td>
<td>• Round in shape</td>
<td>• Clever</td>
</tr>
<tr>
<td></td>
<td>• Non-bony</td>
<td>• Much idea in mind</td>
</tr>
<tr>
<td>Palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Round in shape</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fingers</td>
<td>• Polite</td>
</tr>
<tr>
<td></td>
<td>• Long</td>
<td>• Respect others</td>
</tr>
<tr>
<td></td>
<td>• Thin</td>
<td></td>
</tr>
<tr>
<td>Palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Thin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Narrow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Palm</td>
<td>• Trustful</td>
</tr>
<tr>
<td></td>
<td>• Shape between circle and rectangle</td>
<td></td>
</tr>
</tbody>
</table>
(iii) **Palm Skin Color**
Each palm color has a meaning or description towards life.

<table>
<thead>
<tr>
<th>Color</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Having others help to reach goals in life</td>
</tr>
<tr>
<td>Pink</td>
<td>Success without much workload in life</td>
</tr>
<tr>
<td>Red</td>
<td>Busy and rich life</td>
</tr>
<tr>
<td>Stasis Red</td>
<td>Hard life and easy to have accident</td>
</tr>
<tr>
<td>Dust</td>
<td>Busy and heavy workload life</td>
</tr>
<tr>
<td>Greenish yellow</td>
<td>Easy to sick throughout life</td>
</tr>
<tr>
<td>Greenish white</td>
<td>Always scared and shocked</td>
</tr>
<tr>
<td>Green</td>
<td>Have a bad digestive system in body</td>
</tr>
</tbody>
</table>

*(So, 中國掌相, 2007)*

(iv) **Hand Mount**
Hand has several mounts. Each mounts show a personality and if it is strong and huge, then it dominates and that person has that personality.

<table>
<thead>
<tr>
<th>Mount Name</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jupiter Mount</td>
<td>Power and Leadership</td>
</tr>
<tr>
<td>Saturn Mount</td>
<td>Academic and Mysterious</td>
</tr>
<tr>
<td>Sun Mount</td>
<td>Art and Reputation</td>
</tr>
<tr>
<td>Mercury Mount</td>
<td>Science and Business</td>
</tr>
<tr>
<td>Upper Mars Mount</td>
<td>Patience and Resistance</td>
</tr>
<tr>
<td>Lower Mars Mount</td>
<td>Aggression and Struggle</td>
</tr>
<tr>
<td>Moon Mount</td>
<td>Mysterious and Imagination</td>
</tr>
<tr>
<td>Venus Mount</td>
<td>Love</td>
</tr>
</tbody>
</table>

*(So, 掌丘掌紋篇, 2005)*
(v) Fingers
Fingers can be divided into 3 parts and each part has its meaning towards characteristic. If a particular part is fattest, it dominates and represents personality of that person.

<table>
<thead>
<tr>
<th>Fattest Part</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Part</td>
<td>Thinking</td>
</tr>
<tr>
<td>Middle Part</td>
<td>Reality</td>
</tr>
<tr>
<td>Bottom Part</td>
<td>Instinct</td>
</tr>
</tbody>
</table>

(So, 掌丘掌紋篇, 2005)

Fingers position can be used in palm reading as guessing relationship. Middle finger means oneself and other fingers represent other people. If distance between a particular finger and middle finger is shorter, then its represented relationship is closer and better.

<table>
<thead>
<tr>
<th>Finger that Closer to Middle Finger</th>
<th>Better Relationship with</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thumb</td>
<td>Parent and Grandparents</td>
</tr>
<tr>
<td>Index finger</td>
<td>Brothers and sister</td>
</tr>
<tr>
<td>Ring finger</td>
<td>Wife or husband</td>
</tr>
<tr>
<td>Baby finger</td>
<td>Son or daughter</td>
</tr>
</tbody>
</table>

(So, 中國掌相, 2007)

(c) Social Media Integration
Social media is a global popular phenomenon such that many people are involving in this most popular online community worldwide. Social media are web-based and practice that share content, opinions, insights, experiences, perspectives, and media (Cohen, 2011). As stated in conScore Media Metrix from March 2007 to October 2011, there is a 174% increase of social networking audience. It is nearly 1 in 5 minutes online is spent on social networks nowadays. Statistic from conScore Media Metrix (Shaw, 2012) also showed the largest decline in engagement with email and instant but highest increase in engagement with social networking.

The upward trend of social networking is expected to increase continuously. Therefore, integration of social network into the app is necessary. It can enable the app lasts longer in the market.
3. **Design and Methodology**

(a) **Automatic Recognition Algorithm**
An auto-recognition algorithm is designed and implemented in this project to recognize palm shape, finger and palm lines. This part has been jointly done with a student, Chung Tsz Yeung, who works on a similar app with me on android platform. The below figure shows the overview of the process where input is a hand image and output are extracted finger, palm and palm line. The output is used to carry out palm reading analysis.

![Diagram of the process](image)

**Fig. 1**

(i) **Assumption**
There are some constraints on the input hand photo for the algorithm to work. The input photo should be
- A right hand in upright orientation
- Taken in normal lighting condition
- Background is stable and dark
- All fingers and the whole palm are visible
- Fingers should be separated apart

Fig. 2 shows an example of a suitable image.
(ii) **Pre-processing**

The pre-process procedure is to convert the input raw color photo into a binary image. This converts the image to a suitable format for parsing. The raw photo is converted to BGR (a variation of RGB) color format at the beginning.

**Desaturation**

The method used by OpenCV was chosen to desaturate a color photo into grayscale photo. As the input color model uses red, green and blue as its primary color, the graylevel of each pixel can be defined by the following formula:

\[
Grayscale = 0.299R + 0.587G + 0.144B
\]

where R, G, B are illumination level of red, green and blue colors respectively. 

(Opencv dev team, 2013)

Fig. 3 shows a desaturated photo after applying the method on Fig. 2.

**Hand Extraction**

Image thresholding is used to transform the grayscale image into a binary image. A histogram on the graylevels used is needed for this purpose (see Fig. 4). The threshold value can be determined from the local minima between 50 and 100. A pixel belongs to the area of the hand if its graylevel is higher than the threshold value. Our experiments show the threshold value lies around 60 or 90. Fig. 5 shows a binarized photo after undergoing the thresholding process.
Dilation
Noise must exist in the image and this affect our result. Thus, it is necessary to remove the noise. Fig. 6 act as an example to show even the original hand image fulfills all requirements of the input but noise still existing on binary image result (see Fig. 7).

A flood filling technique was used to remove all components that are not connected to the center of palm. The center of palm may be defined as the point at 30% height from the bottom and center horizontally. The first step is to fill another value \( t_d \) at the center of palm so that the value \( t_d \) is dilated to the whole component that connecting to the center point of palm (see Fig. 8). The second step is run another thresholding using

\[
I'(x, y) = \begin{cases} 
1, & I(x, y) = t_d \\
0, & I(x, y) \neq t_d 
\end{cases}
\]

Fig. 9 shows a binary image of using the dilation method on Fig. 8.
Fingers, palm and palm line are the interested part of algorithm. Therefore, the area covering the center of the palm is the region of interest (ROI) in this algorithm. This section outlines the processes to extract the ROI.

**Locating Special Points**

Statistical method is used to locate the special points. Firstly, the hand outline plots as a graph. Suppose a Cartesian coordinate system is used. The horizontal axis is x-axis, and the vertical axis is y-axis. The bottom left corner is taken as origin and has the lowest coordinate values (0, 0). For each x-axis, the maximum value of y-coordinate from the previous step is plotted so that each x-axis has only one y-value (see Fig. 10). Let \( y_i \) be the y-value for \( x = i \), \( d_w \) and \( d_h \) be the width and the height of the hand excluding boundary black areas respectively. An average value \( \alpha \) is then obtained by dividing the area of the hand \( A \), i.e. white pixels, by \( d_h \).

\[
\alpha = \frac{A}{d_h}, \quad A = \sum_{i=0}^{d_w} y_i
\]

The first point that raising above \( \alpha \) from leftmost (lowest \( x \) value) is took as \( P_1 \), and the last point that goes dropping below \( \alpha \) is took as \( P_2 \). Fig. 11 shows their corresponding locations. Thumb is ignored in the experiment while focusing on other four fingers above the palm. All turning points above \( \alpha \) are the peaks of fingertips; conversely, all turning points below \( \alpha \) are the corner points between fingers. The lowest tough that supposes to be the gap between ring finger and little finger is named as \( P_l \).

Then, turning points can be obtained by calculating the sign of the slope. It is a turning point if the sign of the slope is changed. As there may have noise in the graph and produce large amount of very closed turning points, sequences of closed turning point are replaced by one middle turning point by calculating their distances. Thus, the remaining turning points are either fingertips or finger gaps. Fingertips are located at points with slope changes from positive to negative, while finger gaps are located at points with slope changes from negative to positive.

Fig. 11 is shown as an example with all the special points are marked. Blue points are the fingertips; yellow points and the lowest red point are the finger gaps. The lowest red point \( P_c \) is the lowest red point while remaining red points are marked as the \( p_1 \) and \( p_2 \) respectively.
Using the positions of \( P_c \), highest fingertips and the two finger gaps that nearest to it, the longest finger can be extracted. The upper bound is the \( y \)-coordinate of the highest fingertip, the lower bound is the \( y \)-coordinate of the lowest finger gap, the right and left bound are the \( x \)-coordinate of the two finger gaps nearest to the highest fingertip. An example is shown in Fig. 12.

The area bounded by three special points \( P_1, P_2 \) and \( P_c \) and the \( x \)-axis are used to extract the palm image. The bounds are shown in Fig. 13.

**Interpolation**

To extract the region of palm line for analysis, the region of palm line should only contain the palm but not include the background. Interpolation method, which uses scan lines to interpolate a monochrome upright palm photo linearly, is used to accurately determine the region of palm.

To begin with, the outline of the hand is drawn on a new image (see Fig. 14) and is split by a horizontal line \( L_1 \) at \( P_c \) (see Fig. 15). The bottom part of the image is used to carry interpolation. Two contour lines are the result of interpolating a monochrome upright palm photo linearly. A vertical scan line \( L_2 \) scans from the center of the palm to the left and stops when it intersects a background pixel. Another vertical scan line \( L_3 \) scans similarly from the center to the right and stops when it intersects background pixel.

Fig. 16 shows as an example of interpolation process on \( L_2 \) and Fig. 17 shows the result of \( L_2 \) and \( L_3 \).
ROI Determination

L₁, L₂ and L₃ from the previous step determine the top, left and right boundaries of ROI of palm line. Bottom boundary is determined by following equation:

$$\text{ROI Height} = \max \left( \frac{d_i + d_c}{d_w}, d_c \right)$$

where $d_i$ is the vertical distance between the L₁ and the bottom slide of the image, $d_c$ is the horizontal distance between the L₂ and L₃ and $d_w$ is the horizontal distance between p₁ and p₂.

The Fig. 18 shows an example for the adjusted bottom boundary with label as L₄, and Fig. 19 shows the ROI extracted from the original image.

(iv) Principle Palm Line Extraction and Connection

After extracting ROI, the next process is to extract useful lines inside ROI, which the lines to be extracted are assumed to be principle palm lines. The contrast between palm lines and the palm is low, which makes line extraction
challenging. Extracting lines directly from an image with low contrast would yield lots of useless lines or too few useful lines. A number of steps are carried out in this process to increase the quality of extracted lines.

Gray Equalization
Since the area of ROI is small enough, normalization on graylevels distribution can be carried out on ROI to increase the contrast between palm lines and the palm. A histogram is needed for this purpose. Define \( H(i) \) as the histogram on an intensity \( i \) for \( 0 \leq i < 256 \) and \( H_c(i) \) as following.

\[
H_c(i) = \sum_{k=0}^{i} H(k)
\]

The image can then be normalized using \( H_c \).

\[
l(x, y) = 255 \times \frac{H_c(I(x, y)) - \min \{H_c\}}{\max \{H_c\} - \min \{H_c\}}
\]

(Opencv dev team, 2013)

Fig. 20 shows the original histogram of the gray image (Fig. 22) and Fig. 21 shows the new histogram of the image after processing gray equalization. Fig. 23 shows the result image after gray equalization.

Median Filtering
Then, median filtering is used to get rid of the noise and maintain the features of principle lines well. Its function \( M \) is defined as:

\[
M(x, y) = \text{med}_W G'(x, y)
\]

where med is a median operation and \( W \) is a window function

(Hanada, Muneyasu, & Asano, 2009)
In our experiment, a 15×15 window function is used. Fig. 24 shows an example showing median filtering applied on Fig. 23.

![Fig. 24](image)

**Edge Detection**
An edge detection algorithm is then used to extract lines from the image. The contrast of every point and all other points is taken into account during the process. A canny edge detection algorithm is used in the experiment, which accepts a gray image, high threshold and low threshold to be its input.

In the experiment, high threshold and low threshold is set to the following values:

\[
\begin{align*}
\text{High Threshold} &= \mu + \sigma + k \\
\text{Low Threshold} &= \mu - \sigma
\end{align*}
\]

where \(\mu\) is the mean of the image, \(\sigma\) is the standard deviation of the image and \(k\) is a variable. The high threshold is adjusted by a loop outlines below.

Here outlines the steps to obtain a suitable \(k\) value.

1. \(k = 0\)
2. Run Canny edge detection with adjusted high threshold and low threshold
3. Apply square enlarging on the result image
4. Count the total edge pixel
5. If total edge pixel is above 12% of the image, exit the process
6. Else \(k = k - \frac{1}{2}(\text{High Threshold} + \text{Low Threshold})\) and go to step 2

Square enlarging here means to enlarge all 1×1 white pixels into 41×41 white squares.

Fig. 26 to Fig. 32 shows how the loop proceeds to obtain enough pixels for further steps. Fig. 28, Fig. 30 and Fig. 32 are the result of square enlarging. The Fig. 33 shows the final result of extracted points.
Cleaning Line
After extracting the lines, thinning lines algorithm, isolated point elimination and cleaning image are applied to reduce the width of lines and eliminate some short lines and twigs. The value of point \((x, y)\) is 255 when it is an edge pixel, 0 when it is not an edge pixel.

The thinning algorithm is applied to remove short twigs. In a 3 \(\times\) 3 region of an image, points are marked as \(P_1, P_2, \ldots, P_9\) where \(P_1\) represents the center point and other points are numbered in clockwise. The pixel that deleted need to meet the either one of the conditions:

**Condition 1**
1. \(2 \leq NB(P_1) \leq 6\)
2. \(A(P_1) = 1\)
3. \(P_2 \times P_4 \times P_6 = 0\)
4. \(P_4 \times P_6 \times P_8 = 0\)

**Condition 2**
1. \(2 \leq NB(P_1) \leq 6\)
2. \(A(P_1) = 1\)
3. \(P_2 \times P_4 \times P_8 = 0\)
4. \(P_2 \times P_6 \times P_8 = 0\)

\[
NB(P_1) = \sum_{i=2}^{9} (P_i = 255)
\]

where \(A(P_1)\) is the count of 0 255 pattern in the
Isolation point elimination is to remove isolation points with value 255 that are far from other neighbor points. In a 41 × 41 region of an image, the points are marked as $P_1, P_2, \ldots, P_{41}$, $P_1$ represent the center and target point. The target point converts from 255 to 0 when $\sum_{i=2}^{41} P_i \leq 3$.

Cleaning image is then applied to remove all pixels in the two red triangles shown in Fig. 35. The size of the triangles depends on the size of the image.

Connecting Points as Lines

In connecting line step, points received from previous steps are clustered into different line by the locations of the points.

The first step is to cluster points for the life line. A starting point for life line is found by bottom-center part of the image, then the remain points group into life line by location at the top-right and slope with decreasing trend of the previous point. The closest point to the previous point always has a higher priority to be the next point. This processing of finding next point continue until reach the right side of the image with no more point fulfill the requirement of life line.

The selected points are not available for other lines to select. Moreover, unselected points with 10-pixel distance closed to the selected points are also not available for other lines to select. These unavailable points are removed from the possible selected points list.

The next step is to cluster remaining points for the heart line. The starting point is selected from the top right of the image. The remaining points are selected based on location at bottom-left and a decreasing slope. It is preferred to select the point that is the closest to previous points. Clustering process for the heart line stops when there is no more suitable point or reached 40% height from the top of the image.

Points that are selected or close to the selected points are removed to avoid to be selected for other lines.
Points that are selected or close to the selected points are removed to avoid to be selected for other lines.

After clustering life line and heart line, it moves to clustering the last line - intelligent line which the clustering method is similar to heart line which select a starting point on top right of image, then select points based on location at bottom left and a decreasing slope. The clustering stops when there are no more possible points to select.

An example of the clustering result is shown below with life line, heart line, intelligent line highlighted as green, red and blue lines respectively.

![Fig. 37](image)

(b) **Analysis Methodology**

(i) **Fingers Analysis**

The input is the image of the extracted longest finger (see Fig. 38) from the step for Fig. 12. It is filtered and converted to a binary image (see Fig. 39). As mentioned in background study, different widths on finger parts have different meaning on the personal characteristic. The 30%, 60%, 90% height of the image are selected to measure the width of the finger. This can be done by counting the number of white pixels along the horizontal axis at those particular heights.

![Fig. 38](image) ![Fig. 39](image)

(ii) **Palm Shape Analysis**
The image extracted from the step for Fig. 13 is used to analysis palm shape. Analysis on palm shape is based on the distribution of black pixels on the image. Take Fig. 40 as an example. Since the black pixels distribute in three out of four contour of the image, and the number of the black pixels decreases when it is closer to the center of the image, this palm shape is classified as a circular palm shape.

![Fig. 40](image)

(iii) **Palm Lines Analysis**
Once points of the palm lines are obtained, all lines are analyzed to extract useful information. The information needed is summarized below
1. Curve of the line
2. Length of the line
3. Positions of the points

**Finding Curve of the Line**
A list of points is obtained after users inputting lines. By finding the rightmost point of the list, it can assume that the starting point \((x_s, y_s)\) of line is obtained. It is similar for the ending point \((x_e, y_e)\) that locates at leftmost. Curve thus can be obtained using the below formula.

\[
\text{Curve} = \frac{y_s - y_e}{x_s - x_e}
\]

**Finding Length of the Line**
Having the staring point and the ending point of the curve, length can be obtained using the below formula.

\[
\text{Length} = \sqrt{(x_s^2 - x_e^2) + (y_s^2 - y_e^2)}
\]

The values are then compared with pre-defined range, which was set according to palm reading theories, to generate palm reading explanations.

(c) **Design of Smart Palm Reading App**
There are three iOS apps are going to be developed within a year. They are theory-based and shall be written in Chinese.
Among these three applications, two of them are palm reading analysis apps (in fact it is one app with two versions) while the remaining one is a palm reading e-book app.

(i) Smart Palm Reading App

There are two versions for the Smart Palm Reading App, “advanced” and "basic" versions. Both app allow users to draw palm lines themselves for analysis though import and take photos. They also can share explanation to Facebook and record previous analysis.

The common basic flow of Smart Palm Reading App is shown in the below flowchart.

The major difference between the advance version and basic version is that advance version has the function to recognize palm lines automatically by simply input an image to it.

The following flowchart illustrates the process flow design of the Smart Palm Reading app on inputting, analysis and sharing. In the flowchart, red part only exists in the advance version, and light yellow boxes means they have corresponding user interface(s).
The app starts on the main menu, which provides three choices for users to select. They are “take photo”, “import photo” and “review record”. User can select either take photo in real time on their hand or import photo from the album for carry out the palm reading analysis.

There are two operation modes, which are automatic recognition mode and user interactive mode, in advance version. In contrast, basic version only contains the user interactive mode. User may select the mode at the main menu to carry out different analysis in advance version.

In user interactive mode, once user inputs a hand image into the app, users can adjust the photo by moving, rotation and zooming. They then draw the palm lines after inputting image, and the app generates an analysis result. In automatic recognition mode, the app does not need users to adjust the photo and draw lines. The app generates the result automatically once users inputted a hand image.

When an analysis result is generated, user may read it on the screen and share the result to Facebook. Meanwhile, it is stored into the database. Users may then return to the main menu afterwards. If users click the “review record” button on the main menu, then the app displays a list of past records for users to choose and review.

As introduced before, there was a palm reading app for iOS platform in last year. This previous app is taken into comparison. The following table lists a comparison of features among the previous app, the proposed basic and advanced versions of the palm reading app.

<table>
<thead>
<tr>
<th>Features</th>
<th>Previous</th>
<th>Basic</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review palm history</td>
<td>×</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Share results to existing social networks</td>
<td>×</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Analysis palm photo from:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• importing through photo album</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
(ii) **Palm Reading E-book App**

In previous implementation, there are some simple descriptions on life line, intelligence line and love line bundled with the palm reading app to teach users some basic palm knowledge. In this project, the educational part is no longer bundled with the main app but detached as a new individual app named “Palm Reading E-Book”. It offers iPhone and iPad version.

Palm Reading E-Book app contains theories developed by Peter So. It is going to contain six topics on hand shape, palm color, hand mount, finger size and position. Zooming in and out, highlighting, navigation controls and other reading assistance tools shall be provided in the app in order to convenient users.

**Smart-linking among Articles for e-Book app**

Links in articles are created in a Wikipedia-style for users to conveniently look up terms that they do not understand. This process is done automatically with an algorithm.

For the smart-linking algorithm, it fetches the list of all the articles in the preprocessing stage, and search for these keywords in the article in real-time. If a keyword exists in the article, an `<a>` tag will be created and surround them immediately. The position of searching pointers needs to be calculated and adjusted carefully during the iteration.

A custom “palm://” protocol and a client-server model are designed for the the smart linking feature. The user smartphone itself serves as both server and client. The server generates a dynamic webpage at real time, while the client intercepts and redirects all the resource request events. Their roles and flows are listed below.

<table>
<thead>
<tr>
<th>Smartphone as <strong>Server</strong></th>
<th>Smartphone as <strong>Client</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Listens to requests</td>
<td>1. Intercepts resource loading events</td>
</tr>
<tr>
<td>2. Fetches an article from the database</td>
<td>2. If the destination protocol is “palm://”, connects to the phone itself; otherwise, connects to</td>
</tr>
</tbody>
</table>
4. Add links to the HTML using the smart-linking algorithm
5. Output the HTML to client

<table>
<thead>
<tr>
<th>external servers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Receives a HTML document response</td>
</tr>
<tr>
<td>4. Displays to users</td>
</tr>
</tbody>
</table>

(d) Social Media Integration

An open-source iOS library named “ShareKit” may be deployed into the project in order to connect to public social media and to implement social network features. This library offers drop-in share features for all iOS apps (Weiner, n.d.). With its help, URLs, image, text, and files can be shared to popular social media such as Facebook, Twitter and other electronic services like Email and Google Reader.

Nevertheless, official SDKs from different popular social media may be used to implement social network features. Facebook and Twitter both offer a SDK for this purpose.

(e) Database Design

An SQLite database is going to be developed for storing palm records created by users, its relevant information and social media information.

Besides, another SQLite database is going to be developed for efficiently collecting and handling all the information and palm reading theories. This palm reading knowledge database would be embedded in the e-book app.

A database scheme is designed for the Smart Palm Reading App. The concept of relational database is also applied in the design for a better space and data management. Each analysis record contains many lines which each line composes of many points. The design of the database schema is shown in the following diagram.

![Database Diagram](image)

Another database is designed to store the content of e-Book so that the RAM usage would not be too demanding. There are three tables designed for the e-Book app – Articles, Keywords and MenuItems. Items in MenuItems are the topics that show in the topic list. The menu lists many topics and each topic links to many articles. In the same time, each keyword maps to an article while an article may have many
alternative keywords as its title. The following diagram shows the database schema of the e-Book app.

Fig. 41
4. Implementation and Experimental Result

(a) Rewriting Smart Palm Reading App

In last year, there was a Smart Palm Reading App, but it was buggy. Many parts have been rewritten in this year. This section describes what have been rewritten.

(i) Revising layouts

In the previous app, the camera button is not clearly shown in the main page. Besides, the position of GUI components was not correctly located at its designated place across different iOS devices. Therefore, the layouts are revised to provide a more user-friendly and stable user interfaces.

Fig. 42 shows the basic version of the main menu while Fig. 45 shows the advanced version of the main menu.

![Fig. 42](image1)

![Fig. 43](image2)

![Fig. 44](image3)

Furthermore, a splash screen is designed and implemented for pre-loading startup resources. Fig. 45 shows a splash screen.
(ii) Creating new icon for the apps

The icon for the palm reading app was redesigned. There is a tiny different in palm reading app for basic version and advance version. Furthermore, a new icon for the new e-Book app was also designed.
(iii) **Preserving Drawn Lines on Canvas**

To get a palm analysis report, user needs to draw a few lines after user takes photo on his (or her) palm or imports the photo from album. Owing to the fact that some lines may have intersection with another line, users may need to reference previous drawn lines while drawing a new line. However, in the previous implementation, the drawn line disappears each time after user has confirmed his drawing.

In order to be more user-friendly, drawn lines are preserved on the screen after user has confirmed drawings in the new implementation. The following screenshot demonstrates retaining different type of lines in the drawing canvas.

![Fig. 47](image)

For the implementation details, the previous project uses a screen-capturing approach to store the drawn lines, while coordinates of all the line points are stored instead of an image to redraw lines in both the canvas and the analysis report screen. It is explained more detailed in the next section.

(iv) **Translating to Object-oriented Code**

Since Objective-C is an object-oriented programming language, it would be best if codes are written in an object-oriented style. The previous implementation uses a procedure style to write codes, and there are many repetitive codes for the same tasks. Therefore, much time was used to rewrite a considerably large portion of codes to tidy up relationships between objects. Much hard-coded functionality was removed. Now, it is much easier and flexible to add additional lines for second development stage.

A few classes have been created during the process. Some class diagrams are provided below as a reference.
(b) Implementing New Features

There are a new features implemented for the Smart Palm Reading App. These features are allocated to basic version or advanced version according to the version comparison table defined in the design.

(i) Palm Record Review Database

Although there is a class named “DBHelper” for accessing SQLite database in the previous project, there is only interface but no usable implementation at all. No real records were stored but a hardcoded “record” is stored in the app.

This project addressed the issue and implemented the process of manipulating database records. Records are saved automatically after each analysis process in the new implementation. All the drawn lines, palm image and the result of analysis are preserved in the database. Hence, the report screens are the same when users generate the analysis report at the first time, restart the application and review the record.

Users may access any of their records at any time at a record list screen (see Fig. 49). They may also delete their records at the screen. Fig. 50 and Fig. 51 show an example that how records in the database are listed to users and how records can be deleted. In this example, the 4th record is deleted.
(ii) Social Network Integration

Preparatory Registration
A Facebook developer account was registered and the palm reading app was registered on Facebook (see Fig. 52) to offer social network features. API permission was obtained from Facebook to allow the app to access Facebook user information and post feeds. The Facebook app can be cross-platform so that the Android developer of palm reading app does not need to register again (see Fig. 53).

Implementation of Sharing Feeds to Facebook
This is a new feature to the app. Share button is added into the apps for sharing the palm analysis report to Facebook (see Fig. 54). Facebook API is used to link the app to Facebook and implement the sharing function.

Fig. 55 to Fig. 57 demonstrate how a user may share his or her feeling along with the report to Facebook.

![Fig. 54](image)

![Fig. 55](image)

![Fig. 56](image)

![Fig. 57](image)

It is worthwhile to mention that the app can link to the login page for Facebook if the user not yet logins his or her Facebook account or installed Facebook apps in device when the share button is pressed.

(c) Implementing of Auto-recognition Algorithm

The auto-recognition algorithm was tested in MATLAB and then implemented in C++ with OpenCV. It has trained and tested it in computer before implementing it for iOS and Android mobile devices. Finally, the algorithm was implemented as a shared library for use in mobile apps.
(d) **Auto-recognition Library Integration**

Hybrid approach is applied in the integrating automatic recognition on Smart Palm Reading App. The application may directly access official APIs and hardware feature with optimized performance, while maintaining the neat of codes and design. Android platform would receive an extra benefit of high performance in image processing. Fig. 58 shows the hybrid approach diagram of the app.

![Hybrid approach diagram](image)

**Fig. 58**

In iOS platform, the integration between the C++ shared library and the Objective-C iOS platform is relatively simple. This is because iOS supports the Objective-C++ programming language, which is a mixture of C++ and Objective-C. A wrapper layer written in Objective-C++ will integrate the auto-recognition library into the advance version of the app.

(e) **Developing Advanced Version App**

The advanced version has all the features included in the basic version. There are more functions and little UI difference for the advanced version. A switch is added on the main page of the app for user to select whether to enable auto-recognition mode or not (see Fig. 59).
Camera Preview

When the auto-recognition mode is on, a different camera screen is displayed for the “Take Photo” option. Light blue lines will be displayed to outline the recognized hand in camera preview (see Fig. 60). This is provided as a feedback for users whether their hand is acceptable for the automatic recognition algorithm.

The image is passed from the iOS camera to the shared library by C++ and returned an image with blue outlining the hand shape from the shared library to user interface every camera frame.

Palm Line Recognition

Once a hand image is inputted via any method, the app directly jumps to the analysis part for reading summery without the need of adjusting photo or drawing lines. Line patterns are automatically extracted and analyzed under automatic recognition mode. This involves calling the C++ library and generating analysis result.
(f) **Palm Reading eDBook App**

(i) **Accessible Tools in eDBook app**

Zooming and scrolling features should be provided in the eDBook app for different group of users to read articles with a seamless experience. A zooming example is demonstrated in Fig. 65 that took after the article shown in Fig. 64 is zoomed.

In order to implement it, a cross-platform HTML approach is adopted as the major component of the eDBook app. A `UIWebView` control is used to display the webpages and supports zooming and scrolling. Furthermore, webpages in `UIWebView` can display links which will be mentioned in the next section.
(ii) Smart-linking among Articles for e-Book app

To implement the smart linking feature, a custom “palm://” protocol and a client-server model is used, as described in the design. The actual roles and flows used in the implementation are listed below.

<table>
<thead>
<tr>
<th>Smartphone as Server</th>
<th>Smartphone as Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Listens to requests</td>
<td>1. Intercepts resource loading events</td>
</tr>
<tr>
<td>2. Fetches an article from the database</td>
<td>2. If the destination protocol is “palm://”, connects to localhost; otherwise, connects to external servers</td>
</tr>
<tr>
<td>3. Generate a HTML document of the article</td>
<td>3. Receives a HTML document response</td>
</tr>
<tr>
<td>4. Add links to the HTML using a smart-linking algorithm</td>
<td>4. Displays in a UIWebView control</td>
</tr>
<tr>
<td>5. Output the HTML to client</td>
<td>5. Sets up zooming and scrolling functions</td>
</tr>
</tbody>
</table>

(iii) Database

The implementations of accessing to and bundling database have been completed. Regarding to the copyright policy, all the articles have been already rephrased and filled into the Articles table of the database. Image also has redrawn, bundled with the app and filled its path into the Article table of the database.

(g) Autosizing for Different devices

Both user interface of palm reading app and e-Book app have used auto-sizing in implementation. Auto-sizing is used to provide user interface that can be fit to different screen resolution of iOS devices. Since iPod is similar to iPhone, no much tweak is required. The Advanced version and Basic version of the Smart Palm Reading app and the e-Book app runs smoothly under iPad and iPod.

The screencasts shown on next page demonstrate how the apps are run without distortions under iPad (Fig. 66 to Fig. 76) and iPod (Fig. 77 to Fig. 82).
iPad Screencasts

Fig. 66

Fig. 67

Fig. 68

Fig. 69

Fig. 70

Fig. 71
掌色

中國相法，最重要掌色，除顏色外，還要看每日氣色之變化。但不論什麼顏色，都要
照順為佳。resource.png 一切歸一，一生必有
所成：顏色枯黃，婚姻不幸，女
則難耐夫。掌色可

Fig. 77  Fig. 78  Fig. 79  Fig. 80  Fig. 81  Fig. 82
5. **Evaluation and Discussion**

(a) **Automatic Recognition Algorithm**

30 hand images that fulfill the assumption of the input image were used to test the correctness and accuracy of the algorithm. The evaluation of the algorithm is listed in below.

- 30/30 images generate hand contour
- 26/30 images generate line result
- 23/30 images generate at least 2 correct lines result
- 14/30 images generate perfect result
- 4/30 images generate wrong and useless result

There are only 13.3% of failed results that did not generate any useful information. The step of ROI extraction, too little edge pixels extracted and too much noise pixels account for the failure of the algorithm.

**Failure on extracting ROI**
Fig. 86 shows final line connection on ROI (see Fig. 84) on original image (Fig. 83). It is observed that the size of extracted ROI is too small, which leads to inadequate edge pixels for line connection.

By the algorithm, the upper-boundary of the ROI should be the lowest finger gap which as known as the lowest turning point. **Since the graph plot by the maximum value of y-coordinate by each x-axis, it causes the lowest turning point becomes the finger gap between middle finger and the ring finger (see Fig. 87)**. This causes wrong detection on interpolation and thus obtaining a wrong ROI. The suggested solution is to check the position of the lowest finger gap in a later stage with backtracking. This can be done by firstly obtain a new image by the inner area by the red points and the bottom slide of the image (see Fig. 88), then interpolating the image vertically from the center to the top.
Too much or too little edge pixels on connecting lines

The threshold value can affect the number of extracted edge pixels much. Since the best high threshold and low threshold are selected and used on the canny edge detection, it is found that there exists some cases still cannot obtain any useful points for connection. Fig. 92 shows the poor connection result on the original image (Fig. 89). It is suggested that using other edge detection algorithm to improve the result.
(b) Device Compatibility
Different real devices including iPod, iPhone and iPad and different iOS versions have been tested on the user interface and functionality. The details of the devices tested are listed in the following table.

<table>
<thead>
<tr>
<th>Device</th>
<th>Screen Size</th>
<th>Resolution</th>
<th>iOS version</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone 4</td>
<td>3.5-inch</td>
<td>960 × 640</td>
<td>iOS 6.1.2</td>
</tr>
<tr>
<td>iPhone 5s</td>
<td>4-inch</td>
<td>1136 × 640</td>
<td>iOS 7.0.6</td>
</tr>
<tr>
<td>iPod 5G</td>
<td>4-inch</td>
<td>1136 × 640</td>
<td>iOS 6.1.3</td>
</tr>
<tr>
<td>iPad</td>
<td>9.7-inch</td>
<td>2048 × 1536</td>
<td>iOS 7.0.4</td>
</tr>
</tbody>
</table>

It was found that Smart Palm Reading app Basic version, Smart Palm Reading app Advance version and Palm Reading E-book app can run successfully in all the different devices and iOS version. The user interfaces have not been distorted, and the functionality runs well. A minor problem is found on the iPad that it is difficult to recognize the hand automatically under camera preview, because the range of the camera of iPad is too large.

(c) Overall Completeness

The progress on different project objectives is summarized below.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Addressed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>To develop and implement an algorithm to recognize principal palm lines</td>
<td>✓</td>
</tr>
<tr>
<td>To revise and develop new features for the Smart Palm Reading App</td>
<td>✓</td>
</tr>
<tr>
<td>To develop an iOS palm reading e-book app</td>
<td>✓</td>
</tr>
<tr>
<td>To ensure stable running of all these apps in different iOS devices</td>
<td>✓</td>
</tr>
<tr>
<td>To develop and implement an algorithm to recognize principal palm lines</td>
<td>✓</td>
</tr>
</tbody>
</table>

During development phase, the project strictly followed schedule and was in good progress. All the objectives of the project have been successfully completed on time. The project schedule is listed in the appendix.

6. Conclusion
Three mobile applications on iOS platform have been successfully developed. They are basic version of Smart Palm Reading App, advanced version of Smart Palm Reading App and Palm Reading e-Book App. An automatic recognition algorithm also has been developed on recognizing palm lines from a hand photo and written in C++ library with OpenCV. The overall performance of the algorithm is acceptable and thus the algorithm has integrated into advanced version of Smart Palm Reading App.

For future development, there are still areas to improve on automatic recognition algorithm, Smart Palm Reading app and Palm Reading E-book app.
Accuracy, runtime and number of extracted features can future improve on the algorithm. For Smart Palm Reading app, extending the app to more different social media on sharing, adding more palm reading analysis topic on the app, adding more text explanation on the analysis result and linking the app to the e-Book app for improving the convenient of the app are potential areas to develop and work on. Regarding to the palm reading e-book, bookmarking and jotting notes may possible to add into the app.
7. References


8. **Appendix**

(a) **Schedule**

The following table lists the original project planning chart.

<table>
<thead>
<tr>
<th>Task</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project objective defining and long-term significances declaring</td>
<td>1/6</td>
<td>3/6</td>
</tr>
<tr>
<td>Market research on existing iOS app</td>
<td>4/6</td>
<td>17/6</td>
</tr>
<tr>
<td>Research on palm reading knowledge</td>
<td>18/6</td>
<td>2/7</td>
</tr>
<tr>
<td>Research on social network integration</td>
<td>3/7</td>
<td>9/7</td>
</tr>
<tr>
<td>Defining major features</td>
<td>10/7</td>
<td>14/7</td>
</tr>
<tr>
<td>UI flow design</td>
<td>15/7</td>
<td>20/7</td>
</tr>
<tr>
<td>UI layout design</td>
<td>18/7</td>
<td>5/8</td>
</tr>
<tr>
<td>Defining technical specifications and requirements</td>
<td>5/8</td>
<td>19/8</td>
</tr>
<tr>
<td>Writing project proposal</td>
<td>12/8</td>
<td>30/8</td>
</tr>
<tr>
<td>Research on image recognition theory</td>
<td>31/8</td>
<td>25/11</td>
</tr>
<tr>
<td>Reading past student’s code and understanding the iOS development</td>
<td>31/8</td>
<td>30/10</td>
</tr>
<tr>
<td>UI layouts implementation</td>
<td>10/9</td>
<td>30/10</td>
</tr>
<tr>
<td>E-Book database development</td>
<td>17/9</td>
<td>1/10</td>
</tr>
<tr>
<td>E-book app implementation</td>
<td>2/10</td>
<td>10/11</td>
</tr>
<tr>
<td><strong>Interim testing (Milestone)</strong></td>
<td><strong>11/11</strong></td>
<td><strong>13/11</strong></td>
</tr>
<tr>
<td>Hand Mount Questions implementation</td>
<td>14/11</td>
<td>24/11</td>
</tr>
<tr>
<td>Studying topics on computer vision in detail</td>
<td>25/11</td>
<td>31/3</td>
</tr>
<tr>
<td>Extending features of draw-lines function</td>
<td>6/1</td>
<td>1/2</td>
</tr>
<tr>
<td>Auto-recognition of palm shape recognition implementation</td>
<td>1/2</td>
<td>15/3</td>
</tr>
<tr>
<td>Auto-recognition of finger distance and size recognition implementation</td>
<td>16/3</td>
<td>24/3</td>
</tr>
<tr>
<td>Social network integration</td>
<td>6/1</td>
<td>31/3</td>
</tr>
<tr>
<td>Integrating and organizing functions in the app</td>
<td>26/3</td>
<td>29/3</td>
</tr>
<tr>
<td>UI layout testing on single device</td>
<td>29/3</td>
<td>1/4</td>
</tr>
<tr>
<td>UI layout testing on different devices</td>
<td>1/4</td>
<td>3/4</td>
</tr>
<tr>
<td>Final testing and fix outstanding issues</td>
<td>3/4</td>
<td>7/4</td>
</tr>
<tr>
<td><strong>Project presentation (Milestone)</strong></td>
<td><strong>7/4</strong></td>
<td><strong>11/4</strong></td>
</tr>
<tr>
<td>Formal write-up of project report</td>
<td>1/4</td>
<td>18/4</td>
</tr>
</tbody>
</table>

The next page displays a time chart for the above schedule.
This page shows an updated timetable of project plan.

![Fig. 93](image-url)
In this project, a C++ shared library has been built to support automatic recognition features. This section describes the APIs provided by the library in detail.

```cpp
void handOutline(Mat &cameraImag, Mat &outputImage)
```
This function is to recognize hand contour from an input hand image and draw it to the output image. It would not fail if a hand cannot be recognized. It is designed to use in camera preview.

**Parameters**
- **Input** _matInput_ Camera image in Matrix format
- **Output** _matOutput_ Processed image with hand contour drawn in Matrix format

```cpp
bool setTurningPT(Mat &outputImage, Mat &imgalline, Mat &imgle, Mat &imghd, Mat &imght, int &height, vector<int>&headpt_x_out, vector<int>&headpt_y_out, vector<int>&lifept_x_out, vector<int>&lifept_y_out, vector<int>&heartpt_x_out, vector<int>&heartpt_y_out)
```
This function is to recognize principal palm lines from an input hand image. Coordinates of the points of the recognized lines will be returned, and the recognized lines will be drawn on the input image. The region of interest will be returned as well. It is designed for analysis.

**Parameters**
- **Input**/ **Output** _outputImage_ Input: Camera image in Matrix format. Output: ROI image in Matrix format.
- **Output** _imgalline_ Hand image with three principal palm lines drawn in Matrix Format.
- **Output** _imgle_ Hand image with the drawn life line in Matrix format.
- **Output** _imghd_ Hand image with the drawn head line in Matrix format.
- **Output** _imght_ Hand image with the drawn heart line in Matrix format.
- **Output** _height_ Height of the ROI image.
- **Output** _headpt_x_out_ List of x-coordinates of the recognized head line.
- **Output** _headpt_y_out_ List of y-coordinates of the recognized head line.
- **Output** _lifept_x_out_ List of x-coordinates of the recognized life line.
- **Output** _lifept_y_out_ List of y-coordinates of the recognized life line.
- **Output** _heartpt_x_out_ List of x-coordinates of the recognized heart line.
- **Output** _heartpt_y_out_ List of y-coordinates of the recognized heart line.

**Returns**
- **bool** Return true if the lines are recognized without error, false otherwise.

**Exception**
This function can throw runtime error due to assertions in the OpenCV library.
(c) **Task Division**

The task division is as follow.

<table>
<thead>
<tr>
<th>Task</th>
<th>Cheung Shirley</th>
<th>Chung Tsz Yeung</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Algorithm Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Automatic recognition</td>
<td>L</td>
<td>A</td>
</tr>
<tr>
<td>• Smart-linking</td>
<td>A</td>
<td>L</td>
</tr>
<tr>
<td><strong>iOS Application Development</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Smart Palm Reading Apps</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>• Palm Reading E-Book App</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td><strong>Android Application Development</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Smart Palm Reading Apps</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td>• Palm Reading E-Book App</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Automatic recognition</td>
<td>L</td>
<td>A</td>
</tr>
<tr>
<td>• Smart-linking</td>
<td>A</td>
<td>L</td>
</tr>
<tr>
<td>• iOS Apps</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>• Android Apps</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td><strong>Shared Library Implementation</strong></td>
<td>L</td>
<td>A</td>
</tr>
</tbody>
</table>

In above table, L means leader and A means assistant.