



Determining visibility using digital photos — A simplified introduction

簡介：利用電腦及數碼相機測量能見度

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Dr. YIP Chi Lap [Beta] 葉志立

Workshop on “Computer-aided visibility measurement using digital cameras” 「利用電腦及數碼相機測量能見度」工作坊 2012-02-25[Sat]

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Have you done your homework? 做了功課沒有？

- ◆ Identify landmarks 識別地標
- ◆ Experiment on camera settings 實驗相機的各種設定
- ◆ Take photos 拍照
- ◆ Examine the photos taken 檢查已拍攝的照片
- ◆ Collect visibility data 收集能見度數據

http://www.weather.gov.hk/vis/vis_index.shtml

http://www.weather.gov.hk/vis/visc_index.shtml

- ◆ Collect related data, e.g., Air pollution index
收集相關數據 (如空氣污染指數)

Identifying landmarks 識別地標

- ◆ Refer to lecture notes “Weather Observation” of an earlier workshop 請參考早前「能見度及其測量方法」講座之「天氣觀測」講義
- ◆ What is the range of visual angles of a good landmark?
一個適合目標的視角範圍是甚麼？
- ◆ Rule of thumb: what is the approximate visual angle spanned by your little finger? Three fingers?
伸臂，尾指所遮的視角大概多少？三隻手指呢？
- ◆ Why are the distances 5km and 30km important?
5公里及30公里的地標距離有甚麼重要？

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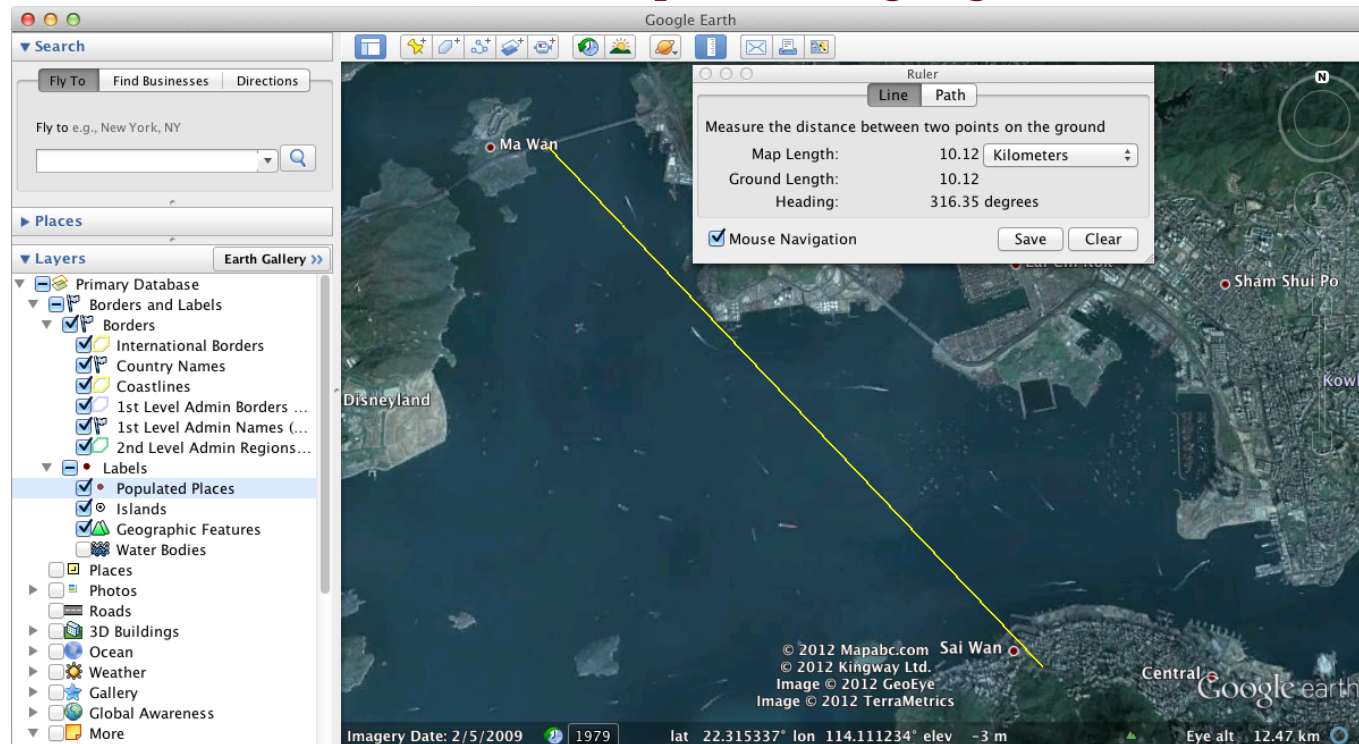
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Measuring distances 測量距離

- ◆ Can be done using the ruler  function of Google Earth

可用 Google Earth 的量度功能 <http://www.google.com/earth/>



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Camera settings 調校相機

- ◆ Goal: clear pictures with maximum depth of field

目標：最大景深而又清晰的圖像

- ◆ Possible settings 可調校的：

- ISO value ISO值 (e.g., 100, 200, 400,...)

- Shutter speed 快門速度

(e.g., 1/1000 s, 1/500 s, 1/125 s, 1/60 s, 1/30 s,...)

- Aperture 光圈 (small to large 從小到大: f/22, f/16,..., f/4)

- Focal length (zoom factor) 焦距 (變焦系數)

- White balance 白平衡

- File format 檔案格式 (e.g., JPEG, Raw)

Depth of field 景深

- ◆ Depth of field is large if objects near to and out of focus are both clear 景深大：對焦位置及前後均清晰
- ◆ Depth of field is small if only objects near to focused location is clear 景深小：對焦位置清晰，其他模糊
- ◆ To get large depth of view, you need 相片要景深大，要：
 - Small aperture (large f-stop number) 細光圈（光圈f數大）
 - Wide or standard view (zoom out) 廣角或標準（放大倍數小）
 - Cameras with small sensing elements 用影像感測器小的相機

What's your observation? 你觀察到甚麼？



2010-06-05 07:00:06 Westward view from Hong Kong Observatory 從天文台往西望

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What's your observation? 你觀察到甚麼？



2010-06-05 08:00:08 Westward view from Hong Kong Observatory 從天文台往西望

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What's your observation? 你觀察到甚麼？



2010-06-05 11:00:09 Westward view from Hong Kong Observatory 從天文台往西望

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Designing an automatic visibility measurement method

設計自動能見度測量法

1. Prepare and preprocess the images 準備和預先處理圖像
2. Analyse some of the photos (say 75% of them) to get one or more values that may be related to visibility
分析部分照片（例如75%）去獲取一個或多個可能與能見度有關的數值
3. Find a way to convert these values to visibility reading
找方法去轉換這些數值為能見度讀數
4. Test on the remaining photos 利用剩餘的照片測試
5. Repeat from step 2 to refine the method 由第2步再做，以改進方法

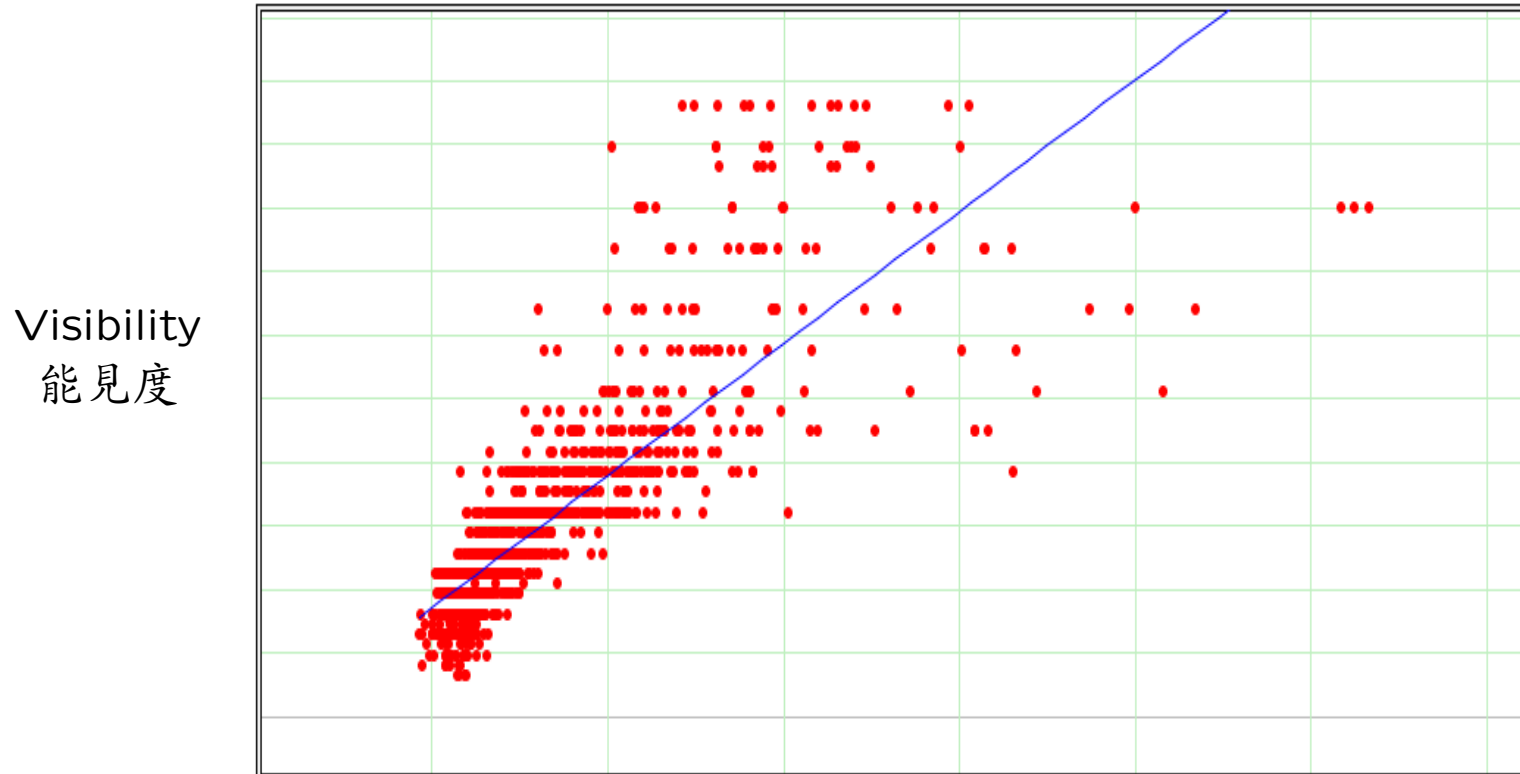
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An example 例子



Landmark-to-background average brightness difference
地標與背景之平均光度差異

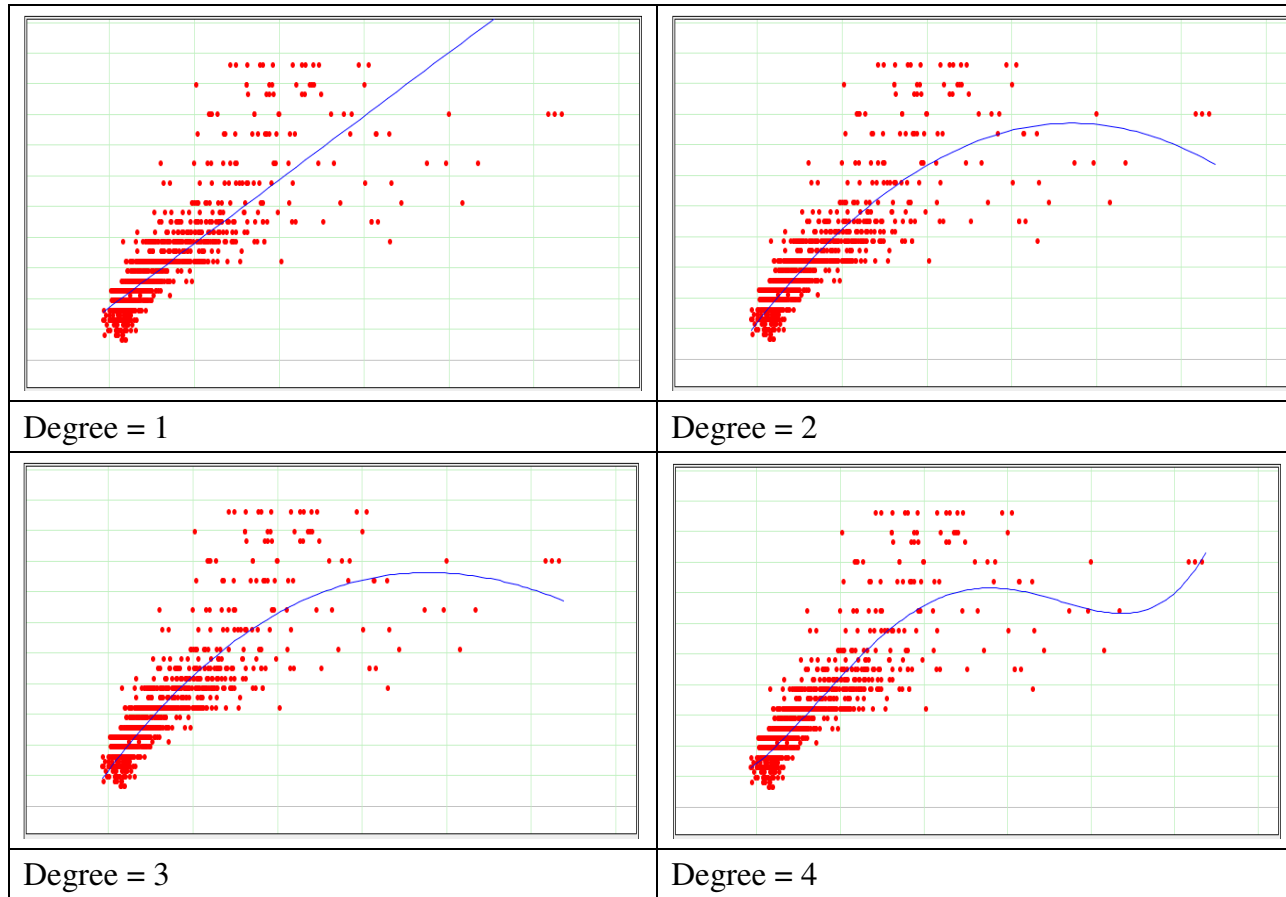
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Multiple ways to analyse 多種分析方法



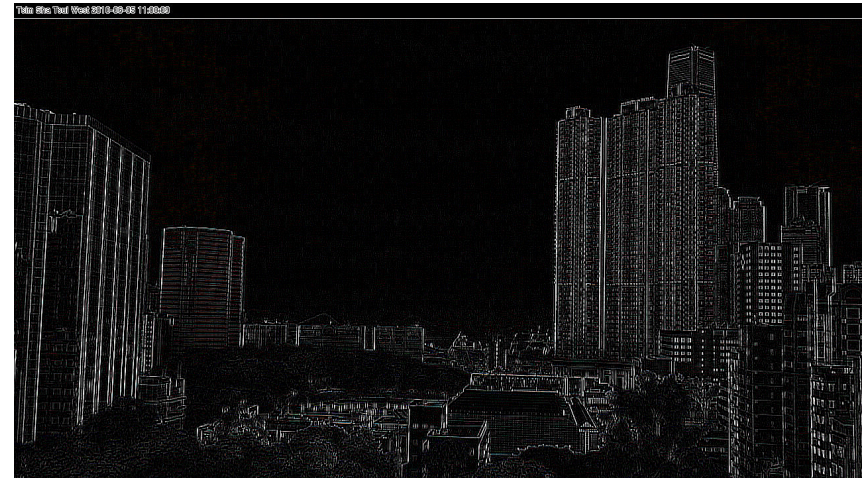
Preprocessing 影像的預先處理

- ◆ Minimize change to the photo whenever possible
盡量減少改變照片
- ◆ e.g., Crop the images so that all of them cover the same area — okay if analysis involves a fixed area on the photo
例：裁剪圖像，使他們全部覆蓋同一區域 — 可以，用於分析照片的固定區域
- ◆ e.g., Change picture to greyscale to extract the brightness component of the pixels — possible but not necessary as this can be done at analysis time
例：將圖片變成灰階，以取像素的亮度 — 可行但非必要，可在相片分析時一併做
- ◆ e.g., Equalize the image to make it look better — think twice! May destroy information in the image
例：均衡影像光度，令相片更好看 — 三思而後行！可能會破壞圖像中的資料

Examples: greyscale 例子：變灰階



Examples: edge detection 例子：測邊



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Digital photo analysis 分析數碼照片

- ◆ Shows your creativity! 顯示你的創意!
- ◆ Examples 例子:
 - Average brightness (of which area?)
(哪個範圍的) 平均亮度
 - Contrast (of what between which areas?)
(哪幾個範圍的) 對比度
 - Colour (of what?)
(甚麼的) 顏色
 - Sharpness of edges of landmarks (how?)
(如何找出) 地標邊緣的清晰度

Weather effects 天氣的影響

- ◆ Clouds 雲
 - Reduce contrast 降低對比度
 - Highlight part of the scene 突出部分場景
- ◆ Rain 雨
- ◆ Position of the sun 太陽位置
 - Azimuth (direction) and elevation of the sun changes every second 方位與高度每秒在變
 - Causes lighting effects (e.g., shades and highlights) 產生光效 (如陰影和亮位)
 - Affects contrast 影響對比度

A mini-example of the investigation process

探查過程的微型例子

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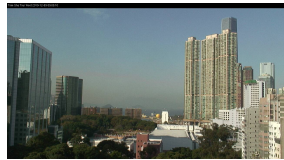
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Collect data and postulate 集資料、提假設

- ◆ Photos have been taken, and reference visibility found

拍了照，收集了能見度考資料



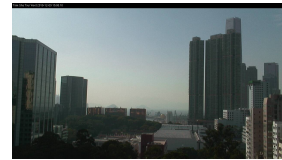
18km



20km



16km



15km



15km

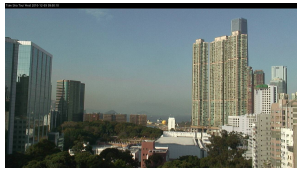
- ◆ After inspecting the photos, it was postulated that the brightness difference between the two islands is related to visibility reading

檢查照片後，假設兩山的亮度差與能見度有關



Investigation 探查 (1)

- ◆ Find out the brightness difference 找出兩山的亮度差



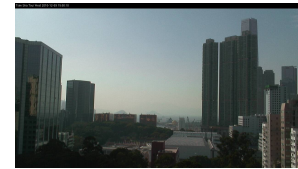
18km



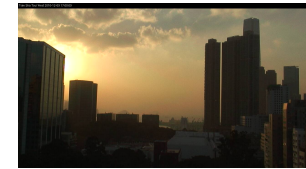
20km



16km



15km



15km

Brightness value of the island on the left 左山的亮度:

101

123

126

152

126

Brightness value of the island on the right 右山的亮度:

116

139

142

162

134

Difference of brightness values, ignoring sign 亮度差，不理正負

15

16

16

10

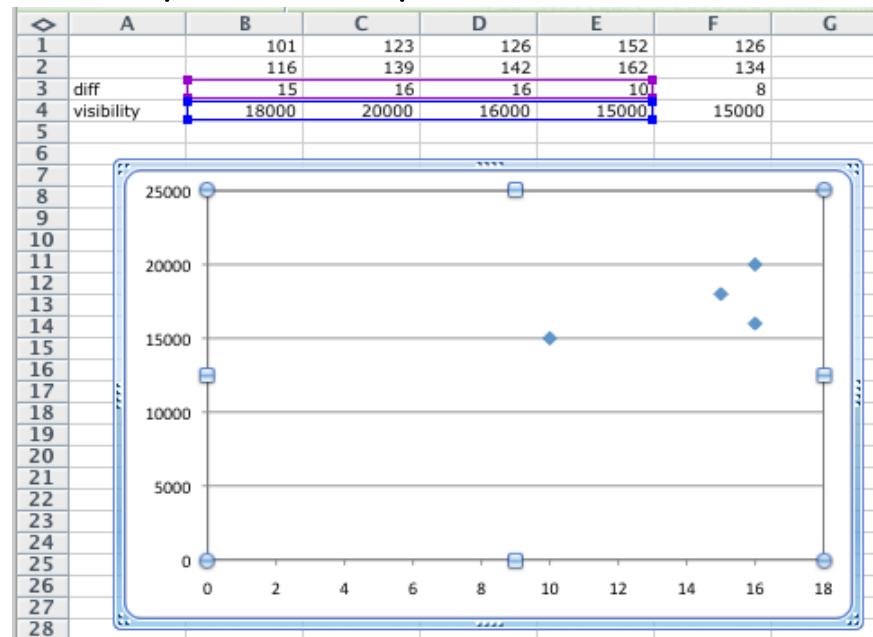
8

Investigation 探查 (2)

- ◆ Decided to use the first four pictures for “training” so the results will not over-fit this set of data only

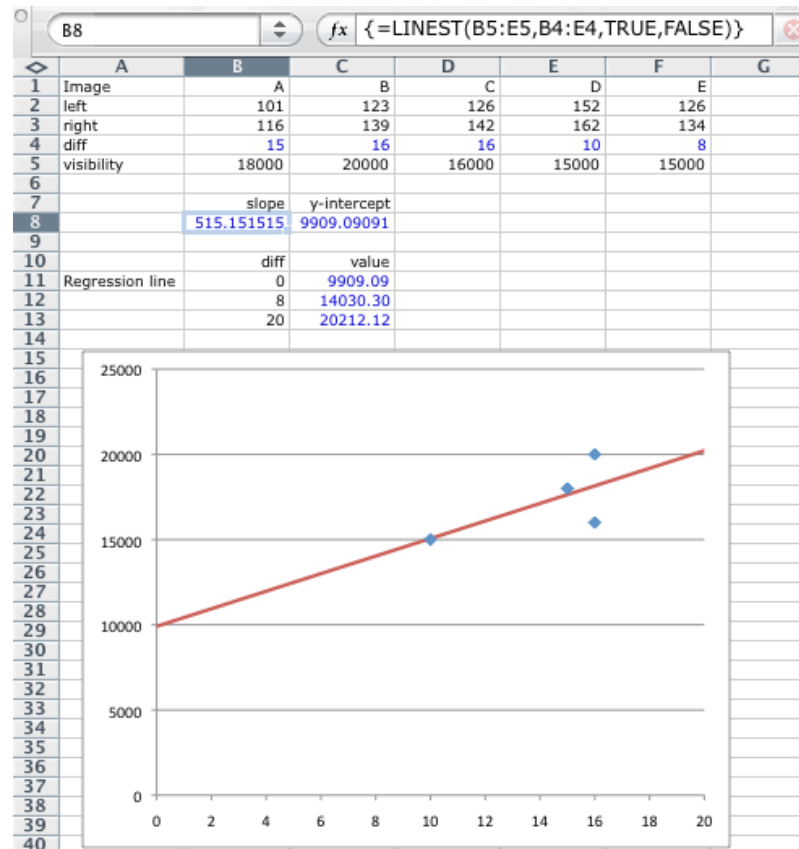
決定用首四張相來「訓練」模式，以防結果只在此組資料有用

- ◆ Use excel for a scatter plot the points 利用excel製散點圖



Investigation 探查 (3)

- ◆ Do linear regression 用線性回歸分析



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Investigation 探查 (4)

- ◆ Formulate questions for conclusion and further improvement
 - Brightness difference of 8 gives visibility of 14km, not unreasonable
亮度差為8時，能見度14km,並非無理
 - More photos need to be taken for the results to be meaningful
結果要有意義，要用多些相片
 - Are there other quantities that are useful for finding out visibility readings?
有沒有其他數值可用來找出能見度？

Investigation 探查 (5)

- ◆ More questions 更多的問題
 - How about using cross-validation to improve the results?
用交叉驗證來改善結果又如何？
 - How do the clouds affect the results? 雲有影響結果嗎？
 - Would it be useful to create a photo that is the average of all the photos? 將所有相片做個平均，有用嗎？
 - Is it useful to manually mark sky / sea / land?
人手區分天、海、地，有用嗎？
 -

What can we use to
examine and manipulate photos?

我們可以用甚麼來查看和編輯相片？

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Image processing software 圖像處理軟件

- ◆ Gimp — The GNU Image Manipulation Program (Open source 開源軟件)

<http://www.gimp.org/>

- ◆ Adobe Photoshop (Commercial 商業軟件)

<http://www.adobe.com/products/photoshop.html>

- ◆ Ulead Photo Impact (Commercial 商業軟件)

<http://www.ulead.com/pi/features.htm>

- ◆ Paint Shop Pro (Commercial 商業軟件)

<http://www.corel.com/corel/product/index.jsp?pid=prod4220093>

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Mathematics packages 數學處理軟件

- ◆ GNU Octave (Open source 開源軟件)

<http://www.gnu.org/software/octave/>

- ◆ Mathematica for Students (Commercial 商業軟件)

<http://www.wolfram.com/solutions/education/students/>

- ◆ Matlab (Commercial 商業軟件)

<http://www.mathworks.com/products/matlab/>

Multimedia environments 多媒體環境

- ◆ Adobe Flash (Commercial 商業軟件)

<http://www.adobe.com/products/flash.html>

- ◆ Adobe Director (Commercial 商業軟件)

<http://www.adobe.com/products/director/>

Programming languages 編程語言


- ◆ Most major languages support image processing
大部分主要的編程語言均支援圖像處理
- ◆ Java — packages 軟體套件 `javax.imageio.*`, `java.awt.*`,
`javax.swing.*`
- ◆ C — use any library with C bindings 使用任何C綁定庫
- ◆ C++ — use any library with C++ bindings 使用任何C++綁定庫
- ◆ Processing <http://processing.org/> 

Image manipulation libraries 圖像處理軟件庫

- ◆ They are engines for reading, writing, and manipulating images

它們是讀、寫，和操縱圖像的引擎

- ◆ OpenCV

<http://sourceforge.net/projects/opencvlibrary/>

- ◆ CImg library

<http://cimg.sourceforge.net/>

- ◆ Image readers and writer libraries 圖像讀寫軟件庫:

libpng, libjpeg, libtiff, . . .

Miscellaneous 雜項

- ◆ IrfanView (Freeware, image viewer 免費，圖像瀏覽器)

<http://www.irfanview.com/>

- ◆ pixlr editor (Online service, image editor 在線服務，圖像編輯器)

<http://pixlr.com/editor/>



Let's learn to use some tools!

我們一同學習使用一些工具吧！