

紫外線

測量及應用設計比賽

Ultraviolet Radiation

Measurement & Application Design Competition

<http://www.cs.hku.hk/~uv/>

Data Analysis and
Application
數據分析及應用

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Data Analysis and Application

數據分析及應用



We have the data, and then? 有讀數了，然後呢？

```
const float thresholds[] = {
  0.050, 0.227, 0.318, 0.408, 0.503,
  0.606, 0.696, 0.795, 0.881, 0.976, 1.079
};

void setup() {
  Serial.begin(9600);
  pinMode(A0, INPUT);
  analogReference(DEFAULT);
}

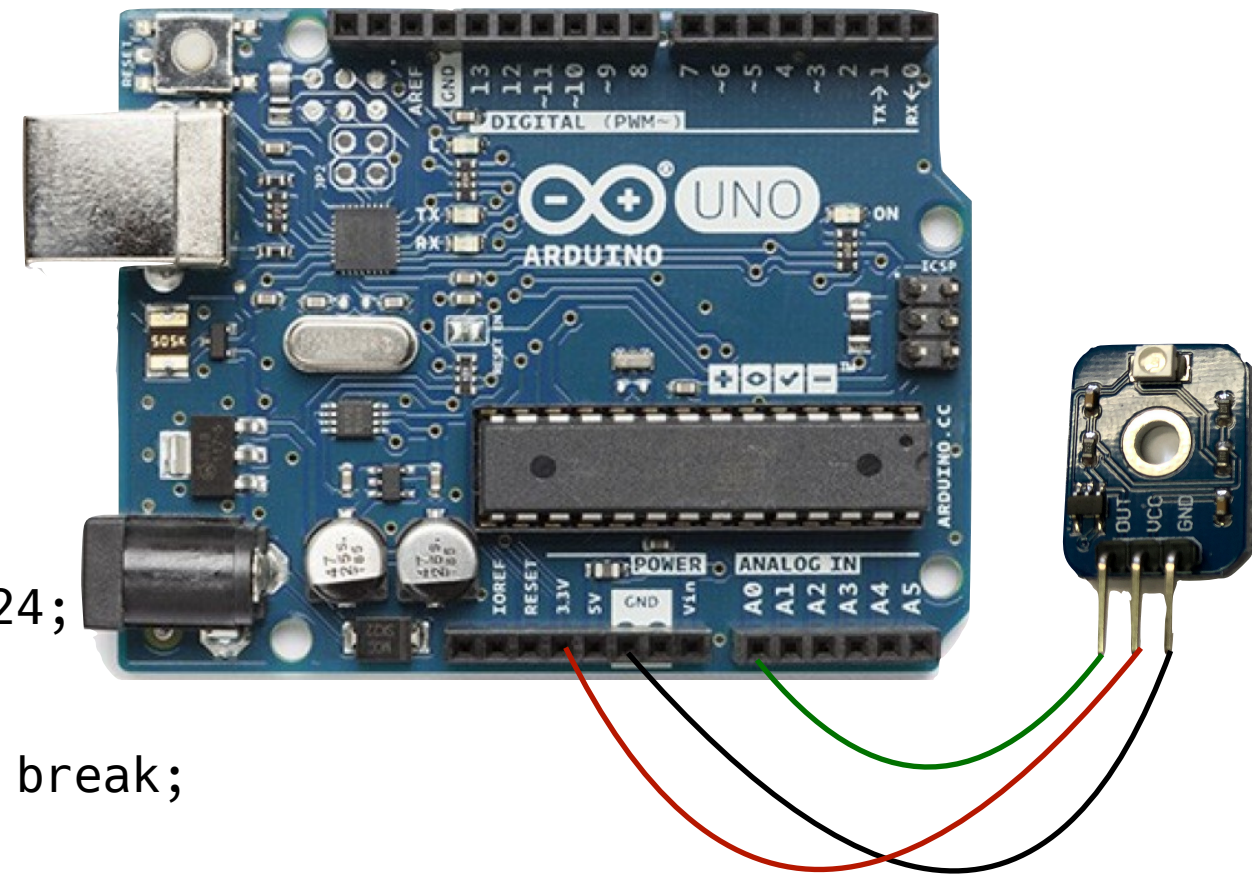
void loop() {
  float sensorVoltage = analogRead(A0)*5.0/1024;
  int uvIndex;
  for (uvIndex=0; uvIndex<12; ++uvIndex) {
    if (sensorVoltage <= thresholds[uvIndex]) break;
  }
  Serial.print(uvIndex);
  Serial.print(" ");
  Serial.println(sensorVoltage);
}
```

接線方式：

VCC：為電源正極輸入口，接入 3.3V-5V 的電壓 ——

GND：為電源負極輸入口 ——

OUT：為模擬信號輸出口，鏈接 MCU 的 I/O 口 ——



What can be done with UV and its measurement data? 紫外線及其量度數據可以用來做甚麼？

- Direct application
直接應用
- Visualisation
可視化
- Control
控制

Direct application 直接應用

Products using UV radiation 利用紫外線的產品



Image source 圖片來源：
http://cdn.teachersource.com/downloads/lesson_pdf/UV-AST.pdf

Products using UV radiation 利用紫外線的產品



Image source 圖片來源：

<http://www.uwatchshop.com/no-1-t3-bluetooth-smart-watch.html>

<http://jr-alarme.info/>

[detector counterfeit bank notes uv detector, 220vac 4w fake notes ultraviolet detection system fake bill us bank note card detectors counterfeit money cards detection system uv detection system item 26661 english.html](http://www.amazon.com/WEMELODY-Ultraviolet-Indicator-Relatives-Protection/dp/B00XGD7SIU)

<https://www.amazon.com/WEMELODY-Ultraviolet-Indicator-Relatives-Protection/dp/B00XGD7SIU>

Products using UV radiation 利用紫外線的產品

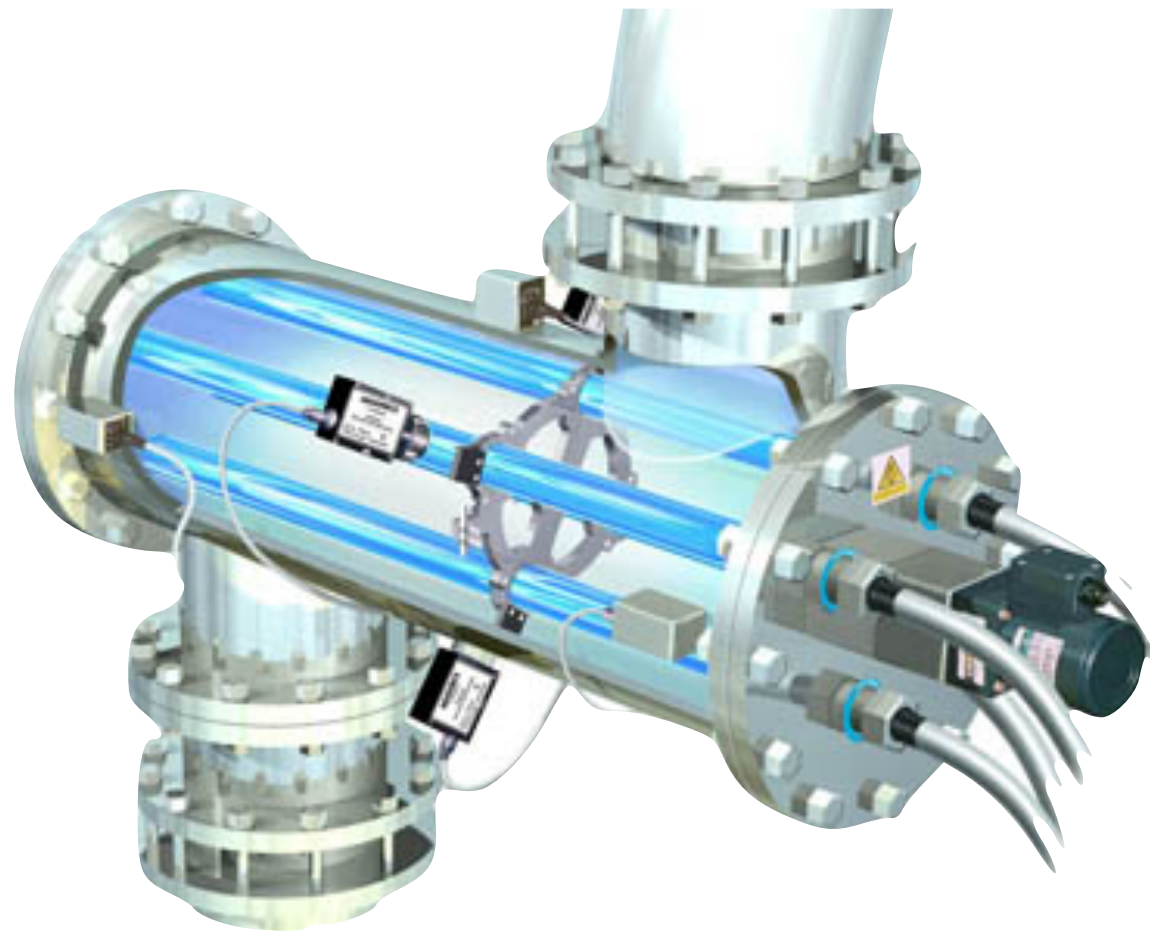


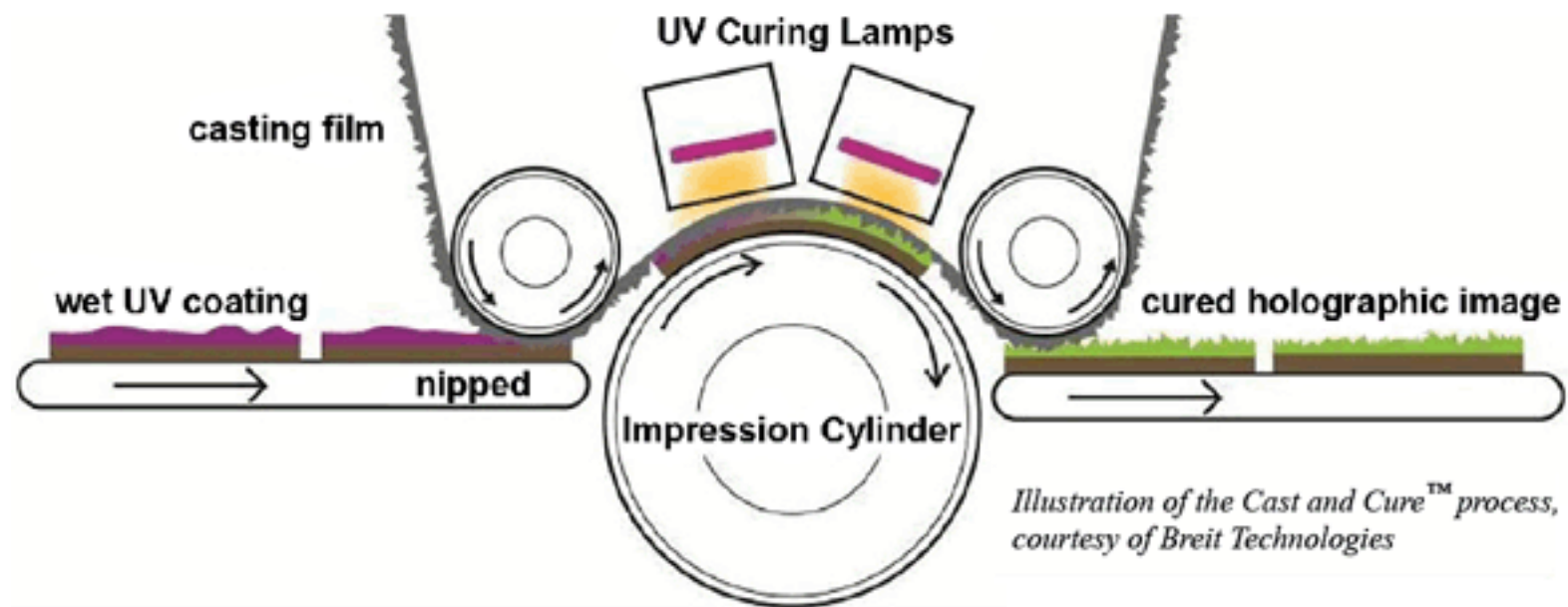
Image source 圖片來源：

<http://halmapr.com/news/aquionics/2006/06/26/the-benefits-of-uv-disinfection-in-the-brewing-and-beverage-industries/>

<http://www.ebay.com/gds/How-to-Install-a-UV-Sterilizer-/10000000178758616/g.html>

<http://www.aquaultraviolet.com/products/uvsterilizers/advantage/15watt-hanger>

Products using UV radiation 利用紫外線的產品



單面UV咭片
(250g雙粉咭 / 局部UV)

雙面UV咭片
(250g雙粉咭 / 局部UV)

Image source 圖片來源：

<http://archive.fsea.com/article.asp?ID=147#.WidlwraB3OQ>

https://www.e-print.com.hk/products_business_name_cards_printing

Quiz!

問答時間！

- Are they all direct applications of UV?
它們是否都是直接利用紫外線的？
- How to sterilise an aquarium using UV?
如何用紫外線替魚缸殺菌？

Visualisation 可視化

Data visualisation

數據可視化

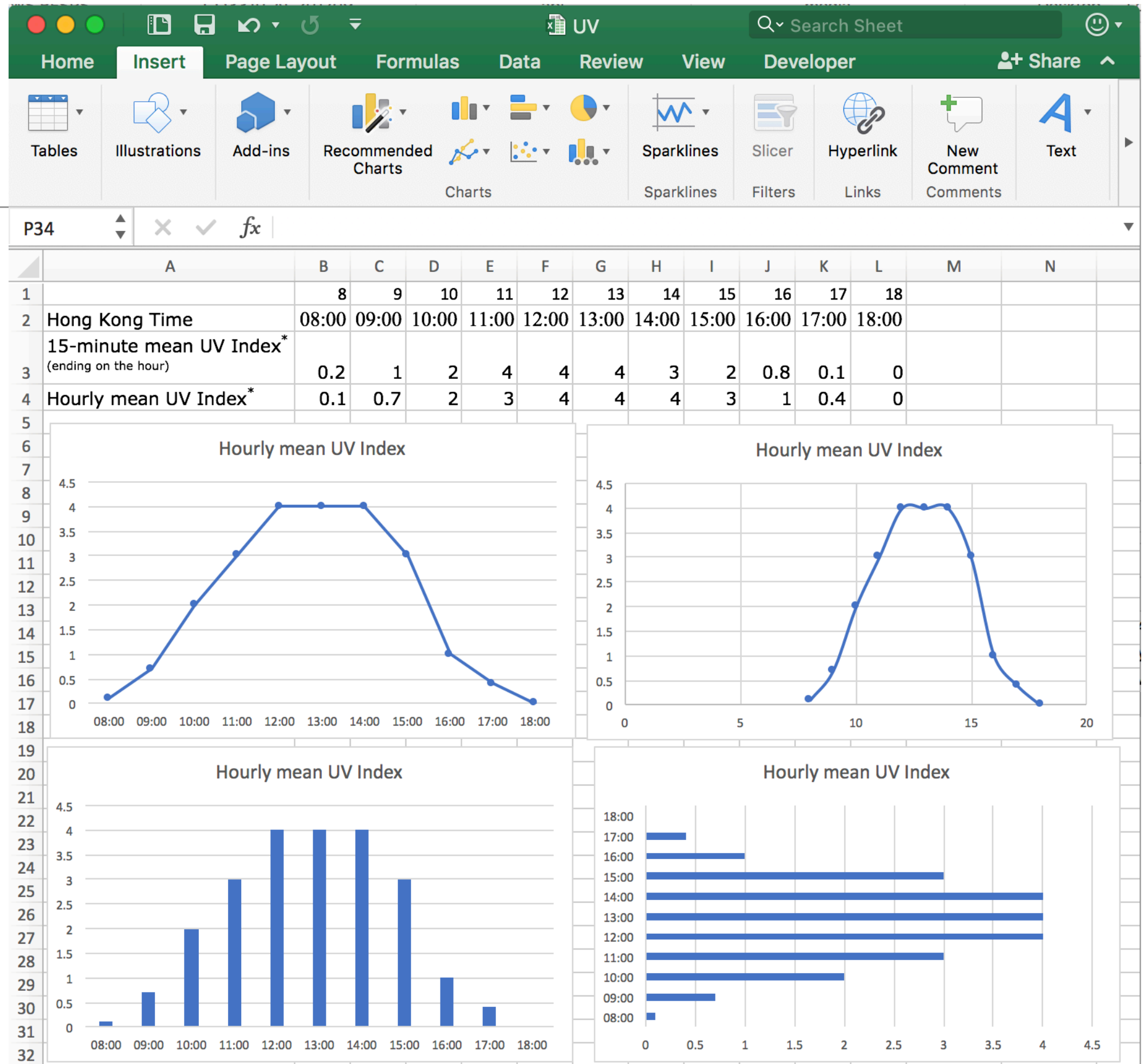
- Microsoft Excel
- Tableau
- gnuplot
- Python: matplotlib.pyplot
- JavaScript: d3.js
- NCL: NCAR Command Language

Data source for the upcoming demos

以下示範之數據來源

- UV index for today (2017-12-06)
<http://www.hko.gov.hk/wxinfo/uvindex/english/euvtoday.htm>
今日紫外線指數 (2017-12-06)
<http://www.hko.gov.hk/wxinfo/uvindex/chinese/cuvtoday.htm>
- Sequence 數列 : [0.1, 0.7, 2, 3, 4, 4, 4, 3, 1, 0.4, 0]

Microsoft Excel



Tableau



- Company specialised in data analytics and data visualisation.
一間從事數據系統計算分析和數據可視化的公司。
<https://www.tableau.com/>
- Offers a free data visualisation portal.
提供免費的數據可視化門戶網站。
<https://public.tableau.com/>
- Uses a desktop application for preparing the visualisation for publication.
提供桌面應用程序來準備可視化文件，以發佈到門戶網站。

Tableau



- Let's try!
試試看！

2017-12-06 UV Index at HKO

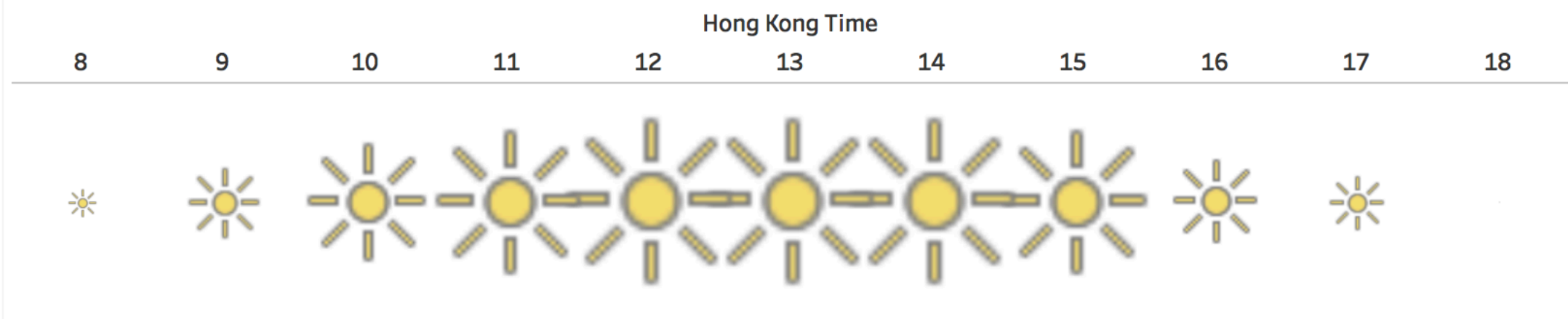


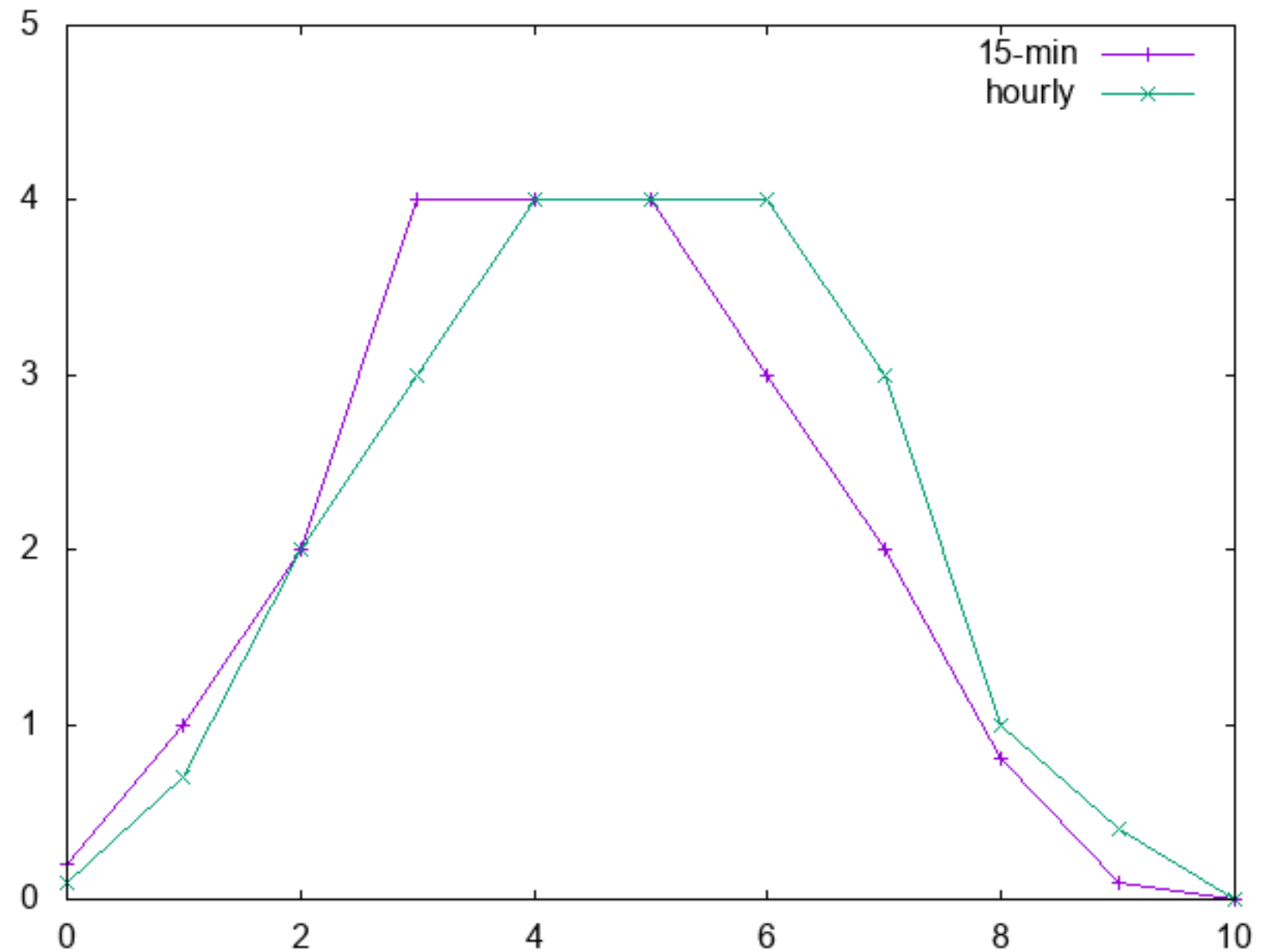
Image source 圖片來源：
<https://public.tableau.com/profile/yip4670/#/>

gnuplot

- An open source application. 開源軟件。
- Can plot functions. 可以繪畫函數。
- <http://www.gnuplot.info/>
<http://gnuplot.sourceforge.net/>
- Has its own language for plotting graphs.
有自己的繪圖語言。
- Demo web site 示範網頁：
<http://gnuplot.info/screenshots/index.html>

gnuplot

- Let's try!
試試看！

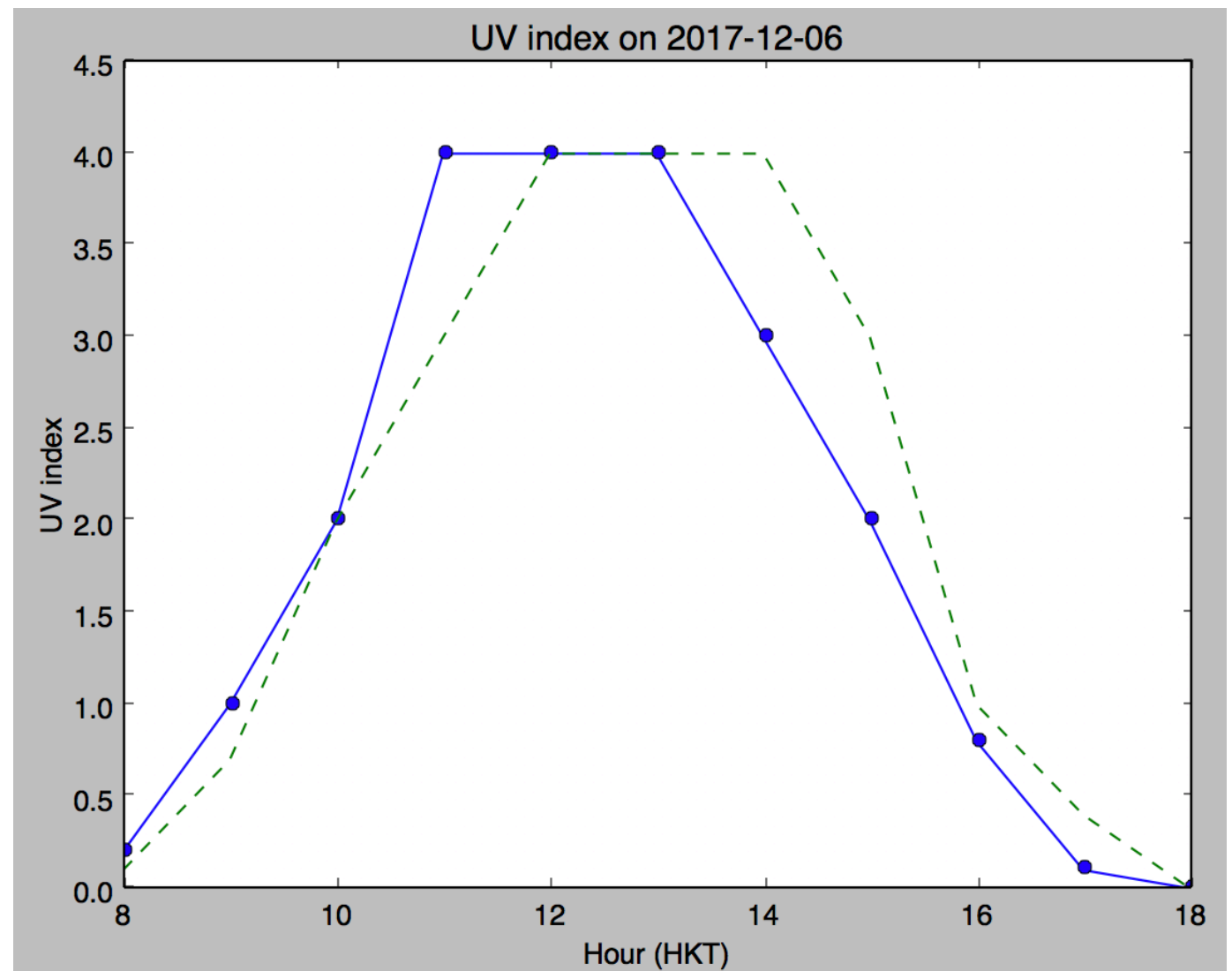


matplotlib.pyplot

matplotlib

- A library in the Python language.
- <https://matplotlib.org/index.html>

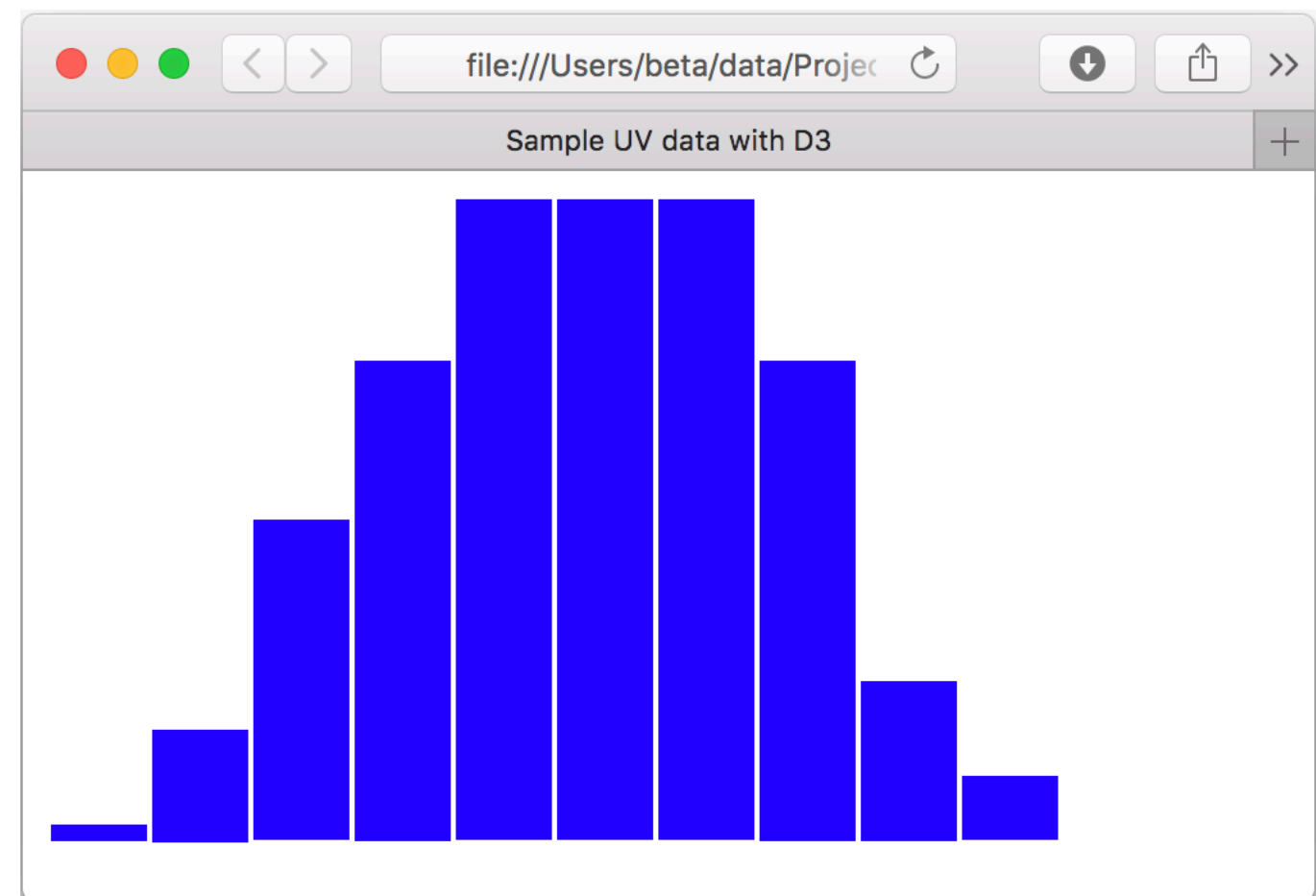
- Let's try!
試試看！





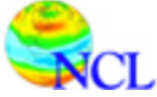
d3.js

- JavaScript library: Data Driven Document
- Widely used for web-based infographics.
廣泛用於製作網頁信息圖。
- <http://www.d3js.org/>



NCAR Graphics



- By University Corporation for Atmospheric Research (UCAR) <http://www.ucar.edu/>
- Used by National Center for Atmospheric Research (NCAR) and meteorological centres worldwide. <https://ncar.ucar.edu/>
- NCAR Graphics web site: <http://www.ncarg.ucar.edu/>
- Uses NCL: NCAR Command Language The NCL logo consists of a small globe with a color gradient from blue at the top to red at the bottom, with the letters "NCL" in blue to its right.
- <https://www.ncl.ucar.edu/index.shtml>

Control 控制

Control

控制

- How do you turn on the light?
你怎樣開燈？
- How do you instruct on which floor the lift should stop?
你怎樣指示電梯應在哪層停？
- How do you operate a calculator?
你怎樣操作計算機？

Switches

開關

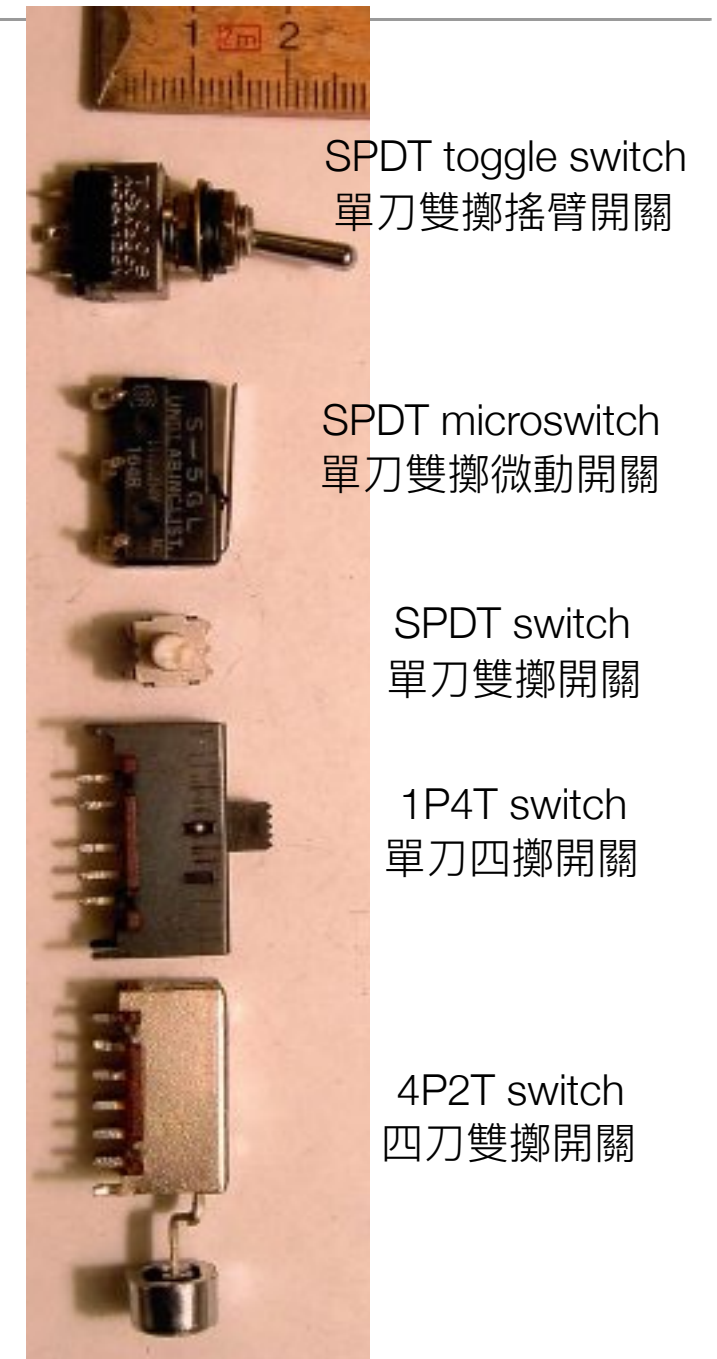
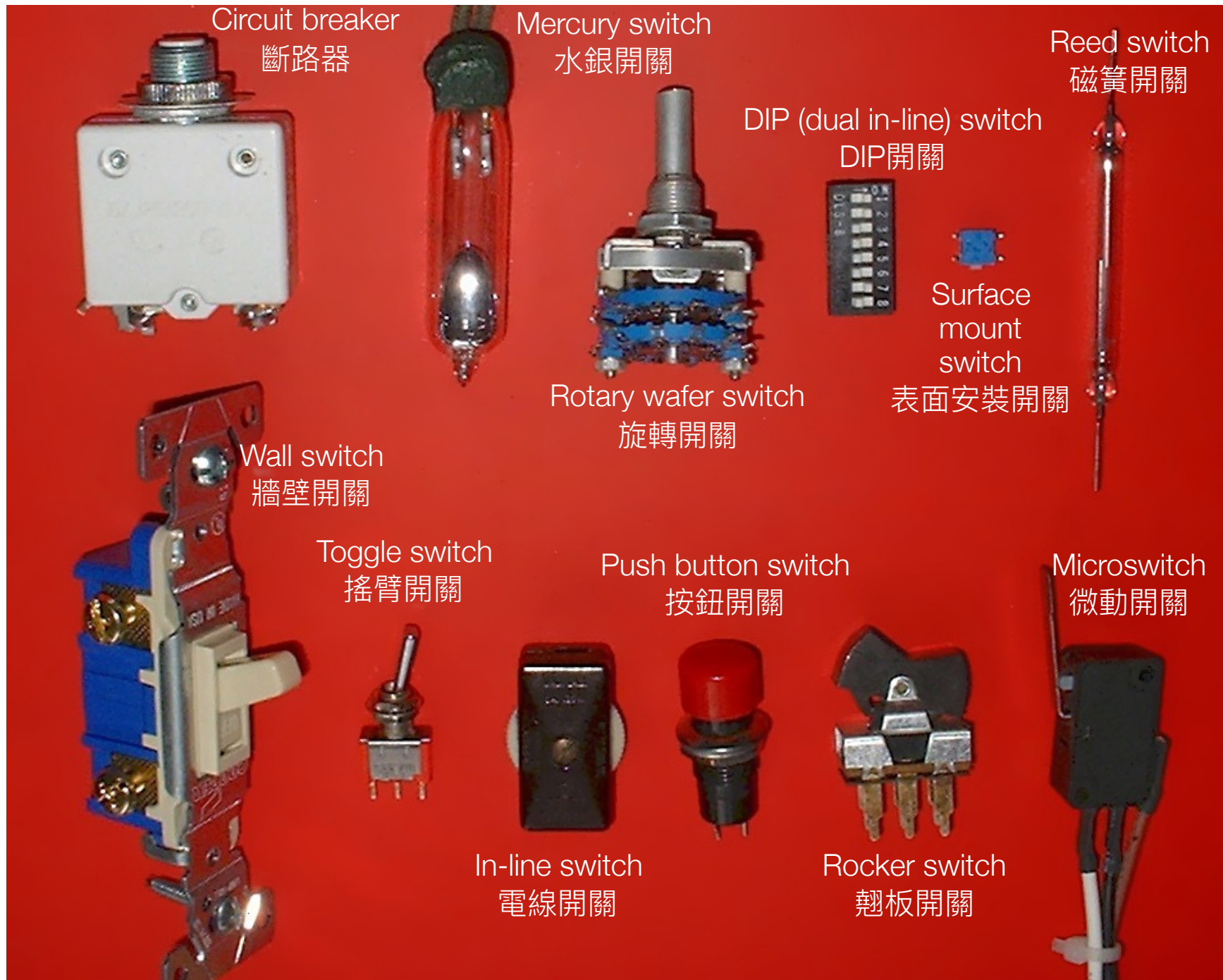


Image source 圖片來源 :

Electrical switches. By ArnoldReinhold. CC-BY-SA-3.0, GFDL. <https://commons.wikimedia.org/wiki/File:Switches-electrical.agr.jpg>

Image of electrical changeover switches. By Glenn. GFDL, CC-BY-SA-3.0 https://commons.wikimedia.org/wiki/File:Changeover_switches.jpg

About switches

關於開關

- Switches let current through under some conditions.
開關在某些情況下允許電流通過。
- Two states: open (current cannot pass through) and closed (can).
有兩種狀態，開（電流不能通過）和關（能）。
- Where are the following switches used?
在哪裏會用到以下的開關？
 - Key switch 鎖匙開關
 - Push button 按鈕開關
 - Tilt switch 傾斜開關
 - Float switch 浮控開關



Image source 圖片來源：

Key Switch, SP-CO, 5 A@ 250 V ac 2-Way. <https://uk.rs-online.com/web/p/key-switches/0825635/>

SPDT On-On Push Button Switch, IP65, IP67, 22 (Dia.)mm, Panel Mount Blue LED, 12V. <https://uk.rs-online.com/web/p/push-button-switches/8118483/>

10 ° Mercury Tilt Switch, 1 A, 220V. <https://uk.rs-online.com/web/p/mercury-tilt-switches/0344883/>

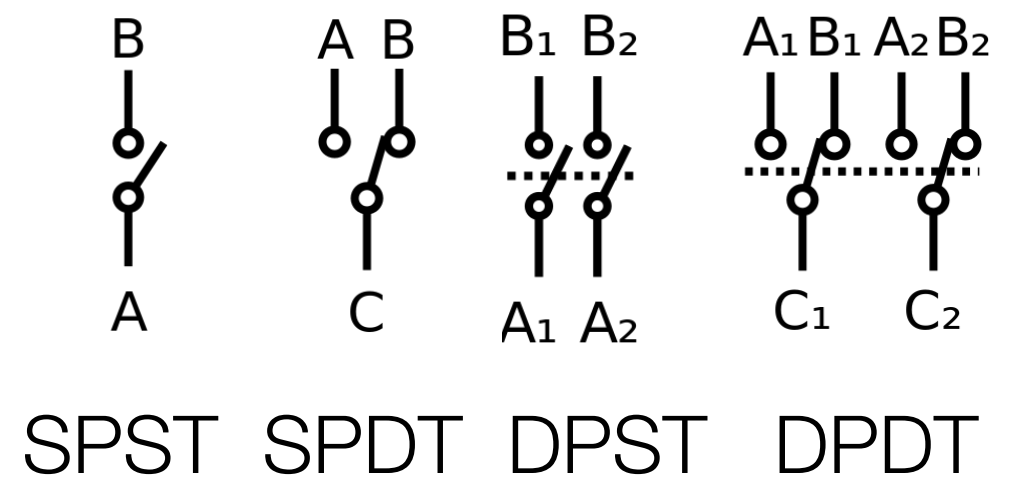
Cynergy3 RSF70 Series Horizontal Mounting Float Switch NO/NC Output. <https://uk.rs-online.com/web/p/level-sensors-switches/8697570/>

Poles and throws

刀數和擲數

- Switches are categorised by the number of poles and throws.
開關用刀數和擲數分類。
- Poles are the number of switches, and throws are the number of choices for each switch.
刀數即開關數目，擲數即每個開關有多少選擇。
- They are abbreviated as xPyT where x and y are numbers, or S for Single, and D for Double.
分類用 xPyT 表示，x 和 y 為數字，或以 S 代表單，D 代表雙。
- Examples, used in both relays and switches 用於繼電器和開關的例子：

- SPST = Single Pole Single Throw 單刀單擲
- SPDT = Single Pole Double Throw 單刀雙擲
- DPST = Double Pole Single Throw 雙刀單擲
- DPDT = Double Pole Double Throw 雙刀雙擲



NO and NC

常開和常關

- 2P6T, etc. can be used for ganged rotary switches.
2P6T 等會用於旋轉開關。
- Some switches like push buttons has a normal state.
有些開關有常態，例如按鈕開關。
- A Normally Open (NO) switch has a normal state that does not conduct electricity.
常開 (NO) 開關常態為開路，即電流不能通過。
- A Normally Closed (NC) switch has a normal state that conducts electricity.
常閉或常關 (NC) 開關常態為閉路，即電流可以通過。

Sensors as switches

傳感器用作開關

- Sensors giving digital output and can be seen as switches conditionally connecting to the power or ground.
用數碼輸出的傳感器可以看作是有條件地將輸出連接到電源或接地的開關。
- Passive InfraRed (PIR) sensor 被動紅外線傳感器
- Bluetooth remote switch 藍芽遙控開關
- How about UV sensors?
紫外線傳感器呢？

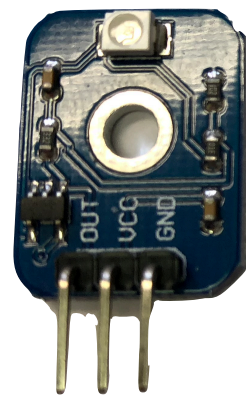
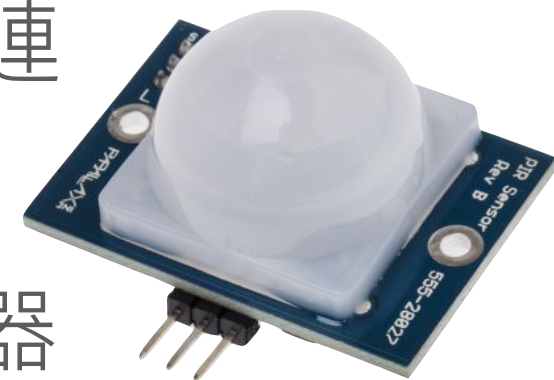


Image source 圖片來源：

Parallax Inc PIR Sensor Module, 555-28027. <https://hken.rs-online.com/web/p/interface-development-kits/7813024/>

AbleNet Blue2 Bluetooth Switch. <https://www.apple.com/hk/shop/product/HJ2W2LL/A/ablenet-blue2-bluetooth-switch>

Hence, Arduino, Raspberry Pi etc.
are programmable switches!

即是說，Arduino、樹莓派等咭片式電腦
可被視為可編程控制的開關！

I can control many things using them!
我可以用它們控制很多東西了！

Some technical info about Arduino outputs

Arduino 輸出端子的一些技術資料

- Some technical info about Arduino output pins:
Arduino UNO 輸出端子的技術資料：
<https://www.arduino.cc/en/Main/ArduinoBoardUno>
- DC Current per I/O Pin: 20mA.
輸入輸出端子最大電流： 20mA.
- i.e., The outputs cannot drive devices that take more than 20mA.
即是說輸出不能驅動要多於 20mA 電流的器件。
- The specification for other Arduino boards can be looked up at:
其他 Arduino 版的技術資料可在這裏找到：
<https://www.arduino.cc/en/Main/Products>

Type	Current
UNO	20mA
101	4mA
Pro	40mA
Pro Mini	40mA
MICRO	20mA
Nano	40mA
Mega	20mA
ZERO	7mA
Due	800mA
Yún	40mA

Power, Voltage, Current

功率、電壓、電流

- Power = Voltage x Current
功率 = 電壓 x 電流
 $P = VI$
- Lighting an LED 點亮LED : 2–5mA
Driving a buzzer 推動蜂鳴器 : 5–10mA
Powering a small motor 驅動小馬達 : 10–50mA
- Incandescent light bulb 白熾燈 : 40–100W
Compact fluorescent light 慳電膽 : 5–20W
Small Christmas light set 小聖誕燈飾串 : 2–10W
- $5V \times 20mA = 100mW = 0.1W$

I want to control something powerful!
我想控制大功率的東西啊！

Driving high current components

驅動高電流的零件

- For Arduino output pin to drive a high current component, a electronic switch is needed.
Arduino 的輸出要驅動高電流的零件，需要一個電子開關。
- Use a small current to drive a mechanical switch that allows larger current: use a Relay.
用小量電流控制一個可讓大電流通過的開關：繼電器。
- Fully electronic solution: use a Power Metal Oxide Semiconductor Field Effect Transistor (MOSFET).
全電子化方案：利用大功率金屬氧化半導體場效應晶體管 (Power MOSFET)。

Electrically controlled mechanical switches: Relay

電控機械開關：繼電器



TAKAMISAWA RY3W-K Relay (2P2T, 3VDC, 18E [1])

TAKAMISAWA RY5W-K Relay (2P2T, 5VDC, 167E [1])

TAKAMISAWA RY6W-K Relay (2P2T, 6VDC, 240E [1])



OMRON H3Y-2 Timer Relay (24VDC, 3min)

OMRON MK2P-I Timer Relay (2P2T, 12VDC, 7A)

OMRON MK2P-I Timer Relay (2P2T, 24VDC, 7A)

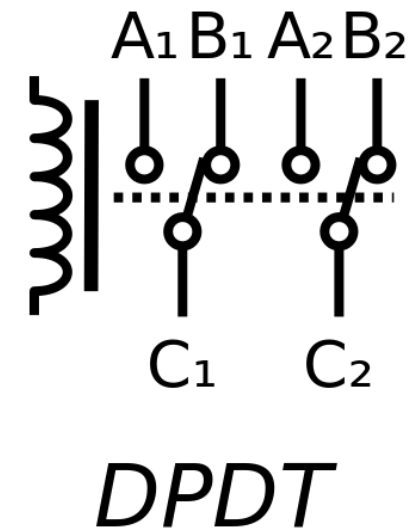
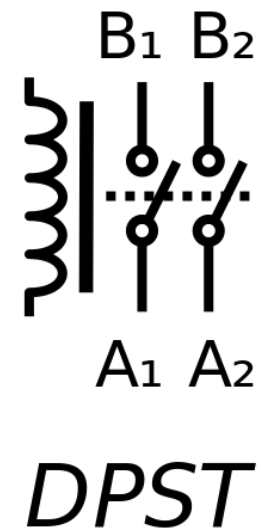
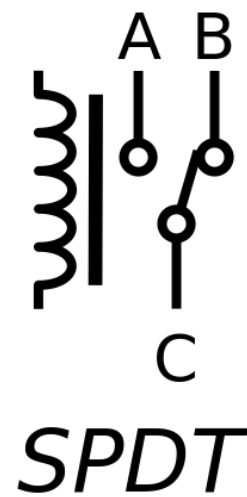
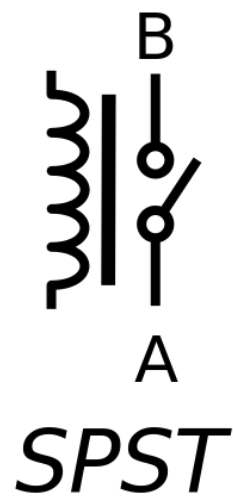


Image source 圖片來源：

WECLOnline.com. http://www.weclonline.com/eng/productlist.asp?page=1&display=photo&mc_code=08&sc_code=012&s2c_code=0001&s3c_code=0010

Electrically controlled mechanical switches: Relay

電控機械開關：繼電器

- What's the power needed to switch on the relay?

繼電器的工作功率是多少？

- Example 例：

TAKAMISAWA RY5W-K Relay (2P2T, 5VDC, 167Ω)

<http://www.weclonline.com/downloads/pdf/07-01-3005.pdf>

	MODEL	Nominal voltage	Coil resistance (±10%)	Must operate voltage	Must release voltage	Nominal power
High Sensitive Type	RY-4.5 W-K	4.5 VDC	135Ω	3.2 VDC	0.23 VDC	150 mW
	RY- 5 W-K	5 VDC	165Ω	3.6 VDC	0.25 VDC	150 mW
	RY- 6 W-K	6 VDC	240Ω	4.3 VDC	0.3 VDC	150 mW
	RY- 9 W-K	9 VDC	540Ω	6.4 VDC	0.45 VDC	150 mW
	RY- 12 W-K	12 VDC	960Ω	8.5 VDC	0.6 VDC	150 mW
	RY- 18 W-K	18 VDC	1,620Ω	12.6 VDC	0.9 VDC	200 mW
	RY- 24 W-K	24 VDC	2,880Ω	16.8 VDC	1.2 VDC	200 mW
	RY- 48 W-K	48 VDC	7,680Ω	32.6 VDC	2.4 VDC	300 mW

- Can Arduino drive it directly?

Arduino 可以直接驅動它嗎？

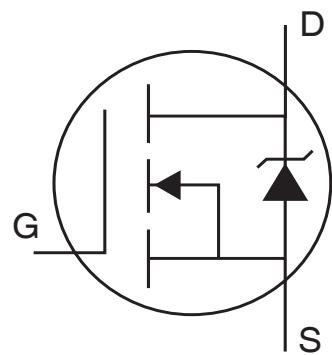
What can we do? 我們可以做甚麼？

- Remember the current ratings of the Arduino models?
記得各種Arduino的輸入輸出端子的最大電流值是甚麼嗎？
- Which Arduino model can be used to directly drive that relay?
哪型號的Arduino可以直接驅動該繼電器？
- Can the fully electronic solution solve the problem?
全電子化方案可以解決問題嗎？

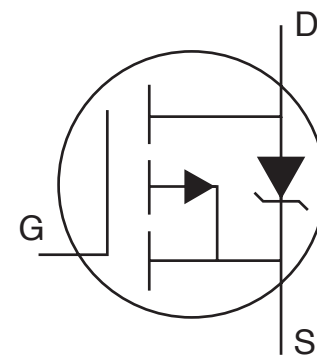
Power MOSFET

大功率金屬氧化半導體場效應晶體管

- A MOSFET has three connections: Source (S), Drain (D), and Gate (G).
MOSFET 有三個接腳：源極 (S)、汲極 (D)、和閘極 (G)。
- There are two types: N-channel and P-channel.
分 N通道和 P通道兩種。
- They can be seen as voltage-controlled amplifiers which is often used as solid state switches.
它們可看成電壓控制的放大器，常用作固態開關。



N-channel MOSFET
e.g., IRF520

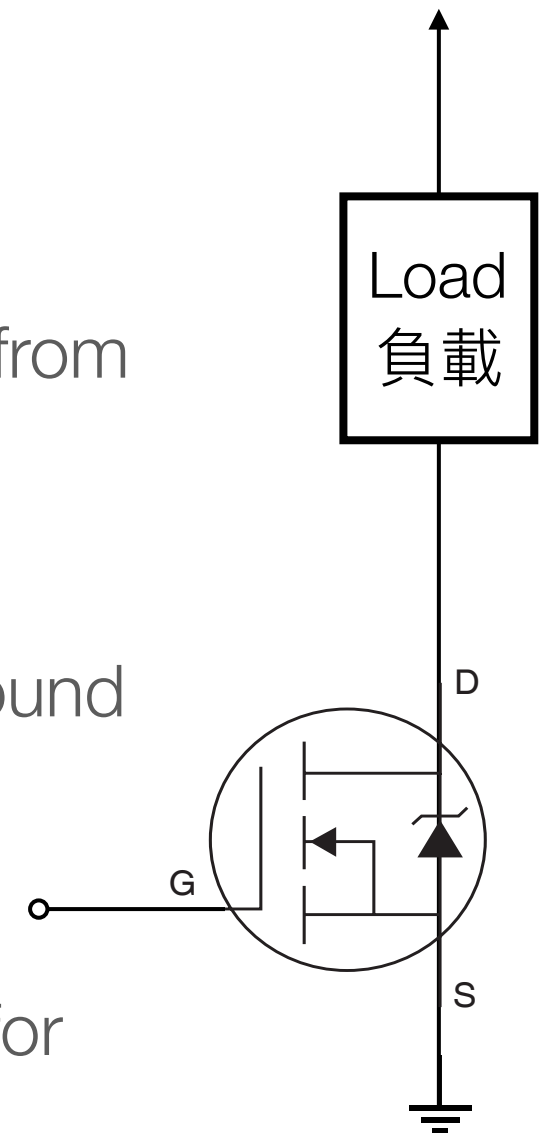


P-channel MOSFET
e.g., IRF5210

Power MOSFET as electronic switch

大功率 MOSFET 用作電子開關

- Sample use of an N-channel MOSFET as an electronic switch.
N通道 MOSFET 作電子開關的應用。
- Connect the Source to ground. 源極接地。
- A positive voltage applied at the Gate opens up the channel from Drain to Source.
對地為正的閘極電壓開通汲極至源極的通道。
- A load can be serially connected through the Drain to the ground via the Power MOSFET.
負載可由電源經 MOSFET 串聯至地。
- Again, actually it is more complicated. Read the data sheet for the MOSFET for details.
實際上比這裏複雜，要知細節，請讀所選 MOSFET 的數據資料。



Power MOSFET references 參考資料

- IRF520
Product info 產品資料 : <http://hken.rs-online.com/web/p/mosfet-transistors/5411180/>
Data sheet 技術資料 : <http://docs-asia.electrocomponents.com/webdocs/0791/0900766b807910f4.pdf>
- IRF5210
Product info 產品資料 : <http://hken.rs-online.com/web/p/mosfet-transistors/5411720/>
Data sheet 技術資料 : <http://docs-asia.electrocomponents.com/webdocs/0791/0900766b807910f5.pdf>
- Application Note 558: Introduction to Power MOSFETs and their Applications; Ralph Locher; Fairchild October 1998.
<https://www.fairchildsemi.com/application-notes/AN/AN-558.pdf>
- Application Note 7500: Understanding Power MOSFETs; Fairchild October 1999.
<https://www.fairchildsemi.com/application-notes/AN/AN-7500.pdf>
- AN11158: Understanding power MOSFET data sheet parameters; Rev. 4; NXP Semiconductors 2014-02-04.
http://www.nxp.com/documents/application_note/AN11158.pdf

Using MOSFET to drive a relay

利用 MOSFET 驅動繼電器

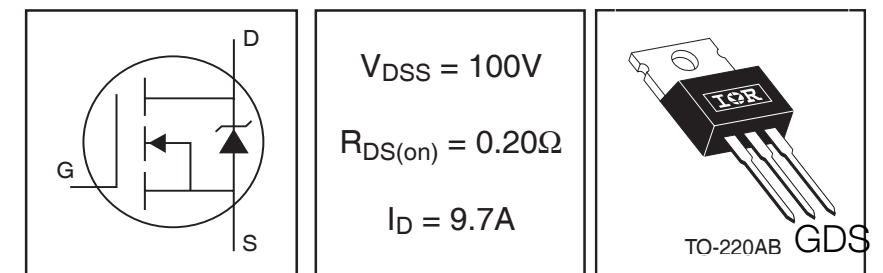
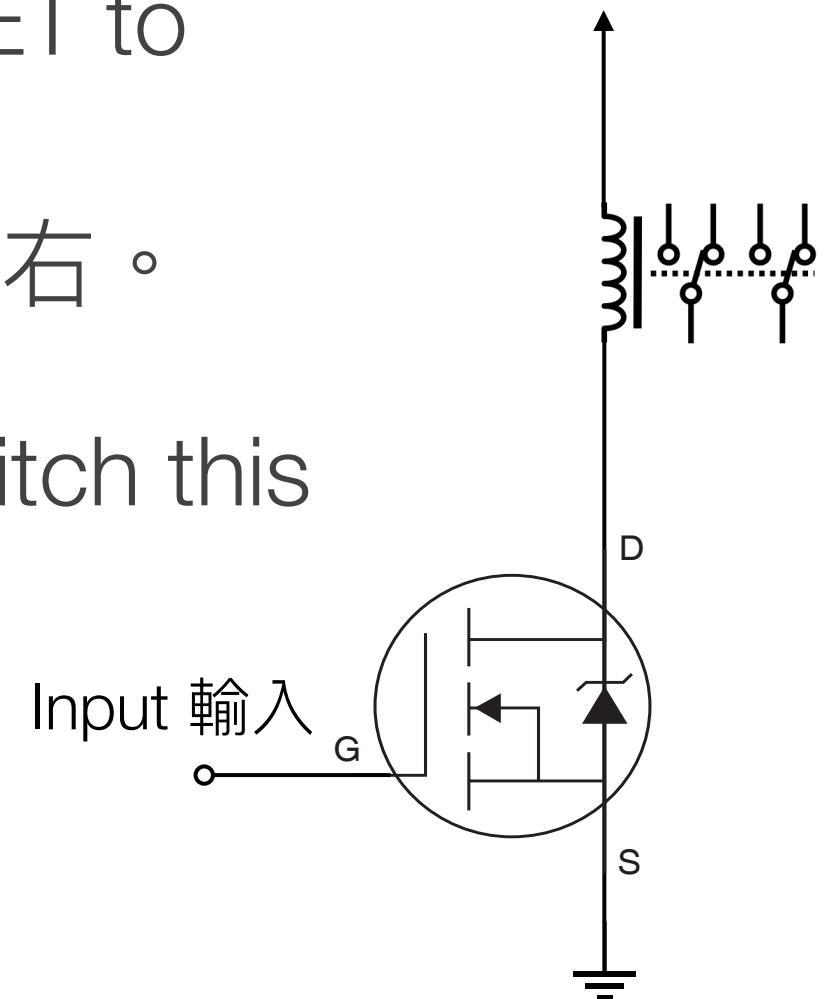
- The circuit schematic for using MOSFET to drive a relay is as shown on the right.

利用 MOSFET 驅動繼電器的電路圖如右。

- We have built a electrically isolated switch this way!

我們設計了一個用 Arduino 來控制，
互相獨立的電路！

- What can be done? Let's try...
可以做甚麼？試試吧……



How about our Christmas tree? 我們的聖誕樹呢？

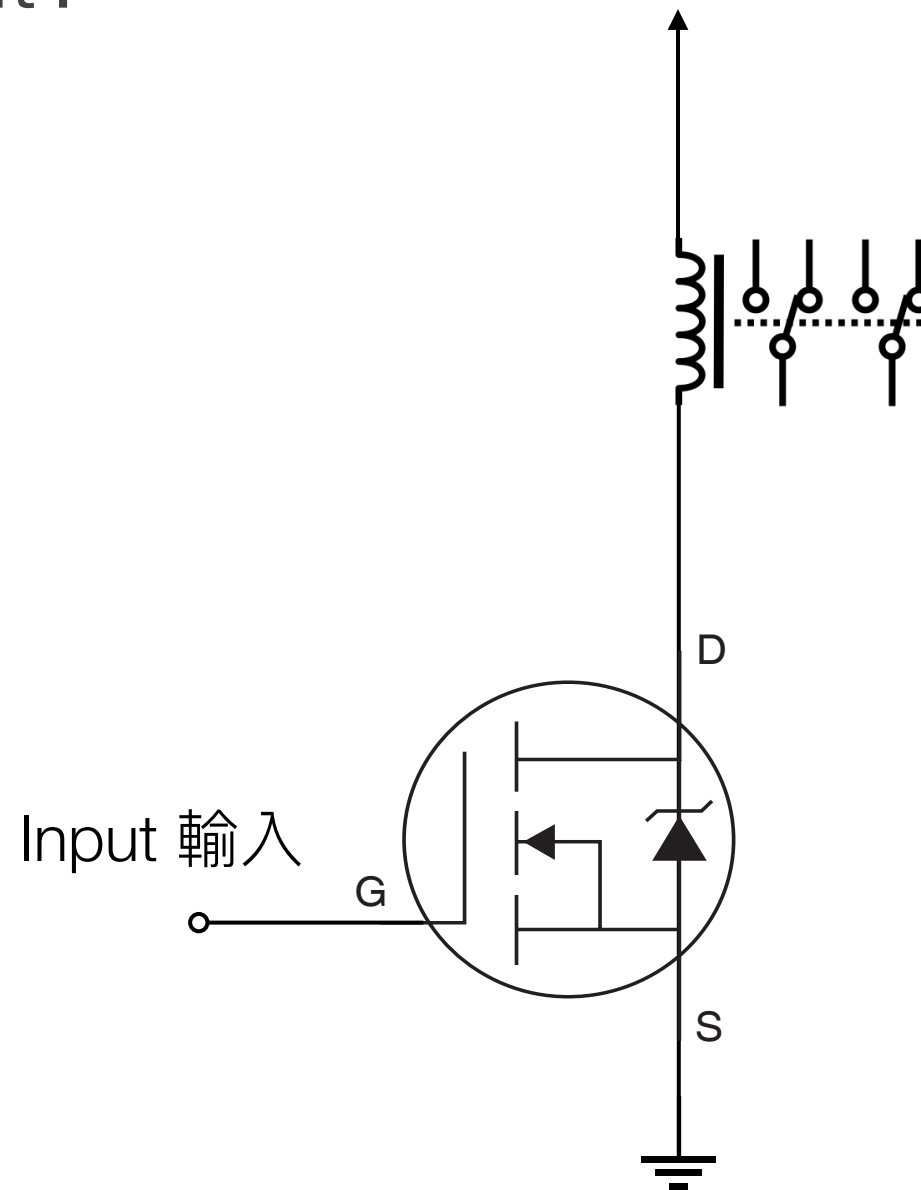
- Can we replace the relay by our Christmas tree?
我們可否將繼電器換成聖誕樹？
- Need to check the data sheet of the MOSFET we use.
要看我們用的MOSFET的數據單張了。

Absolute Maximum Ratings

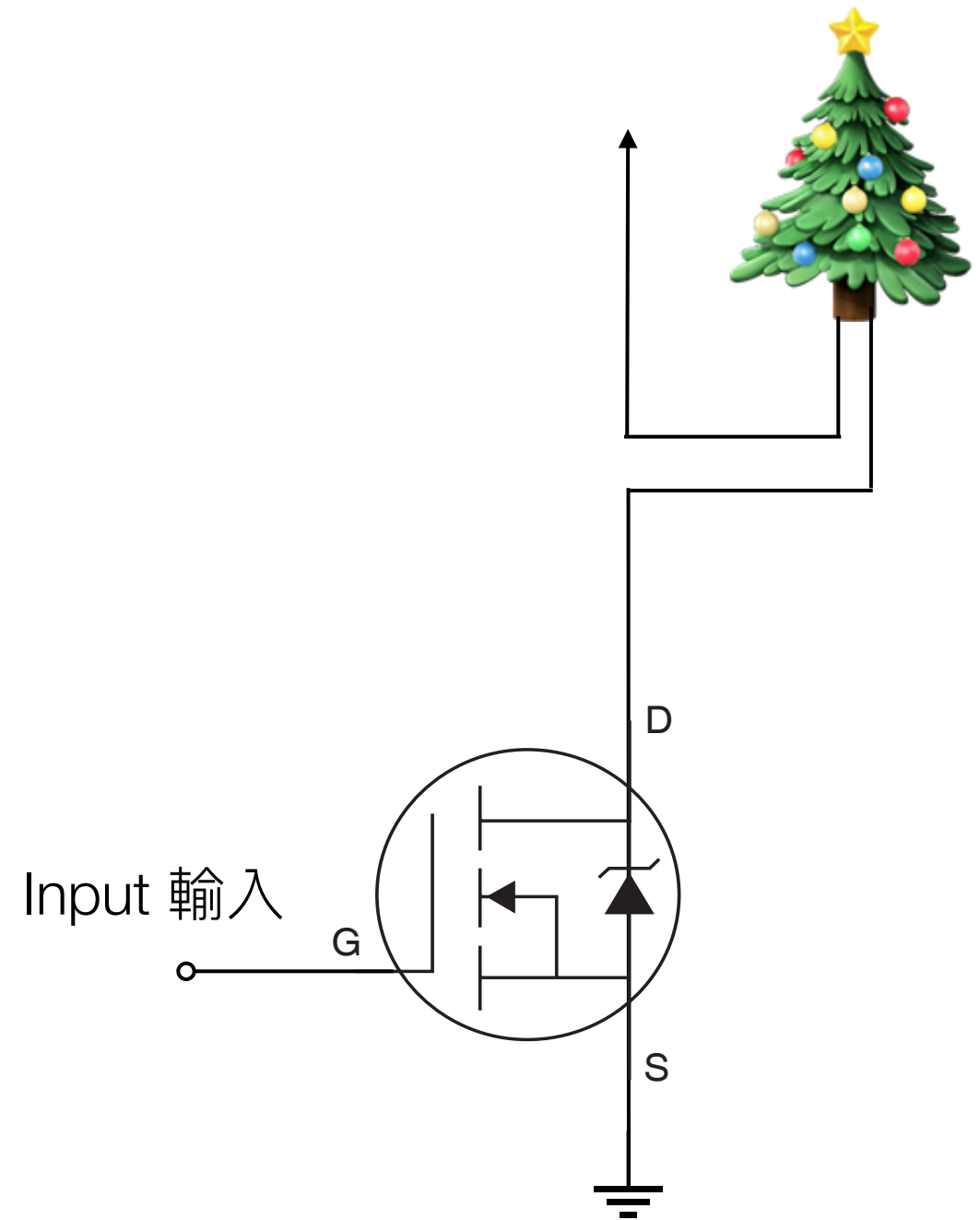
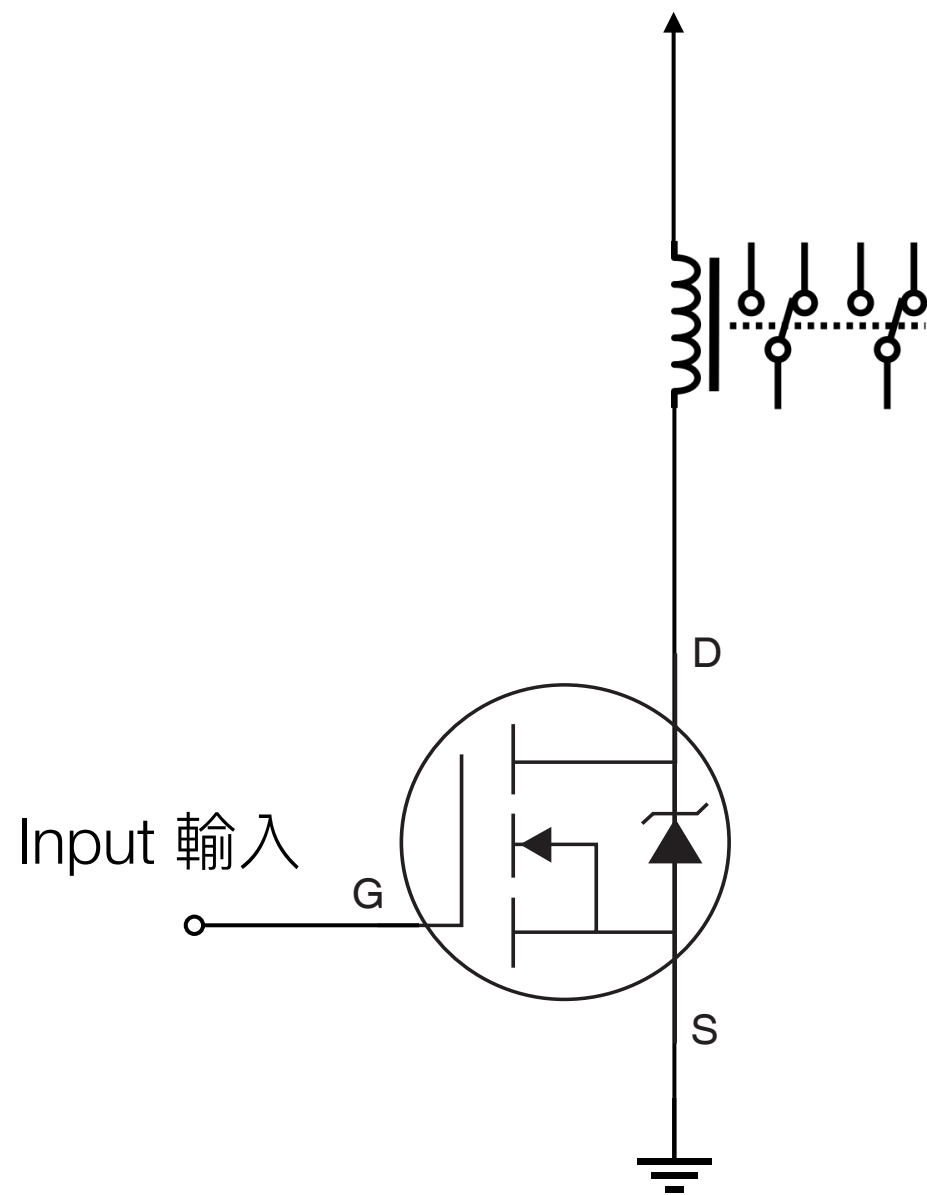
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$	9.7	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$	6.8	
I_{DM}	Pulsed Drain Current ①	38	
$P_D @ T_C = 25^\circ\text{C}$	Power Dissipation	48	W
	Linear Derating Factor	0.32	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy②	91	mJ
I_{AR}	Avalanche Current①	5.7	A
E_{AR}	Repetitive Avalanche Energy①	4.8	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting torque, 6-32 or M3 srew	10 lbf•in (1.1N•m)	

Change the circuit! 改動電路！

- How to change the circuit?
應如何改動電路？



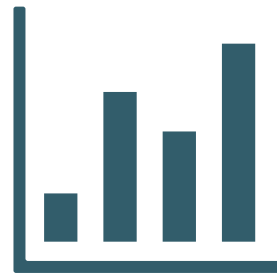
Change the circuit! 改動電路！



How to put things learnt today together?

如何整合今日學到的？

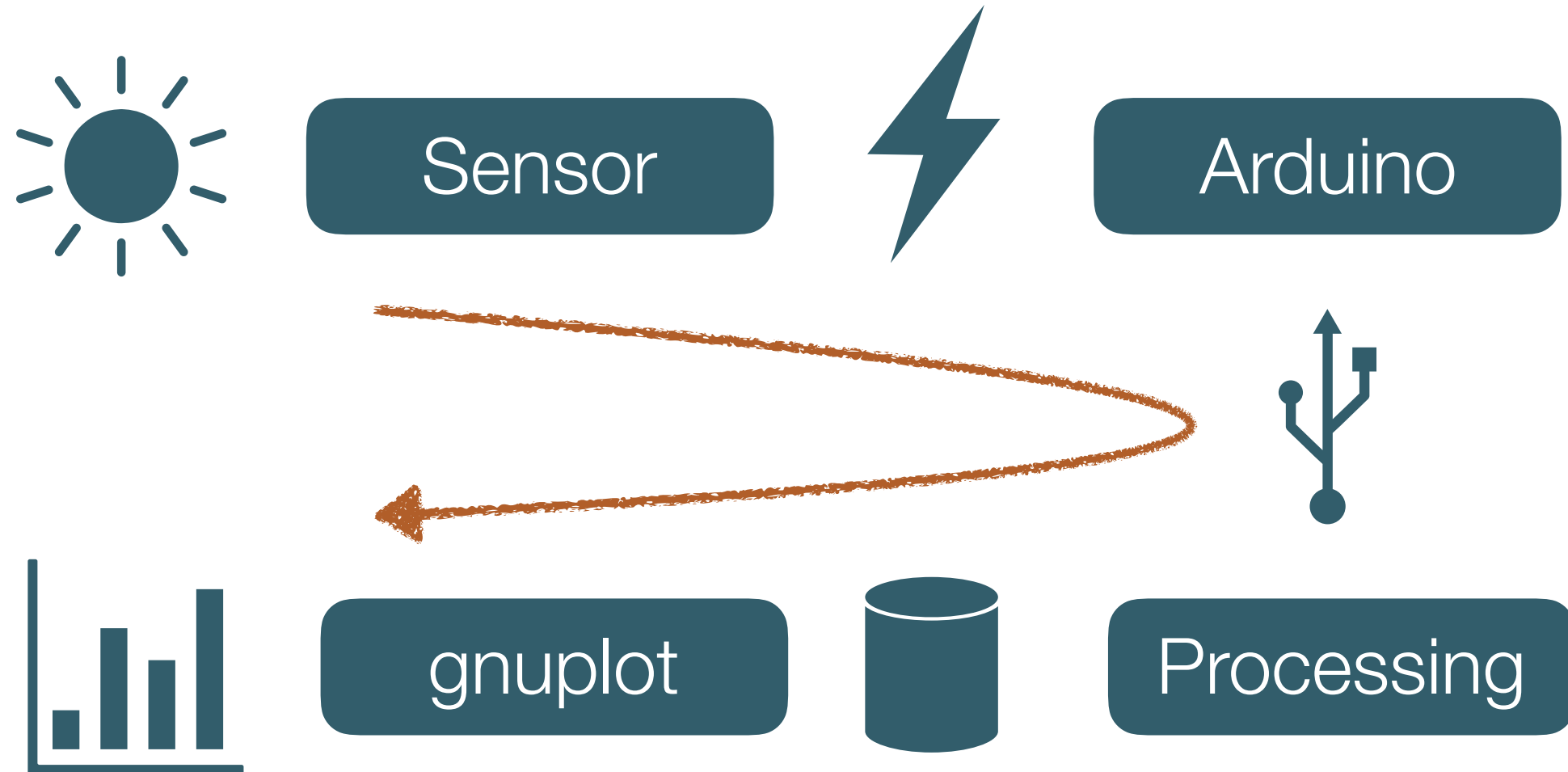
- Sensor readings, visualisation, control → application.
傳感器讀數、可視化、控制 → 應用



- Let's try: Christmas tree lighting control + live graphing
試試吧：控制聖誕樹燈飾 + 即時圖表

Conceptually...

概念上……



Your creativity!
你的創意！

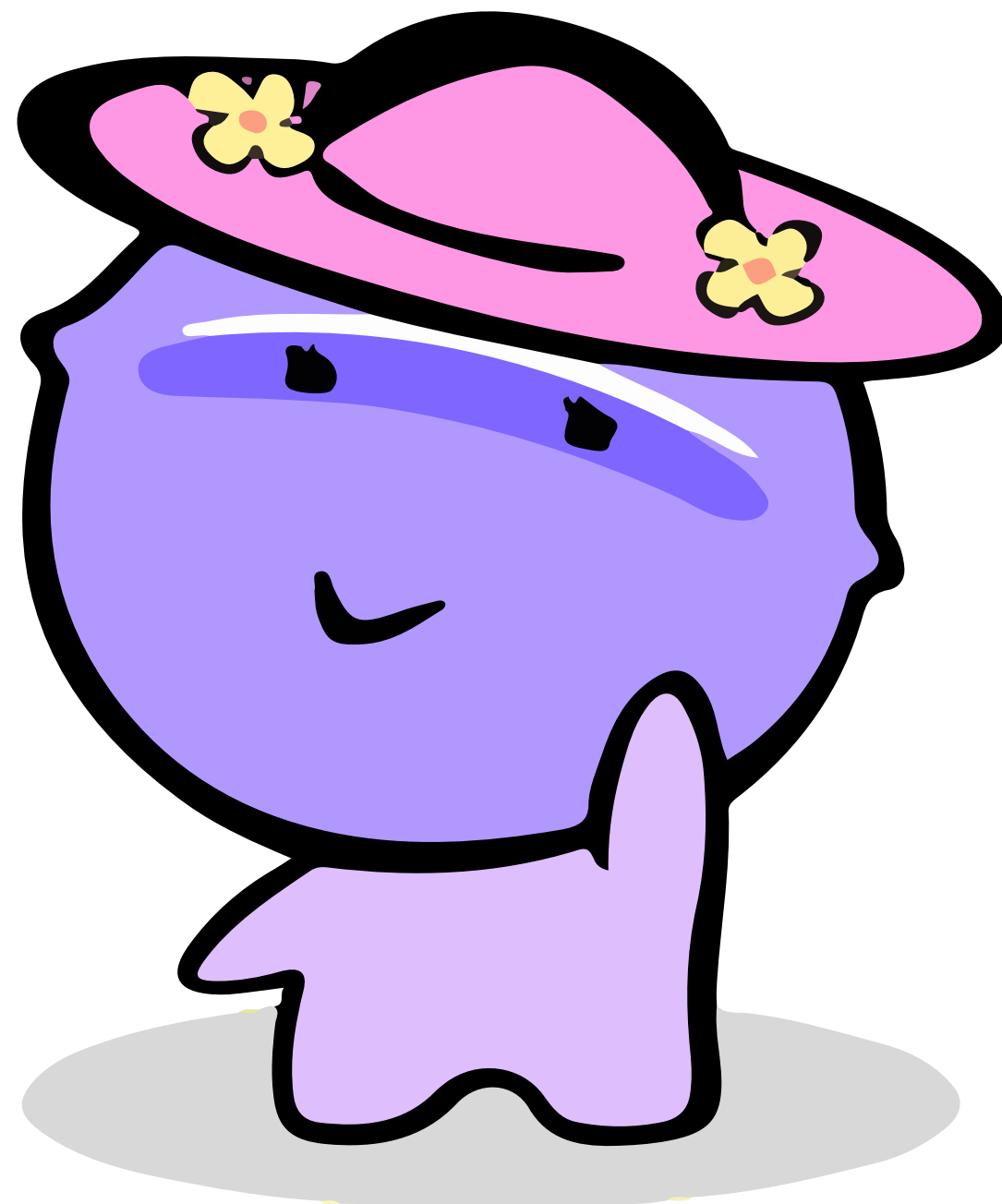
Links 連結



- Competition website 比賽網頁
<http://www.cs.hku.hk/~uv/>
- Facebook page  
<https://www.facebook.com/UVCompetition/>
- Facebook group
<https://www.facebook.com/groups/UVCompetition/>
- Email 電郵 
uv@cs.hku.hk

Thank you 謝謝





<https://www.facebook.com/UVCompetition/>