Chapter 3 Interpolation, Approximation, and Graphics

3-1 Lagrange Interpolating Polynomials

Given a set of data $\{(x_0,f(x_0)),(x_1,f(x_1)),(x_2,f(x_2)),\ldots,(x_n,f(x_n))\}$ for $x_0<x_1<x_2<\ldots<x_n$, then there exists a unique polynomial $p(x)$ of degree at most n with the property that $f(x_k)=p(x_k)$, $k=0, 1, 2, \ldots, n$, and $p(x)=\sum_{k=0}^{n} f(x_k)L_{n,k}(x)$, where

$$L_{n,k}(x)=\frac{(x-x_0)(x-x_1)\cdots(x-x_{k-1})(x-x_{k+1})\cdots(x-x_n)}{(x_k-x_0)(x_k-x_1)\cdots(x_k-x_{k-1})(x_k-x_{k+1})\cdots(x_k-x_n)}=\prod_{\substack{i=0\\ i\neq k}}^{n}\frac{(x-x_i)}{(x_k-x_i)}$$

Eg. Given $x_0=2$, $x_1=2.5$, and $x_2=4$, find a polynomial to fit $f(x)=1/x$.

(Sol.) $f(x_0)=0.5$, $f(x_1)=0.4$, $f(x_2)=0.25$

$$L_{2,0}(x)=\frac{(x-2.5)(x-4)}{(2-2.5)(2-4)}=x^2-6.5x-10$$

$$L_{2,1}(x)=\frac{(x-2)(x-4)}{(2.5-2)(2.5-4)}=\frac{-4x^2+24x-32}{3}$$

$$L_{2,2}(x)=\frac{(x-2)(x-2.5)}{(4-2)(4-2.5)}=\frac{x^2-4.5x+5}{3}$$

$$\therefore\quad p(x)=0.5\cdot(x^2-6.5x-10)+0.4\cdot\left(\frac{-4x^2+24x-32}{3}\right)+0.25\cdot\left(\frac{x^2-4.5x+5}{3}\right)$$

$$=0.05x^2-0.425x+1.15$$

The **error** in Lagrange polynomial for x in $[a,b]$ is

$\frac{f^{(n+1)}(\xi(x))}{(n+1)!}(x-x_0)(x-x_1)\cdots(x-x_n)$, where $\xi(x)$ in (a,b) and $f\in c^{n+1}[a,b]$

$\Rightarrow$ In case $x>x_n$, or $x<x_0$, the error is large. But in case $x_0<x<x_n$, the error is small.

3-2 Cubic Spline Interpolation

A very smooth curve for connecting all the given data can be obtained by setting $S_j(x_j)=f(x_j)$, $S_j(x_{j+1})=S_{j+1}(x_{j+1})$, $S_j'(x_{j+1})=S_{j+1}'(x_{j+1})$, and $S_j''(x_{j+1})=S_{j+1}''(x_{j+1})$, where j=0, 1, 2, …, n.

Boundary condition 1: $S_0''(x_0)=S_{n-1}''(x_n)=0$

Boundary condition 2: $S_0'(x_0)=f'(x_0)$ and $S_{n-1}'(x_n)=f'(x_n)$

Let $S_j(x)=a_j+b_j(x-x_j)+c_j(x-x_j)^2+d_j(x-x_j)^3$ and $h_j=x_{j+1}-x_j$

$$\left.\begin{aligned} &S_j(x_j)=f(x_j)\Rightarrow a_j=f(x_j)\\ &S_j(x_{j+1})=S_{j+1}(x_{j+1})\Rightarrow a_{j+1}=a_j+b_jh_j+c_jh_j^2+d_jh_j^3\\ &S'_{j+1}(x_{j+1})=S'_j(x_{j+1})\Rightarrow b_{j+1}=b_j+2c_jh_j+3d_jh_j^2\\ &S''_{j+1}(x_{j+1})=S''_j(x_{j+1})\Rightarrow c_{j+1}=c_j+3d_jh_j \end{aligned}\right\}$$

$$\Rightarrow h_{j-1}c_{j-1}+2(h_{j-1}+h_j)c_j+h_jc_{j+1}=\frac{3}{h_j}(a_{j+1}-a_j)-\frac{3}{h_{j-1}}(a_j-a_{j-1}) \quad ,$$

j=1, 2, …, n-1$\Rightarrow AC=B$, where A is a tri-diagonal matrix.

Input x_0, x_1, x_2, …, $x_n\Rightarrow h_0=x_1-x_0$, $h_1=x_2-x_1$, …, $h_{n-1}=x_n-x_{n-1}\Rightarrow a_0=f(x_0)$, $a_1=f(x_1)$, …, $a_n=f(x_n)$

Solve $AC=B\Rightarrow C=A^{-1}B\Rightarrow c_j=?$, j=0, 1, 2, …, n.

$$\Rightarrow b_j=\frac{1}{h_j}(a_{j+1}-a_j)-\frac{h_j}{3}(c_{j+1}+2c_j) \quad \text{and} \quad d_j=\frac{1}{3h_j}(c_{j+1}-c_j)$$

$$\Rightarrow S_j(x)=a_j+b_j(x-x_j)+c_j(x-x_j)^2+d_j(x-x_j)^3$$

In case **Boundary condition 1** is selected:

$$A=\begin{bmatrix} 1 & 0 & 0 & \cdots & \cdots & 0\\ h_0 & 2(h_0+h_1) & h_1 & 0 & \ddots & \vdots\\ 0 & h_1 & 2(h_1+h_2) & h_2 & \ddots & \\ \vdots & \ddots & \ddots & \ddots & \ddots & \\ 0 & \cdots & 0 & \ddots & \ddots & 1 \end{bmatrix},\quad B=\begin{bmatrix} 0\\ \frac{3}{h_1}(a_2-a_1)-\frac{3}{h_0}(a_1-a_0)\\ \vdots\\ \frac{3}{h_{n-1}}(a_n-a_{n-1})-\frac{3}{h_{n-2}}(a_{n-1}-a_{n-1})\\ 0 \end{bmatrix}$$

In case **Boundary condition 2** is selected:

$$A=\begin{bmatrix} 2h_0 & h_0 & 0 & \cdots & 0\\ h_0 & 2(h_0+h_1) & h_1 & \ddots & \vdots\\ 0 & h_1 & 2(h_1+h_2) & h_2 & 0\\ \vdots & \ddots & \ddots & \ddots & h_{n-1}\\ 0 & \cdots & 0 & h_{n-1} & 2h_{n-1} \end{bmatrix},\quad B=\begin{bmatrix} \frac{3}{h_0}(a_1-a_0)-3f'(a)\\ \frac{3}{h_1}(a_2-a_1)-\frac{3}{h_0}(a_1-a_0)\\ \vdots\\ \frac{3}{h_{n-1}}(a_n-a_{n-1})-\frac{3}{h_{n-2}}(a_{n-1}-a_{n-2})\\ 3f'(b)-\frac{3}{h_{n-1}}(a_n-a_{n-1}) \end{bmatrix}$$

3-3 The Least-Square Approximation Method

For discrete data $\{(x_0,y_0),(x_1,y_1),(x_2,y_2),\ldots,(x_n,y_n)\}$, a function $y=g(x)$ is said to fit these data if $I=\sum_{i=0}^{n}[y_i-g(x_i)]^2$ achieves its minimum.

For a continuous function $y=f(x)$, $x\in[a,b]$, another function $y=p(x)$ is said to fit the above function if $I=\int_a^b[f(x)-p(x)]^2dx$ is minimized.

Eg. Fit the data in the table by $y=ax^2+bx+c$.

i	0	1	2	3	4
x_i	0	0.25	0.5	0.75	1
y_i	1	1.284	1.6487	2.117	2.7183

(Sol.) $I=\sum_{i=0}^{4}[y_i-ax_i^2-bx_i-c]^2$, $\partial I/\partial a=0$, $\partial I/\partial b=0$, $\partial I/\partial c=0$

$\Rightarrow a$=0.8347, b=0.8641, c=1.0052

Eg. Fit $y=\sin(\pi x)$ by $y=ax^2+bx+c$ on $x\in[0,1]$.

(Sol.) $I=\int_0^1[\sin(\pi x)-(ax^2+bx+c)]^2dx=\int_0^1\sin^2(\pi x)dx+a^2\int_0^1x^4dx$

$+b^2\int_0^1x^2dx+c^2-2a\int_0^1x^2\sin(\pi x)dx-2b\int_0^1x\sin(\pi x)dx-2c\int_0^1\sin(\pi x)dx$

$-2ab\int_0^1x^3dx-2ac\int_0^1x^2dx-2bc\int_0^1xdx$

$\partial I/\partial a=0$, $\partial I/\partial b=0$, $\partial I/\partial c=0\Rightarrow a$=-4.12251, b=4.12251, c=-0.050465

In **Matlab** language, we can use the following instructions to find a polynomial to fit the discrete data $\{(x_0,y_0),(x_1,y_1),(x_2,y_2),\ldots,(x_n,y_n)\}$.

```
>>x=[40,80,120,160,200,240,280,320];
>>y=[19,35,52,69,85.4,101,118.2,133.2];
>>p=polyfit(x,y,2)     %求出 2 次多項式之係數
>>p2=poly2str(p,'x')   %用 x 表示二次多項式
```

```
p =
-0.0000    0.4270    1.6286
p2 =
-4.6131e-005 x^2 + 0.42696x + 1.6286
```

3-4 Rational Function Approximation

Let $r(x)=\frac{p(x)}{q(x)}=\frac{p_0+p_1x+\cdots+p_nx^n}{q_0+q_1x+\cdots+q_mx^m}$ be approximate to $f(x)$. If $f(x)=\sum_{i=0}^{\infty}a_ix^i$, let

$$f(x)\text{-}r(x)=f(x)-\frac{p(x)}{q(x)}=\frac{f(x)q(x)-p(x)}{q(x)}=\frac{\sum_{i=0}^{\infty}a_ix^i\cdot\sum_{i=0}^{m}q_ix^i-\sum_{i=0}^{n}p_ix^i}{q(x)}\approx 0$$

$$\Rightarrow\left(\sum_{i=0}^{k}a_iq_{k-i}\right)=p_k\text{ , }k=0,\ 1,\ \ldots,\ n+m$$

Eg. Use $\frac{p_0+p_1x+p_2x^2+p_3x^3}{q_0+q_1x+q_2x^2}$ to approximate to e^{-x}.

(Sol.) $n=3$, $m=2$, $k=5$, $e^{-x}=1-x+\frac{x^2}{2}-\frac{x^3}{6}+\cdots$

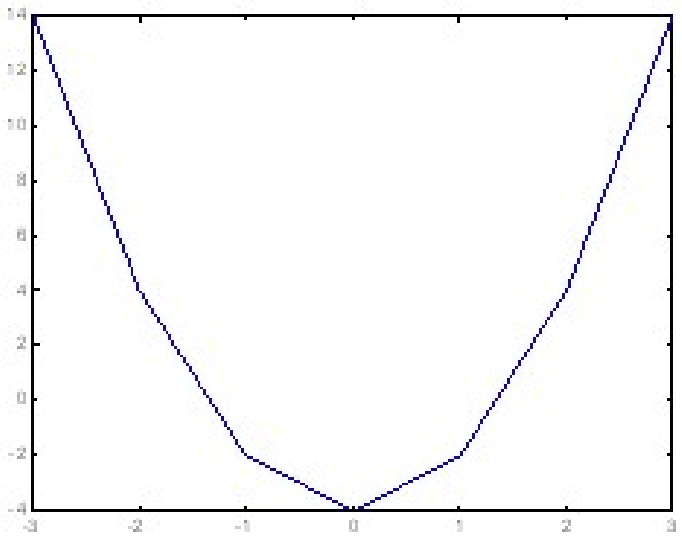
$$\text{Set } q_0=1\Rightarrow\left(1-x+\frac{x^2}{2}-\frac{x^3}{6}+\cdots\right)(1+q_1x+q_2x^2)-(p_0+p_1x+p_2x^2+p_3x^3)$$

$$\Rightarrow\begin{cases}-\frac{1}{120}+\frac{1}{24}q_1-\frac{1}{6}q_2=0\text{ , }\ \frac{1}{2}-q_1+q_2=p_2\\ \frac{1}{24}-\frac{1}{6}q_1+\frac{1}{2}q_2=0\text{ , }\ -1+q_1=p_1\\ -\frac{1}{6}+\frac{1}{2}q_1-q_2=p_3\text{ , }\ 1=p_0\end{cases}\qquad\Rightarrow r(x)=\frac{1-\frac{3}{5}x+\frac{3}{20}x^2-\frac{1}{60}x^3}{1+\frac{2}{5}x+\frac{1}{20}x^2}$$

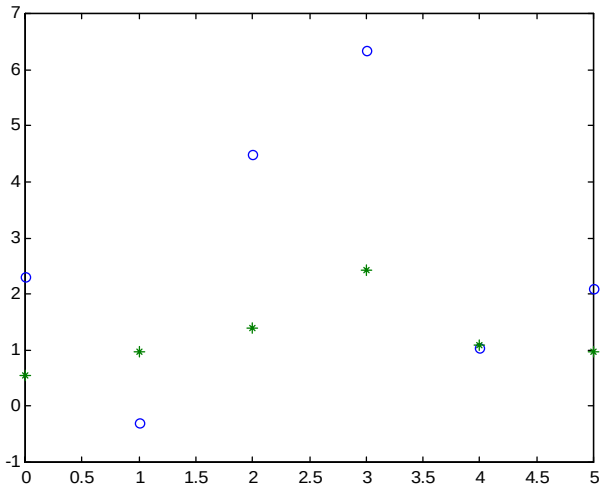
3-5 Draw Graphs Using Matlab Language

In **Matlab** language, we can use the following instructions to draw the 2-dimensional curves of *x*'s and *y*'s.

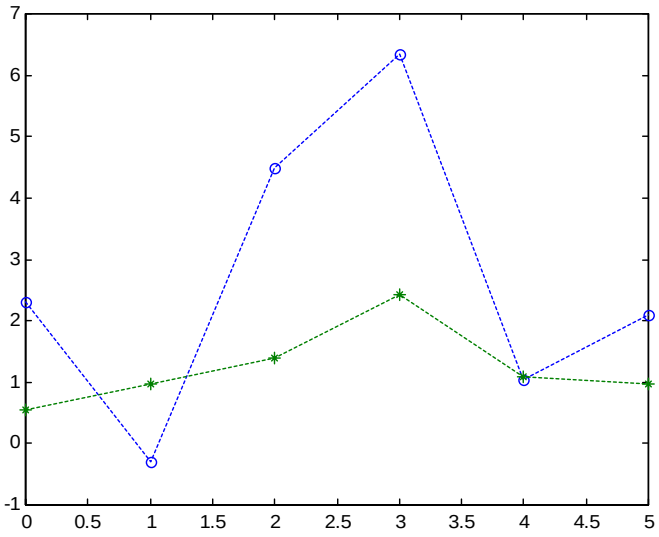
```
>>x=[3,2,1,0,-1,-2,-3];
>>y=[14,4,-2,-4,-2,4,14];
>>plot(x,y)
```



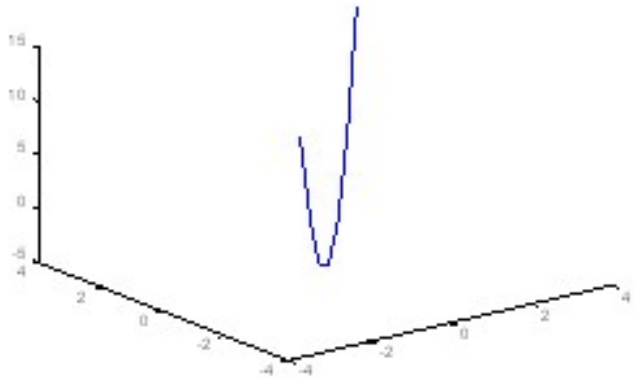
```
>>x=[0 1 2 3 4 5];
>>y1=[2.3 -0.3 4.5 6.34 1.05 2.09];
>>y2=[0.55 0.98 1.39 2.43 1.08 0.97];
>>plot(x,y1,'o',x,y2,'*');
```



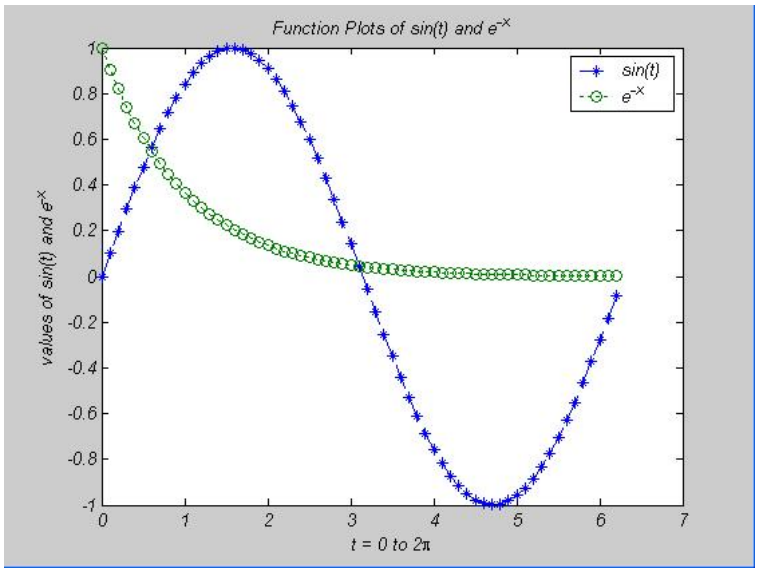
```
>>x=[0 1 2 3 4 5];
>>y1=[2.3 -0.3 4.5 6.34 1.05 2.09];
>>y2=[0.55 0.98 1.39 2.43 1.08 0.97];
>>plot(x,y1,'--o',x,y2,'--*');
```



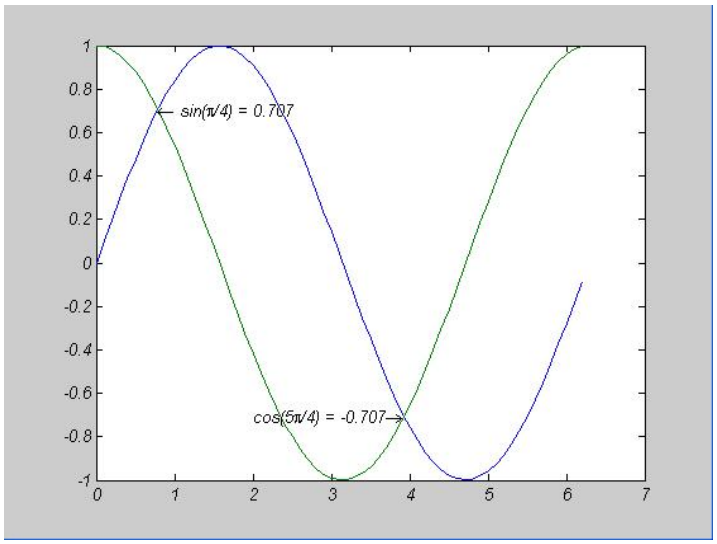

```
>>x=[3,2,1,0,-1,-2,-3];
>>y=[2.9,1.9,0.9,-0.1,-1.1,-2.1,-3.1];
>>z=[14,4,-2,-4,-2,4,14];
>>plot3(x,y,z)
```



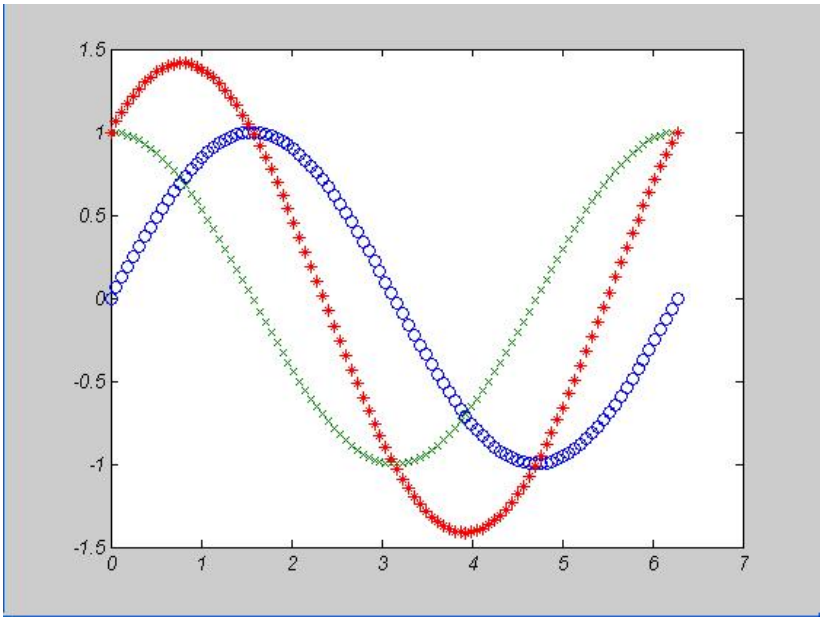
```
>>x = 0:0.1:2*pi; % x=0, 0.1, 0.2, 0.3, 0.4, …, 2π
>>y1 = sin(x);
>>y2 = exp(-x);
>>plot(x, y1, '--*', x, y2, ':o');
>>xlabel('t = 0 to 2\pi');
>>ylabel('values of sin(t) and e^{-x}')
>>title('Function Plots of sin(t) and e^{-x}');
>>legend('sin(t)','e^{-x}');
```



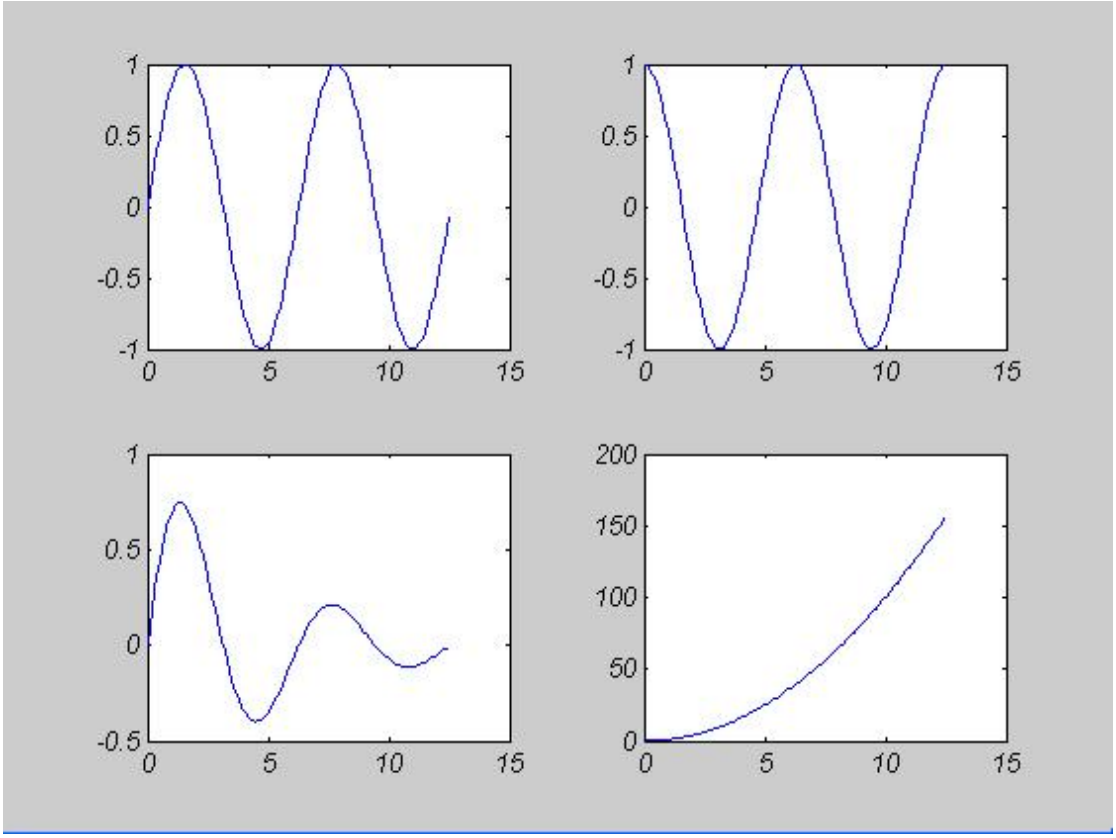

```
>>x = 0:0.1:2*pi;
>>plot(x, sin(x), x, cos(x));
>>text(pi/4, sin(pi/4),'\leftarrow sin(\pi/4) = 0.707');
>>text(5*pi/4,cos(5*pi/4),'cos(5\pi/4)=-0.707\rightarrow','HorizontalAlignment',
      'right');
```



```
>>x = linspace(0, 2*pi); % 在 0 到 2π 間，等分 100 個點
>>plot(x, sin(x), 'o', x, cos(x), 'x', x, sin(x)+cos(x), '*');
```




```
>>x = 0:0.1:4*pi; % x=0, 0.1, 0.2, 0.3, 0.4, …, 4π
>>subplot(2, 2, 1); plot(x, sin(x));                    % left-upper
>>subplot(2, 2, 2); plot(x, cos(x));                    % right-upper
>>subplot(2, 2, 3); plot(x, sin(x).*exp(-x/5));         % left-down
>>subplot(2, 2, 4); plot(x, x.^2);                      % right-down
```

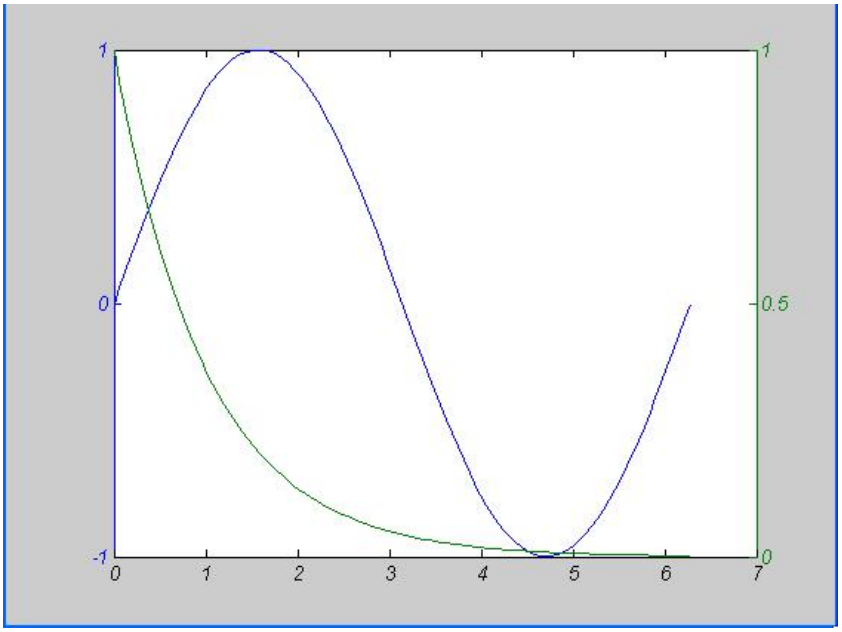


>>*x*=linspace(0, 2*pi); % 在 0 到 2π 間，等分 100 個點

>>*y*1=sin(*x*);

>>*y*2=exp(-*x*);

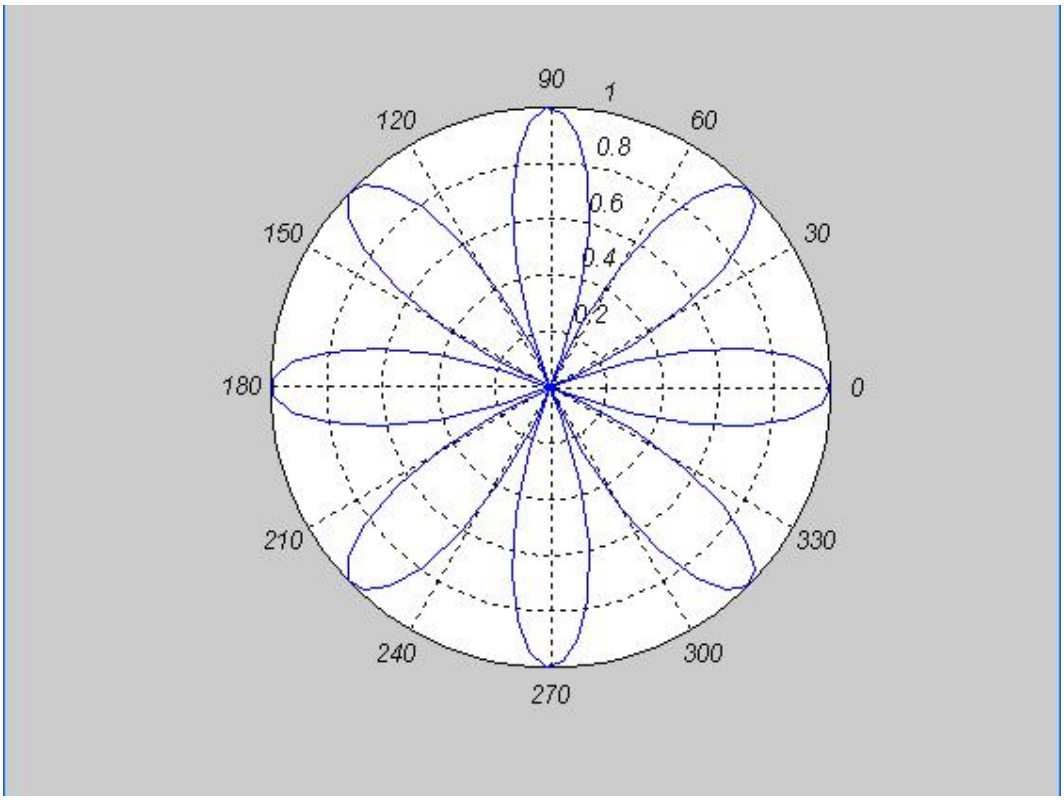
>>plotyy(*x*, *y*1, *x*, *y*2); % 畫出兩個刻度不同的 *y* 軸，分別是 *y*1, *y*2



>>*theta*=linspace(0, 2*pi);

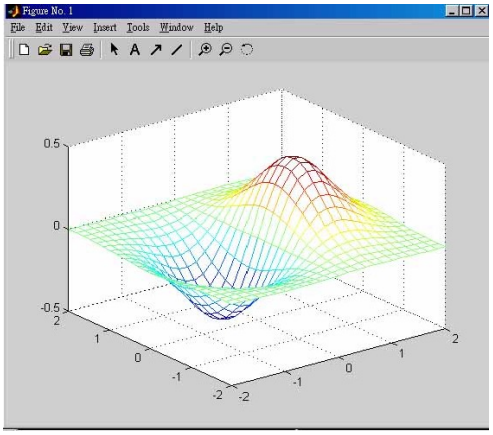
>>*r*=cos(4**theta*);

>>polar(*theta*,*r*);

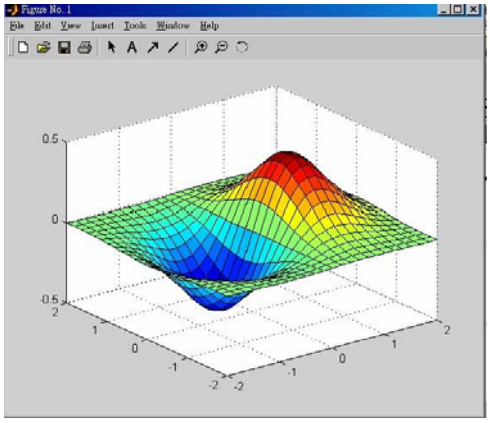


In **Matlab** language, we can use the following instructions to draw the surfaces of *x*'s, *y*'s, and *z*'s.

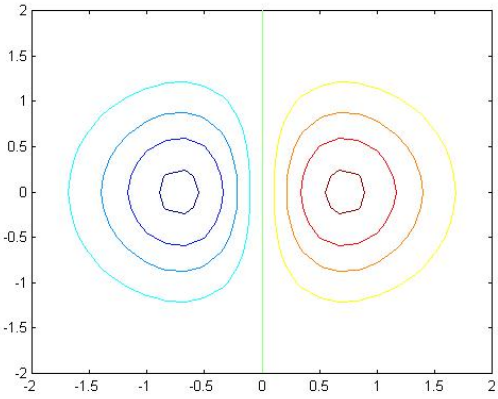
```
>>x=linspace(-2, 2, 25);
y=linspace(-2, 2, 25);
[xx,yy]=meshgrid(x, y);
zz=xx.*exp(-xx.^2-yy.^2); % z=xexp(-x^2-y^2)
mesh(xx, yy, zz) % draw z=xexp(-x^2-y^2)
```



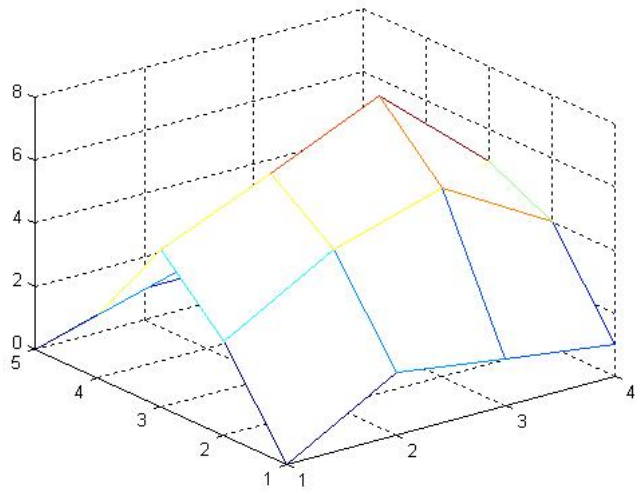

```
>>surf(xx, yy, zz)
```



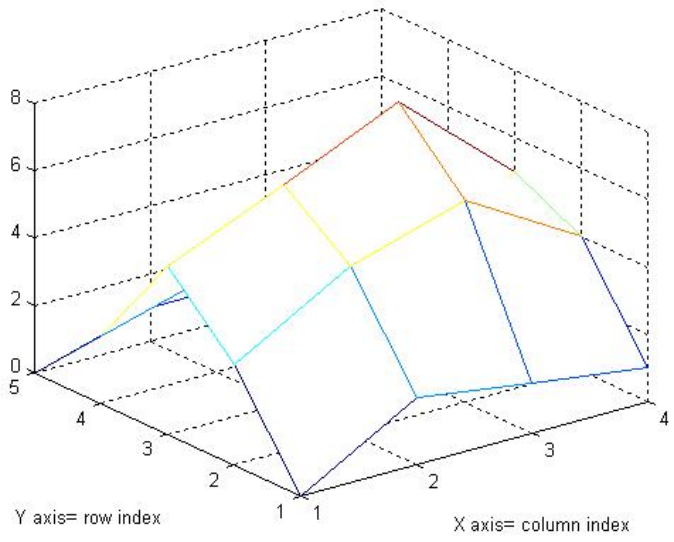

```
>>contour(xx, yy, zz)
```



```
>>x=[1,2,3,4; 1,2,3,4; 1,2,3,4; 1,2,3,4; 1,2,3,4;];
y=[1,1,1,1;2,2,2,2;3,3,3,3;4,4,4,4;5,5,5,5];
z=[0,2,1.5,1; 3,5,6,4; 5,6.5,8,5; 2,3,5,3; 0,1,1,0];
mesh(x,y,z)
```




```
>>z=[0,2,1.5,1; 3,5,6,4; 5,6.5,8,5; 2,3,5,3; 0,1,1,0];
mesh(z);
xlabel('X axis= column index');
ylabel('Y axis= row index');
for i=1:size(z,1)
      for j=1:size(z,2)
         h=text(j, i, z(i,j)));
      end
end
```



Eg. A MATLAB function of drawing 3D/2D profiles (by Dr. W.- Y. Wu 吳維揚博士)

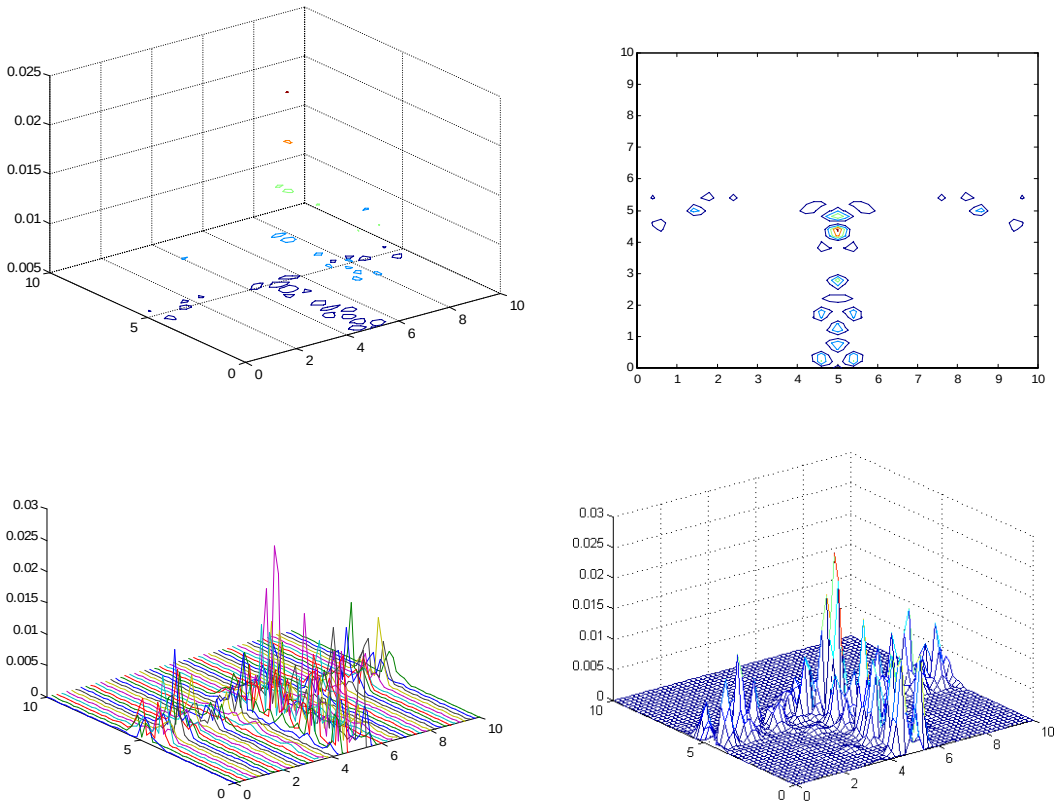
Source program:

```
%read a file and plot
function draw(F,N)
fid=fopen(F,'r');
A=fscanf(fid,'%e',[N,inf]);
A=A.';
M=size(A,1);
if N==2
   plot(A(:,1),A(:,2));
elseif N==3
   count=0;
   for l=1:M
      if A(1)==A(l)
         count=count+1;
      else
         break;
      end
   end
   X=zeros(count,M/count); Y=X; Z=X;
   for t=1:M
      X(t)=A(t,1);
      Y(t)=A(t,2);
      Z(t)=A(t,3);
   end
   figure
   mesh(X,Y,Z);
   figure
   plot3(X,Y,Z);
   figure
   contour(X,Y,Z);
   figure
   contour3(X,Y,Z);
else
disp('error input');
end
fclose(fid);
```

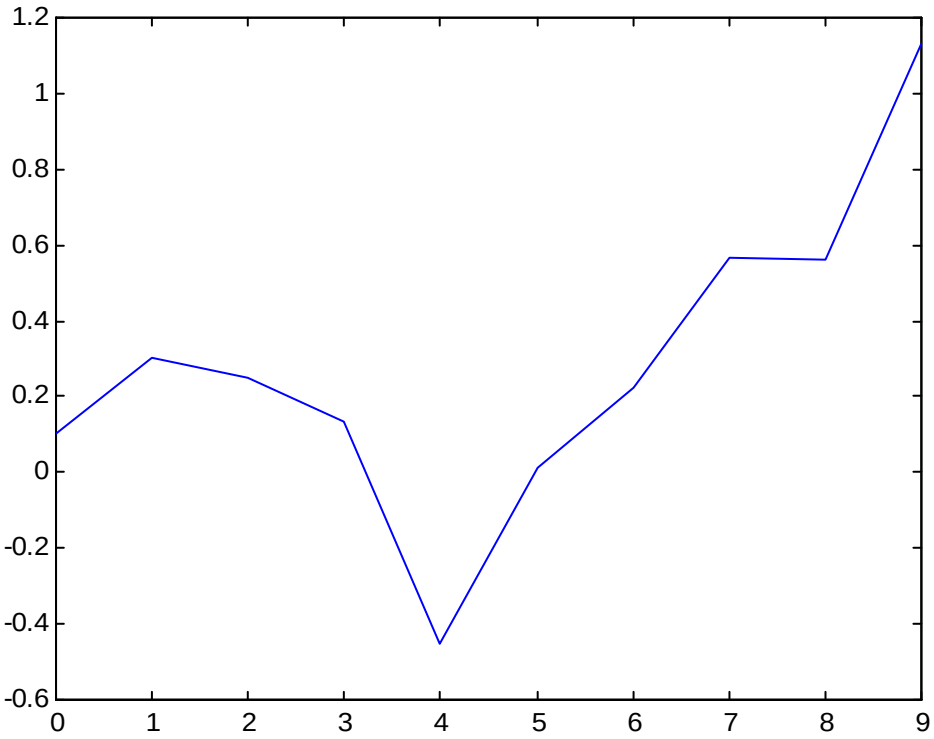
Usages:

1. draw (‘c:\directory\3Dfilename’,3)
2. draw (‘c:\directory\2Dfilename’,2)

>>draw ('D:\matlab\bin\fort.11',3)



>>draw ('D:\matlab\bin\fort.12',2)



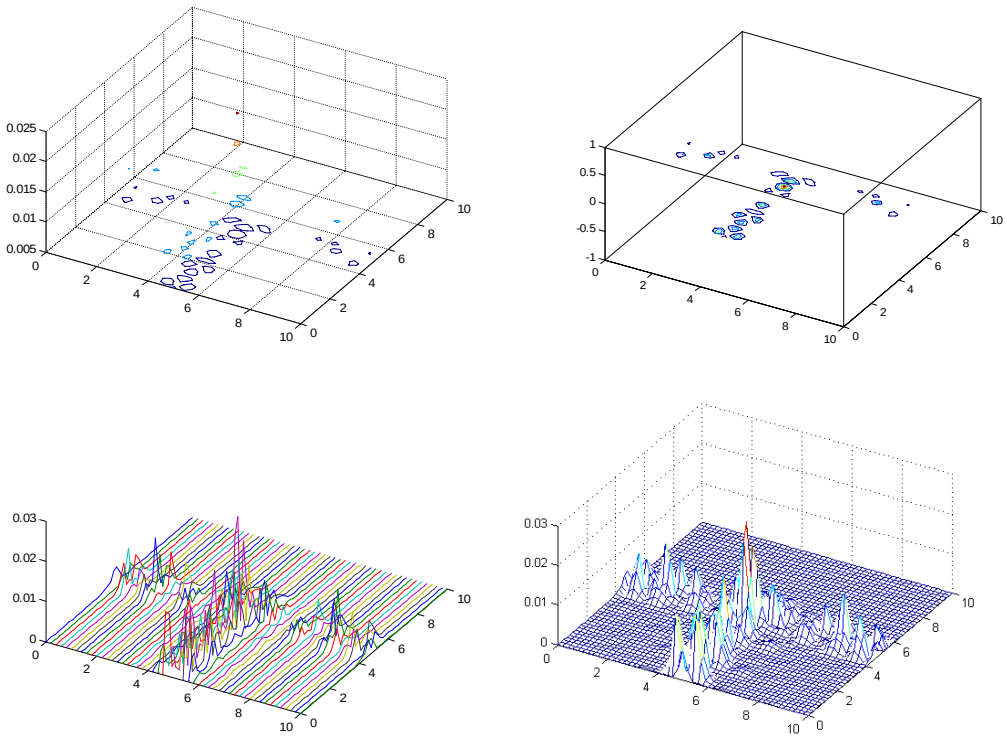
Eg. A modified MATLAB function of drawing 3D profiles from distinct view angles (by Dr. G. -D. Chang 張高德博士)

Source program:

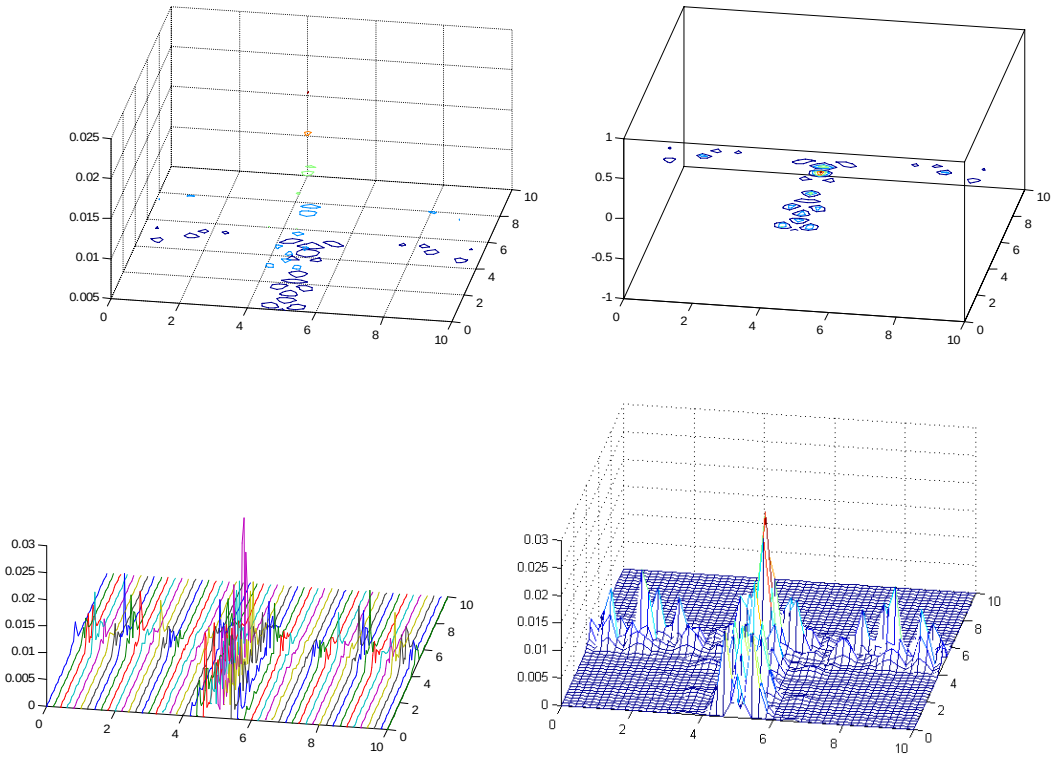
```
function drawc(F,N,angle1,angle2)
fid=fopen(F,'r');
A=fscanf(fid,'%e',[N,inf]);
A=A.';
M=size(A,1);
if N==2
   plot(A(:,1),A(:,2));
elseif N==3
   count=0;
   for l=1:M
      if A(1)==A(l)
         count=count+1;
      else
         break;
      end
   end
   X=zeros(count,M/count); Y=X; Z=X;
   for t=1:M
      X(t)=A(t,1);
      Y(t)=A(t,2);
      Z(t)=A(t,3);
   end
   figure
   mesh(X,Y,Z);
   view([angle1,angle2]);
   figure
   plot3(X,Y,Z);
   view([angle1,angle2]);
   figure
   contour(X,Y,Z);
   view([angle1,angle2]);
   figure
   contour3(X,Y,Z);
   view([angle1,angle2]);
else
disp('error input');
end
fclose(fid);
```

Usage: drawc (‘c:\directory\3Dfilename’,3,angle1,angle2)

>>drawc ('D:\matlab\bin\fort.11',3,30,50)



>>drawc ('D:\matlab\bin\fort.11',3,10,40)



Eg. A MATLAB function of drawing distinct 2D curves (by Dr. G. -D. Chang)

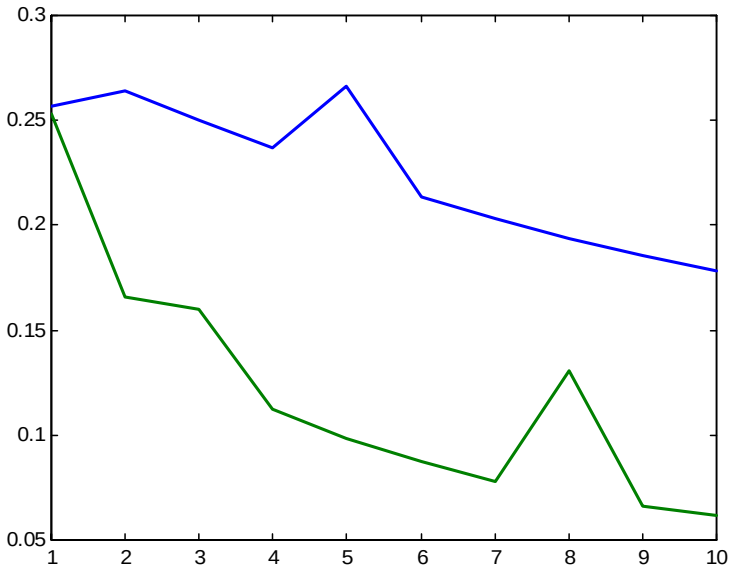
Source program:

```
function draw2D(F,N)
fid=fopen(F,'r');
A=fscanf(fid,'%e',[N,inf]);
fclose(fid);

%clear;
%N=14;
%A=rand(N,100);
A=A.';
ik=1;
for id=1:2:N
    Ax(:,ik)=A(:,id);
    Ay(:,ik)=A(:,id+1);
    ik=ik+1;
end
h1=plot(Ax,Ay);
set(h1,'linewidth',2);
```

Usage: draw2D ('c:\directory\filename having *n* 2D curves', 2*n*)

```
>>draw2D ('D:\matlab\bin\fort.13',4)
```



3-6 Image Processing by Matlab Language

Matlab 指令名稱：

imread	讀取影像
imshow	顯示影像
imwrite	儲存影像
ginput	滑鼠圖像輸入
round	四捨五入
floor	無條件捨去
ceil	無條件進位
rgb2gray	轉成灰階
eval	執行字串
aviread	讀取 AVI 檔
aviinfo	讀取 AVI 訊息
histeq	平均分布
mean	平均值

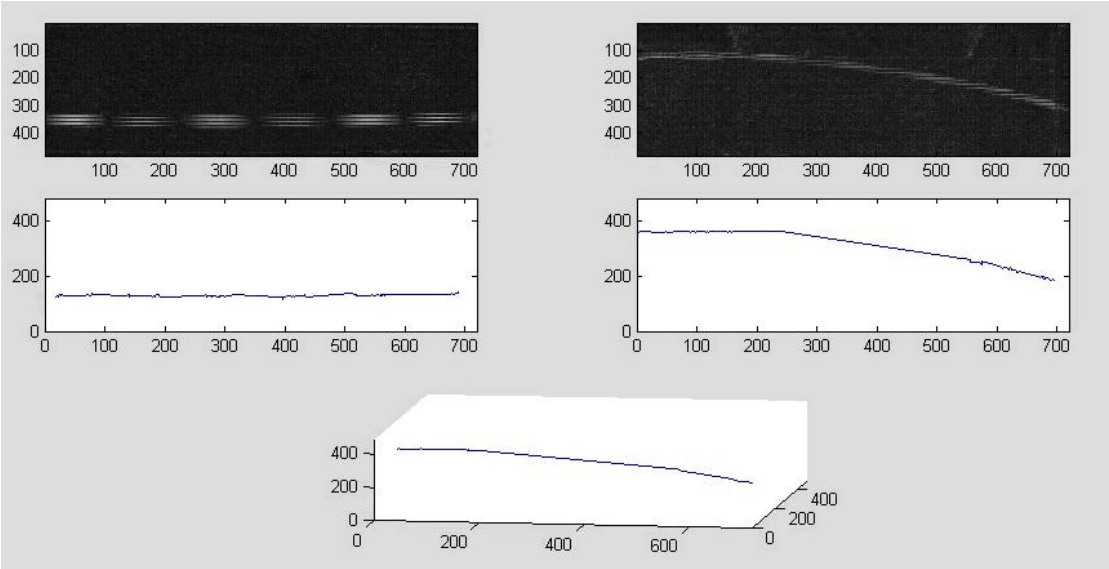
Eg. Reconstruction of 3D trajectory of flying baseball by two digital video cameras-Version 1. Assume the pixels of the video screen are 480×720. (by B. -H. Chen, 陳柏皓)

(Sol.)
```
clear all;
rgb1=imread('1\1.jpg'); rgb2=imread('1\2.jpg'); rgb3=imread('1\3.jpg');
rgb4=imread('1\4.jpg'); rgb5=imread('1\5.jpg'); rgb6=imread('1\6.jpg');
rgbup=uint8(abs(double(rgb6)-double(rgb5))+abs(double(rgb5)-double(rgb4))+abs(double(rgb4)-double(rgb3))+abs(double(rgb3)-double(rgb2))+abs(double(rgb2)-double(rgb1)));
rgb1=imread('2\1.jpg'); rgb2=imread('2\2.jpg'); rgb3=imread('2\3.jpg');
rgb4=imread('2\4.jpg'); rgb5=imread('2\5.jpg'); rgb6=imread('2\6.jpg');
rgb7=imread('2\7.jpg'); rgb8=imread('2\8.jpg'); rgb9=imread('2\9.jpg');
rgbleft=uint8(abs(double(rgb9)-double(rgb8))+abs(double(rgb8)-double(rgb7))+abs(double(rgb7)-double(rgb6))+abs(double(rgb6)-double(rgb5))+abs(double(rgb5)-double(rgb4))+abs(double(rgb4)-double(rgb3))+abs(double(rgb3)-double(rgb2))+abs(double(rgb2)-double(rgb1)));
n1=1; n2=1; n3=1; x1(1)=0; y1(1)=0; x2(1)=0; y2(1)=0;
for j=1:720,
    k1=0; k2=0; sum1=0; sum2=0;
    for i=1:480,
        if rgbup(i,j,1)>=80 & rgbup(i,j,2)>=80 & rgbup(i,j,3)>=80,
            sum1=sum1+(481-i); k1=k1+1;
        end
```

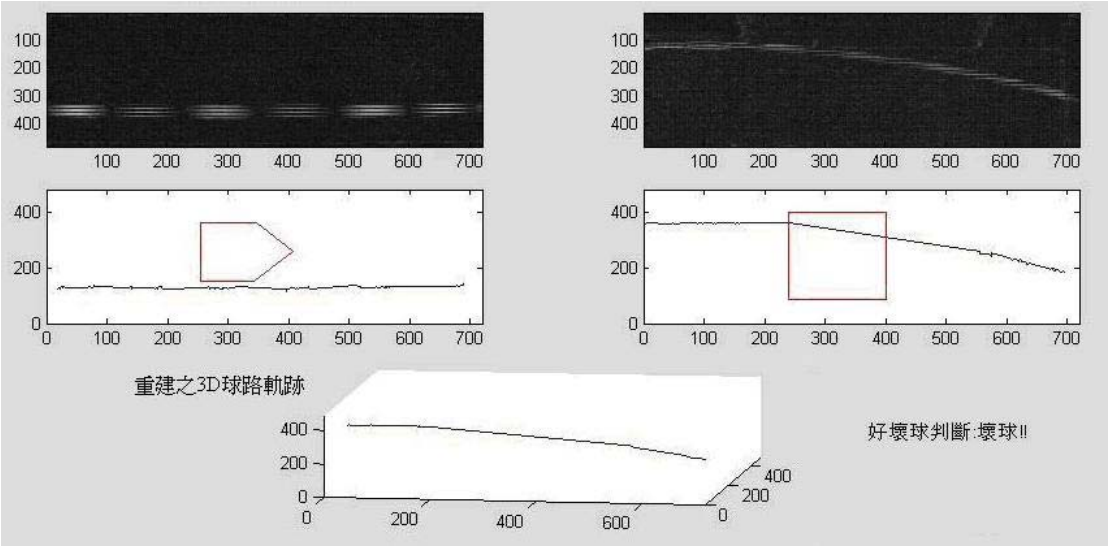
```
            if rgbleft(i,j,1)>=80 & rgbleft(i,j,2)>=80 & rgbleft(i,j,3)>=80,
                sum2=sum2+(481-i); k2=k2+1;
            end
            if k1~=0 && sum1~=0 && i==480,
                x1(n1)=sum1/k1; y1(n1)=j; n1=n1+1;
            end
            if k2~=0 && sum2~=0 && i==480,
                x2(n2)=sum2/k2; y2(n2)=j; n2=n2+1;
            end
            if k1~=0 && sum1~=0 && k2~=0 && sum2~=0 && i==480,
                x(n3)=j; y(n3)=x1(n1-1); z(n3)=x2(n2-1); n3=n3+1;
            end
        end
    end

    subplot(3,2,1); image(rgbup);
    subplot(3,2,2); image(rgbleft);
    subplot(3,2,3); plot(y1,x1); axis([0,720,0,480]);
    subplot(3,2,4); plot(y2,x2); axis([0,720,0,480]);
    subplot(3,2,5); plot(480-y,z); axis([0,480,0,480]);
    subplot(3,2,6); plot3(x,y,z); axis([0,720,0,480,0,480]);
```

Results:



Modified results (The range of judging strike is depicted):



∴The flying ball is not a strike. It is a ball!

Matlab 支援原始的 AVI 檔案

安裝 DVSD codec 可讓 Matlab 支援 DVSD 格式的 AVI.

Eg. Reconstructions of 3D trajectory of pitched baseball by two digital video cameras-Version 2. (AutoReadVideo.m by B. -H. Chen)

(Sol.)

(2005-5-4)

```
clc;
clear all;
close all;
%------------filter setting---------------
%blim=[70,70]; % Range:0~255
read_type='v'; % v -> video or p -> picture
filtercontrol=[9,9];% 0,1,3
filterline=[1,300];
afilterline=[1,1];
%inferi=[1,1];
%inferf=[2,3];
sample=[0.7,0.7326];
contrast_select=[9,9]; % 0 -> Increase the contrast , others -> close this function (only
picture type)
predict_num=10; % predict number , predict the in/out trajectory
distance=[300,300];
%------------------------------
%Find the picture number
if read_type=='p',
      filetype='jpg';
      filetarget={'1\','2\'};
      path1=dir(char(filetarget(1)));
      path2=dir(char(filetarget(2)));
      files_count=[0 0];
      for j=1:2,
            for i=1:length(eval(['path' int2str(j)])),
                  if findstr(getfield(eval(['path' int2str(j) '(i)']),'name'),filetype),
```

```
                files_count(j)=files_count(j)+1;
            end
        end
    end
    filenumber=files_count;
end
%-------------------------------
for timec=1:2,
    % Control filter:控制讀取範圍
    clear find;
    if filtercontrol(timec)==0,
        i0=1;
        i1=(481-filterline(timec));
    elseif filtercontrol(timec)==1,
        i0=(481-filterline(timec));
        i1=480;
    elseif filtercontrol(timec)==3,
        i0=(481-afilterline(timec));
        i1=(481-filterline(timec));
    else
        i0=1;
        i1=480;
    end
    im_cal=0;im_past=0;
    if read_type=='v',
        % get Up or left/right:利用色差
        f_string=sprintf('%d.avi',timec);
        VideoInfo = aviinfo(f_string);
        I_frame_stop=VideoInfo.NumFrames;
        for ix=1:1:I_frame_stop
            Video=aviread(f_string,ix);
            if ix>1,
                im_cal=im_cal+abs(double(Video.cdata)-double(im_past));
                im_past=Video.cdata;
            else
                im_past=Video.cdata;
            end
        end
```

```
else
    for i=1:filenumber(timec),
        rgb(:,:,:,i)=imread([filetarget{timec} int2str(i) '.' filetype]);
        if contrast_select(timec)==0,
            rgb(:,:,1,i)=histeq(rgb(:,:,1,i));%histeq()  強化對比
            rgb(:,:,2,i)=histeq(rgb(:,:,2,i));
            rgb(:,:,3,i)=histeq(rgb(:,:,3,i));
        end
        if i>=2,
            im_cal=im_cal+abs(double(rgb(:,:,:,i))-double(rgb(:,:,:,i-1)));
        end
    end
end
eval(sprintf('rgbo%d=uint8(im_cal);',timec));
%轉成灰階
im=rgb2gray(eval(sprintf('rgbo%d',timec)));
%im=mean(eval(sprintf('rgbo%d',timec)),3)
%im=rgb2ycbcr(eval(sprintf('rgbo%d',timec)));
im=im(:,:,1);
blim=uint8(double(max(max(im)))*sample(timec));
n=1;lk=0;y=0;x=0;o=1;t=2;lnc=0;
%取得有色差位置
for j=1:720,
    k=0;
    sum=0;
    for i=i0:i1,
        if im(i,j)>blim,
            sum=sum+(481-i);
            k=k+1;
        end
        if k~=0 && sum~=0 && i==i1,
            if lk==0,
                lk=k;
            elseif k>lk && o==1 ,
                o=0;
                no=n;
            elseif k<lk && o==0 ,
                o=1;
```

```
                    nc=no+n;
                    if mod(nc,2)~=0,
                        nc=nc-1;
                    end
                    nc=nc/2;
                    if nc~=lnc,
                        find(1,t)=y(nc);
                        find(2,t)=x(nc);
                        t=t+1;
                        fprintf('x=%.0f y=%.0f\n',y(nc),x(nc));
                    end
                    lnc=nc;
                end
                x(n)=sum/k;
                y(n)=j;
                n=n+1;
                lk=k;
            end
        end
    end
    find(1,1)=1;
    %前端點預測

temp=(find(2,3:(3+predict_num))-find(2,2:(2+predict_num)))./(find(1,3:(3+predict_num))-find(1,2:(2+predict_num)));
    find(2,1)=find(2,2)-mean(temp)*(find(1,2)-find(1,1));

%find(2,1)=find(2,1+inferi(timec))-(find(2,2+inferi(timec))-find(2,1+inferi(timec)))/(find(1,2+inferi(timec))-find(1,1+inferi(timec)))*(find(1,1+inferi(timec))-find(1,1));
    if find(2,t-1)<=480,
        find(1,t)=720;
        %後端點預測

temp=(find(2,(t-predict_num):(t-1))-find(2,(t-predict_num-1):(t-2)))./(find(1,(t-predict_num):(t-1))-find(1,(t-predict_num-1):(t-2)));
        find(2,t)=find(2,t-1)+mean(temp)*(find(1,t)-find(1,t-1));

%find(2,t)=find(2,t-inferf(timec))+(find(2,t-inferf(timec))-find(2,t-inferf(timec)-1))/(fi
```

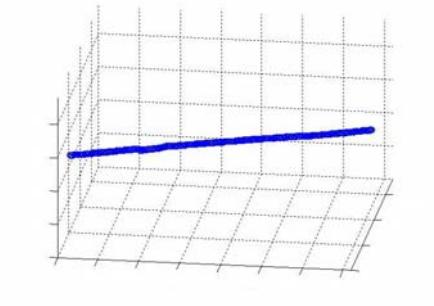
```
nd(1,t-inferf(timec))-find(1,t-inferf(timec)-1))*(find(1,t)-find(1,t-inferf(timec)));
        end
        eval(sprintf('apic%d=find;',timec));
end
%比較兩張影像最大數值
t=1;
tc1=1;
tc2=1;
if max(apic1(1,:))<max(apic2(1,:)),
        comp=max(apic1(1,:));
else
        comp=max(apic2(1,:));
end
%重建影像
for i=1:comp;
        if i==1,
                d3(1,i)=i;d3(2,i)=apic1(2,1);d3(3,i)=apic2(2,1);
        elseif i==max(apic1(1,:)) && max(apic1(1,:))~=720,
                d3(1,i)=i;d3(2,i)=max(apic1(2,:));d3(3,i)=d3(3,i-1);
        elseif i==720,
                d3(1,i)=i;d3(2,i)=apic1(2,length(apic1));d3(3,i)=apic2(2,length(apic2));
        else
                d3(1,i)=i;
                while i~=0,
                        if i>=apic1(1,tc1) && i<apic1(1,tc1+1),
                                break;
                        else
                                tc1=tc1+1;
                        end
                end
                A=apic1(1,tc1+1)-apic1(1,tc1);
                B=apic1(2,tc1+1)-apic1(2,tc1);
                if A==0,
                        d3(2,i)=apic1(2,tc1);
                else
                        d3(2,i)=B/A*(i-apic1(1,tc1))+apic1(2,tc1);
                end
                while i~=0,
```

```
                if i>=apic2(1,tc2) && i<apic2(1,tc2+1),
                    break;
                else
                    tc2=tc2+1;
                end
            end
            A=apic2(1,tc2+1)-apic2(1,tc2);
            B=apic2(2,tc2+1)-apic2(2,tc2);
            if A==0,
                d3(3,i)=apic2(2,tc2);
            else
                d3(3,i)=B/A*(i-apic2(1,tc2))+apic2(2,tc2);
            end
        end
    end
    %繪圖
    figure(1);
    subplot(2,2,1); image(rgbo1); subplot(2,2,2); image(rgbo2);
    subplot(2,2,3); plot(apic1(1,:),apic1(2,:)); axis([0, 720,0,480]);
    subplot(2,2,4); plot(apic2(1,:),apic2(2,:)); axis([0, 720,0,480]);
    figure(2);
    plot3(d3(1,:),d3(2,:),d3(3,:),'o');
    grid;
    view(8,30);
    axis([0, 720,0, 720,0,480]);
    %hgsave(figure(1),'fig1');
    %hgsave(figure(2),'fig2');
    %figure,image(rgbo1);
    %figure,
    %plot(apic1(1,:),apic1(2,:));
    %axis([0, 720,0,480]);
    %figure,image(rgbo2);
    %figure,
    %plot(apic2(1,:),apic2(2,:));
    %axis([0, 720,0,480]);
```

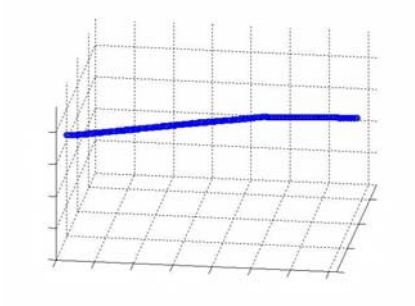
2005-5-4 Experimental Results: (當時攝影方式爲球路從右至左飛行)

文化大學棒球隊投手林永坤：

直球：進壘位置偏中，球路直

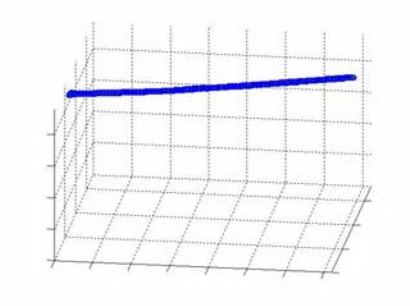


滑球：進壘時略往外角轉彎

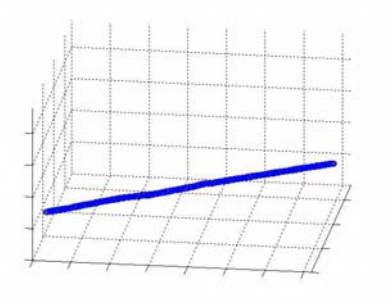


文化大學棒球隊投手黃義哲(2005 年世界盃國手)：

直球：進壘位置偏高但略有尾勁



滑球：進壘位置較低，球路明顯往外角偏移



Eg. Reconstruction of 3D trajectory of flying baseball by two digital video cameras-Version 3. (AutoReadVideo1.m by B. -H. Chen)

(Sol.)

```
clc;
clear all;
close all;
warning off MATLAB:mir_warning_variable_used_as_function
%-----------------------------------------------------------------
sample=[0.5,0.5];
predict_num=4; % predict number , predict the in/out trajectory
distance=[300,300];
%-----------------------------------------------------------------
for timec=1:2,
    clear find;
    im_cal=0;im_past=0;
    % get Up or left/right:利用色差
    f_string=sprintf('%d.avi',timec);
    fprintf('\nVideo %d \n',timec);
    VideoInfo = aviinfo(f_string);
    I_frame_stop=VideoInfo.NumFrames;
    I_Width=VideoInfo.Width;
    I_Height=VideoInfo.Height;
    for ix=1:1:I_frame_stop
        Video=aviread(f_string,ix);
        if ix>1,
            im_diff=abs(double(Video.cdata)-double(im_past));
            if max(max(max(im_diff)))<20,
                continue;
            end
            im_cal=im_cal+im_diff;
            im_past=Video.cdata;
        else
            im_past=Video.cdata;
        end
    end
    eval(sprintf('rgbo%d=uint8(im_cal);',timec));
    % 轉成灰階
    im=rgb2gray(eval(sprintf('rgbo%d',timec)));
    im=im(:,:,1);
```

```
blim=uint8(double(max(max(im)))*sample(timec));
n=1;lk=0;y=0;x=0;o=1;t=2;lnc=0;
%取得有色差位置
for j=1:I_Width,
    k=0;
    sum=0;
    for i=1:I_Height,
        if double(im(i,j))>double(blim),
            sum=sum+(I_Height+1-i);
            k=k+1;
        end
        if k~=0 && sum~=0 && i==I_Height,
            if lk==0,
                lk=k;
            elseif k>lk && o==1 ,
                o=0;
                no=n;
            elseif k<lk && o==0 ,
                o=1;
                nc=no+n;
                if mod(nc,2)~=0,
                    nc=nc-1;
                end
                nc=nc/2;
                if nc~=lnc,
                    find(1,t)=y(nc);
                    find(2,t)=x(nc);
                    t=t+1;
                    fprintf('x=%.0f y=%.0f\n',y(nc),x(nc));
                end
                lnc=nc;
            end
            x(n)=sum/k;
            y(n)=j;
            n=n+1;
            lk=k;
        end
    end
```

```
        end
        find(1,1)=1;
        %前端點預測

temp=(find(2,3:(3+predict_num))-find(2,2:(2+predict_num)))./(find(1,3:(3+predict_num))-fin
d(1,2:(2+predict_num)));
        find(2,1)=find(2,2)-mean(temp)*(find(1,2)-find(1,1));

%find(2,1)=find(2,1+inferi(timec))-(find(2,2+inferi(timec))-find(2,1+inferi(timec)))/(find(1,2
+inferi(timec))-find(1,1+inferi(timec)))*(find(1,1+inferi(timec))-find(1,1));
        if find(2,t-1)<=I_Height,
            find(1,t)=I_Width;
            %後端點預測

temp=(find(2,(t-predict_num):(t-1))-find(2,(t-predict_num-1):(t-2)))./(find(1,(t-predict_num):(
t-1))-find(1,(t-predict_num-1):(t-2)));
            find(2,t)=find(2,t-1)+mean(temp)*(find(1,t)-find(1,t-1));

%find(2,t)=find(2,t-inferf(timec))+(find(2,t-inferf(timec))-find(2,t-inferf(timec)-1))/(find(1,t-i
nferf(timec))-find(1,t-inferf(timec)-1))*(find(1,t)-find(1,t-inferf(timec)));
        end
        eval(sprintf('apic%d=find;',timec));
end
%比較兩張影像最大數值
t=1;
tc1=1;
tc2=1;
if max(apic1(1,:))<max(apic2(1,:)),
        comp=max(apic1(1,:));
else
        comp=max(apic2(1,:));
end
%重建影像
for i=1:comp;
        if i==1,
            d3(1,i)=i;d3(2,i)=apic1(2,1);d3(3,i)=apic2(2,1);
        elseif i==max(apic1(1,:)) && max(apic1(1,:))~=720,
            d3(1,i)=i;d3(2,i)=max(apic1(2,:));d3(3,i)=d3(3,i-1);
```

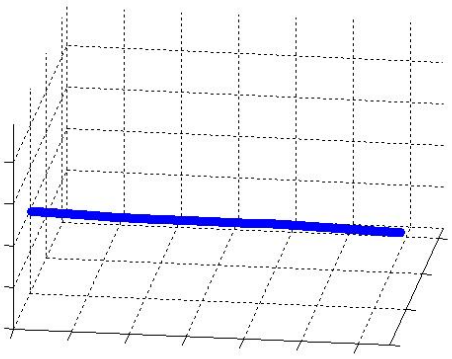
```
    elseif i==720,
        d3(1,i)=i;d3(2,i)=apic1(2,length(apic1));d3(3,i)=apic2(2,length(apic2));
    else
        d3(1,i)=i;
        while i~=0,
            if i>=apic1(1,tc1) && i<apic1(1,tc1+1),
                break;
            else
                tc1=tc1+1;
            end
        end
        A=apic1(1,tc1+1)-apic1(1,tc1);
        B=apic1(2,tc1+1)-apic1(2,tc1);
        if A==0,
            d3(2,i)=apic1(2,tc1);
        else
            d3(2,i)=B/A*(i-apic1(1,tc1))+apic1(2,tc1);
        end
        while i~=0,
            if i>=apic2(1,tc2) && i<apic2(1,tc2+1),
                break;
            else
                tc2=tc2+1;
            end
        end
        A=apic2(1,tc2+1)-apic2(1,tc2);
        B=apic2(2,tc2+1)-apic2(2,tc2);
        if A==0,
            d3(3,i)=apic2(2,tc2);
        else
            d3(3,i)=B/A*(i-apic2(1,tc2))+apic2(2,tc2);
        end
    end
end
%繪圖
figure(1);
subplot(2,2,1);
image(rgbo1);
```

```
subplot(2,2,2);
image(rgbo2);
subplot(2,2,3);
plot(apic1(1,:),apic1(2,:));
axis([0, I_Width,0,I_Height]);
subplot(2,2,4);
plot(apic2(1,:),apic2(2,:));
axis([0, I_Width,0,I_Height]);
figure(2);
plot3(d3(1,:),d3(2,:),d3(3,:),'o');
grid;
view(8,30);
axis([0, I_Width,0, I_Width,0,I_Height]);
%hgsave(figure(1),'fig1');
%hgsave(figure(2),'fig2');
%figure,image(rgbo1);
%figure,
%plot(apic1(1,:),apic1(2,:));
%axis([0, 720,0,480]);
%figure,image(rgbo2);
%figure,
%plot(apic2(1,:),apic2(2,:));
%axis([0, 720,0,480]);
```

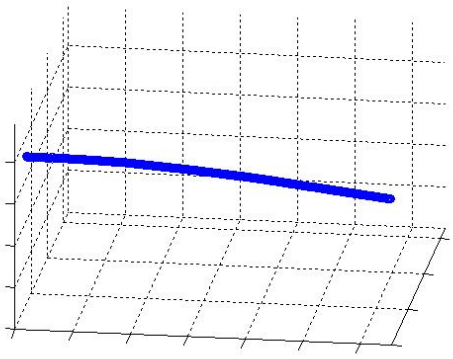
2007-12-26 Experimental Results: (當時攝影方式爲球路從左至右飛行)

文化大學棒球隊投手曾琮萱：測試當天除了指叉球會下墜以外，其餘球路都差不多近似直球，表示他對大部份變化球的球路控制不佳

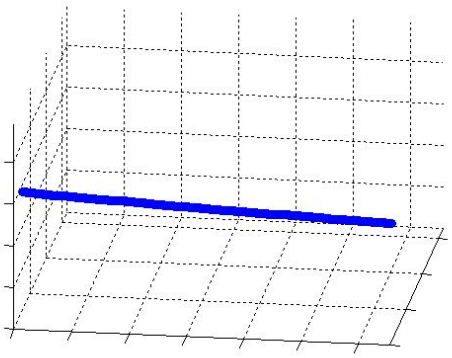
直球

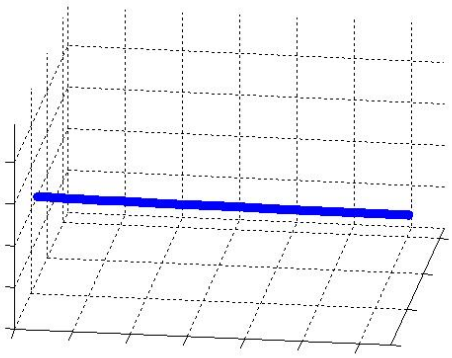


指叉球



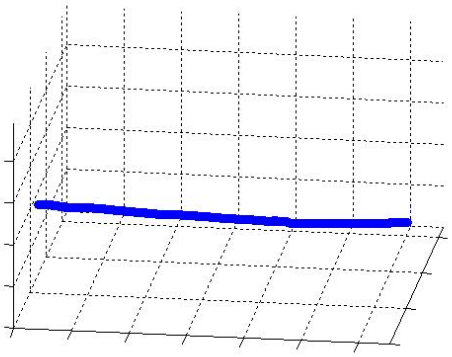
滑球　　變速球

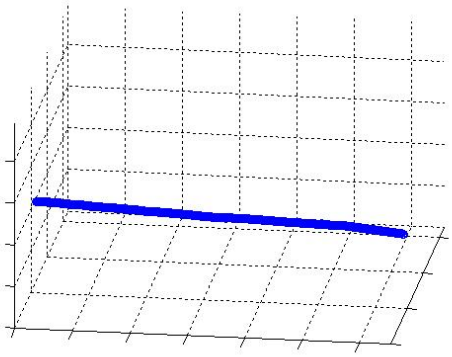




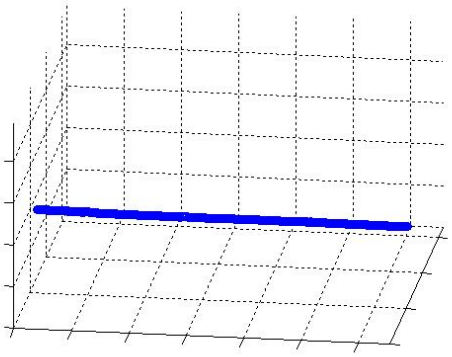
文化大學棒球隊投手廖文楊：測試當天第一個(左)滑球之球路會往右打者外角轉彎，第二個(右)則類似直球無變化，表示他對滑球的球路控制尚不穩定。而其曲球軌跡則類似滑球

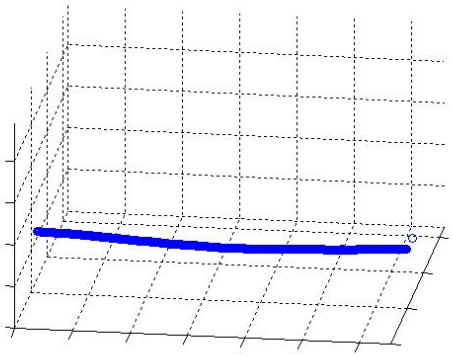
滑球一　　滑球二





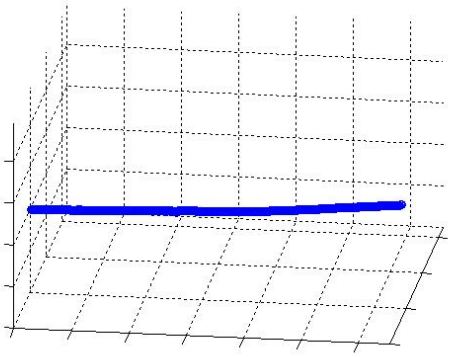
直球　　曲球





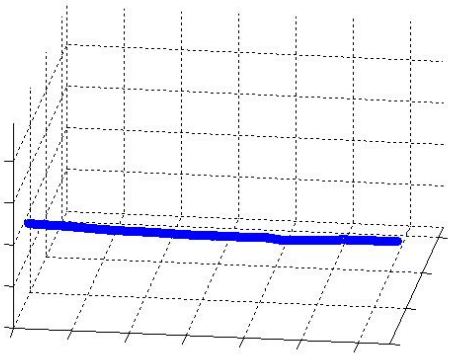
文化大學棒球隊投手王溢正：直球會往右打者外角轉彎，類似滑球，有尾勁

直球

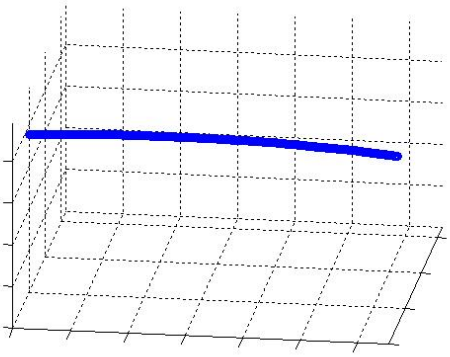


文化大學棒球隊投手許文錚：測試當天第一個(左)變速球之球路類似直球無太多變化，第二個(右)則會下墜，表示他對變速球的球路控制尚不穩定。而其指叉球軌跡則類似直球無變化

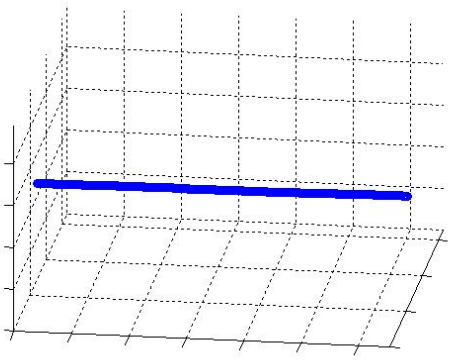
變速球一



變速球二



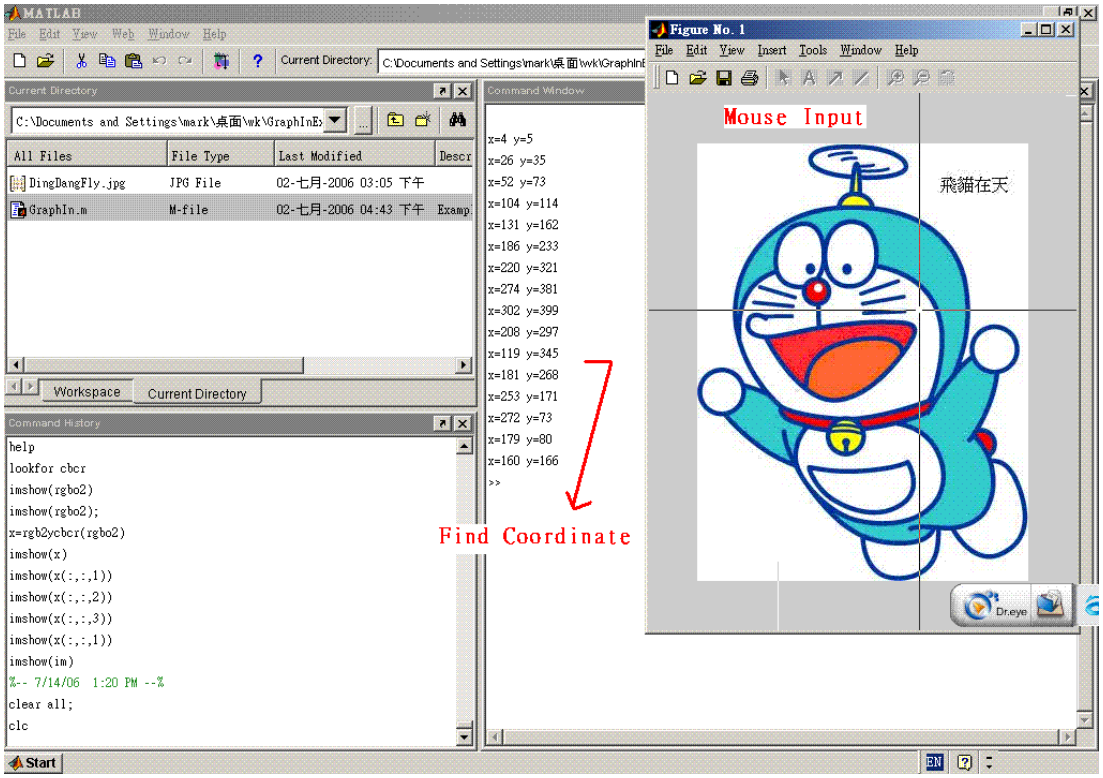
指叉球



Eg. 利用滑鼠點選而取得座標的範例，可用來改寫成判斷好壞球區之範圍

```
% Example: Graphical input from mouse.
clear all;
im=imread('DingDangFly','jpg');
imshow(im);
while 1,
    [x,y,button]=ginput(1);
    if button~=1, break;
    end
    fprintf('\nx=%d y=%d %d',round(x),round(y));
end
close all;
```

Experiment 1: Download GraphIn.m and DingDangFly.jpg



Eg. Reconstruction of 3D trajectory of flying baseball by two digital video cameras-Version 4. (AutoReadVideo3.m by 黃建維)

```
clc;
clear all;
close all;
warning off MATLAB:mir_warning_variable_used_as_function
%------------------------------------------------------------
sample=[0.5,0.5];
predict_num=4; % predict number , predict the in/out trajectory
distance=[300,300];
%------------------------------------------------------------
for timec=1:2,
    clear find;
    im_cal=0;im_past=0;
    % get Up or left/right:利用色差
    f_string=sprintf('%d.avi',timec);
    fprintf('\nVideo %d \n',timec);
    VideoInfo = aviinfo(f_string);
    I_frame_stop=VideoInfo.NumFrames;
    I_Width=VideoInfo.Width;
    I_Height=VideoInfo.Height;
    for ix=1:1:I_frame_stop
        Video=aviread(f_string,ix);
        if ix>1,
            im_diff=abs(double(Video.cdata)-double(im_past));
            if max(max(max(im_diff)))<20,
                continue;
            end
            im_cal=im_cal+im_diff;
            im_past=Video.cdata;
        else
            im_past=Video.cdata;
        end
    end
    eval(sprintf('rgbo%d=uint8(im_cal);',timec));
    % 轉成灰階
    im=rgb2gray(eval(sprintf('rgbo%d',timec)));
    im=im(:,:,1);
    blim=uint8(double(max(max(im)))*sample(timec));
```

```
n=1;lk=0;y=0;x=0;o=1;t=2;lnc=0;
%取得有色差位置
for j=1:I_Width,
    k=0;
    sum=0;
    for i=1:I_Height,
        if double(im(i,j))>double(blim),
            sum=sum+(I_Height+1-i);
            k=k+1;
        end
        if k~=0 && sum~=0 && i==I_Height,
            if lk==0,
                lk=k;
            elseif k>lk && o==1 ,
                o=0;
                no=n;
            elseif k<lk && o==0 ,
                o=1;
                nc=no+n;
                if mod(nc,2)~=0,
                    nc=nc-1;
                end
                nc=nc/2;
                if nc~=lnc,
                    find(1,t)=y(nc);
                    find(2,t)=x(nc);
                    t=t+1;
                    %fprintf('x=%.0f y=%.0f\n',y(nc),x(nc));
                end
                lnc=nc;
            end
            x(n)=sum/k;
            y(n)=j;
            n=n+1;
            lk=k;
        end
    end
end
```

```
        find(1,1)=1;
        %前端點預測

temp=(find(2,3:(3+predict_num))-find(2,2:(2+predict_num)))./(find(1,3:(3+predict_num))-fin
d(1,2:(2+predict_num)));
        find(2,1)=find(2,2)-mean(temp)*(find(1,2)-find(1,1));

%find(2,1)=find(2,1+inferi(timec))-(find(2,2+inferi(timec))-find(2,1+inferi(timec)))/(find(1,2
+inferi(timec))-find(1,1+inferi(timec)))*(find(1,1+inferi(timec))-find(1,1));
        if find(2,t-1)<=I_Height,
                find(1,t)=I_Width;
                %後端點預測

temp=(find(2,(t-predict_num):(t-1))-find(2,(t-predict_num-1):(t-2)))./(find(1,(t-predict_num):(
t-1))-find(1,(t-predict_num-1):(t-2)));
                find(2,t)=find(2,t-1)+mean(temp)*(find(1,t)-find(1,t-1));

%find(2,t)=find(2,t-inferf(timec))+(find(2,t-inferf(timec))-find(2,t-inferf(timec)-1))/(find(1,t-i
nferf(timec))-find(1,t-inferf(timec)-1))*(find(1,t)-find(1,t-inferf(timec)));
        end
        eval(sprintf('apic%d=find;',timec));
end
%比較兩張影像最大數值
t=1;
tc1=1;
tc2=1;
if max(apic1(1,:))<max(apic2(1,:)),
        comp=max(apic1(1,:));
else
        comp=max(apic2(1,:));
end
%重建影像
for i=1:comp;
        if i==1,
                d3(1,i)=i;d3(2,i)=apic1(2,1);d3(3,i)=apic2(2,1);
        elseif i==max(apic1(1,:)) && max(apic1(1,:))~=720,
                d3(1,i)=i;d3(2,i)=max(apic1(2,:));d3(3,i)=d3(3,i-1);
        elseif i==720,
```

```
            d3(1,i)=i;d3(2,i)=apic1(2,length(apic1));d3(3,i)=apic2(2,length(apic2));
        else
            d3(1,i)=i;
            while i~=0,
                if i>=apic1(1,tc1) && i<apic1(1,tc1+1),
                    break;
                else
                    tc1=tc1+1;
                end
            end
            A=apic1(1,tc1+1)-apic1(1,tc1);
            B=apic1(2,tc1+1)-apic1(2,tc1);
            if A==0,
                d3(2,i)=apic1(2,tc1);
            else
                d3(2,i)=B/A*(i-apic1(1,tc1))+apic1(2,tc1);
            end
            while i~=0,
                if i>=apic2(1,tc2) && i<apic2(1,tc2+1),
                    break;
                else
                    tc2=tc2+1;
                end
            end
            A=apic2(1,tc2+1)-apic2(1,tc2);
            B=apic2(2,tc2+1)-apic2(2,tc2);
            if A==0,
                d3(3,i)=apic2(2,tc2);
            else
                d3(3,i)=B/A*(i-apic2(1,tc2))+apic2(2,tc2);
            end
        end
    end

    %繪圖
    figure(1);
    subplot(2,2,1);
    image(rgbo1);
```

```
set( gca, 'XTick', [], 'YTick', [] );
subplot(2,2,2);
image(rgbo2);
set( gca, 'XTick', [], 'YTick', [] );
subplot(2,2,3);
plot(apic1(1,:),apic1(2,:));
axis([0, I_Width,0,I_Height]);
set( gca, 'XTick', [], 'YTick', [] );
subplot(2,2,4);
plot(apic2(1,:),apic2(2,:));
axis([0, I_Width,0,I_Height]);
set( gca, 'XTick', [], 'YTick', [] );
%--------------------------------------------------------------------
figure(2);
plot(apic1(1,:),apic1(2,:),'-');
axis([0, I_Width,0,I_Height]);
set( gca, 'XTick', [], 'YTick', [] );
hold on;
sum=0;
while sum<1
    sum=sum+1;
    [x,y,button]=ginput(4);
    if button~=1, break;
    end
    fprintf('\nx=%d x=%d x=%d x=%d y=%d y=%d y=%d y=%d \n',round(x),round(y));
end
p3=round(x);
p4=round(y);
xll=(p3(1,1)+p3(2,1))/2;
xrr=(p3(3,1)+p3(4,1))/2;
yuu=(p4(1,1)+p4(4,1))/2;
yff=(p4(2,1)+p4(3,1))/2;
XDD=xll:1:xrr;
xboxx=round(xrr-xll);
yxdd=interp1(apic1(1,:),apic1(2,:),XDD);
yggg=yxdd(1,1);
yccc=yxdd(1,xboxx);
if yggg>=yff&&yggg<=yuu&&yccc>=yff&&yccc<=yuu
```

```
        title(("""""""""""""""""""""""""""""""passing the region"""""""""""""""""""""""""""""""))
        else
        title(("""""""""""""""""""""""""""""not passing the region """""""""""""""""""""""""""""""""))
end
%fill(p3,p4,'y')
p33=[xll xll xrr xrr];
p44=[yuu yff yff yuu];
fill(p33,p44,'y')
%-----------------------------------------------------------------
%-----------------------------------------------------------------
figure(3);
plot(apic2(1,:),apic2(2,:),'-');
axis([0, I_Width,0,I_Height]);
set( gca, 'XTick', [], 'YTick', [] );
hold on;
sum=0;
while sum<1
        sum=sum+1;
        [x,y,button]=ginput(4);
        if button~=1, break;
        end
        fprintf('\nx=%d x=%d x=%d x=%d y=%d y=%d y=%d y=%d \n',round(x),round(y));
end
p1=round(x);
p2=round(y);
xl=(p1(1,1)+p1(2,1))/2;
xr=(p1(3,1)+p1(4,1))/2;
yu=(p2(1,1)+p2(4,1))/2;
yf=(p2(2,1)+p2(3,1))/2;
XD=xl:1:xr;
xbox=round(xr-xl);
yxd=interp1(apic2(1,:),apic2(2,:),XD);
ygg=yxd(1,1);
ycc=yxd(1,xbox);
if ygg>=yf&&ygg<=yu&&ycc>=yf&&ycc<=yu
        title(("""""""""""""""""""""""""""""""passing the region"""""""""""""""""""""""""""""""))
        else
        title(("""""""""""""""""""""""""""""not passing the region """""""""""""""""""""""""""""""""))
```

```
end
%fill(p1,p2,'y')
p11=[xl xl xr xr];
p22=[yu yf yf yu];
fill(p11,p22,'y')
%------------------------------------------------------------------------
%--------------------------------------------------------------------
figure(4);
plot3(d3(1,:),d3(2,:),d3(3,:),'o');
set( gca, 'XTick', [], 'YTick', [] ,'ZTick',[]);
grid;
view(8,30);
axis([0, I_Width,0, I_Width,0,I_Height]);
rotate3d on
if
yggg>=yff&&yggg<=yuu&&yccc>=yff&&yccc<=yuu&&ygg>=yf&&ygg<=yu&&ycc>=yf
&&ycc<=yu
      title((""""""""""""""""""""""""""""""""    Strike !! """""""""""""""""""""""""""""""""))
      else
      title((""""""""""""""""""""""""""""""""    Ball !.....    """""""""""""""""""""""""""""""""))
end
%figure(5);
%plot3(d3(1,:),d3(3,:),d3(2,:),'o');
%grid;
%view(8,30);
%axis([0, I_Width,0, I_Width,0,I_Height]);

%hold on
%plot3(p3,p4,p1,'r');
%plot3(bb,b,b,'r');
%rotate3d on
%if yl>=150&&yl<=300&&yj>=150&&yj<=300
 %     title(('wuts a nice strike !!!'))
%else
 %       title((""""""""""""""""""""""""""""""""""""ball !! """""""""""""""""""""""""""""""" '))
%end
%set( gca, 'XTick', [], 'YTick', [] );
%set(get(gca,'color'),'color','g')
```

```
%figure(4);
%plot(apic2(1,:),apic2(2,:));
%axis([0, I_Width,0,I_Height]);


%hgsave(figure(3),'fig3');
%hgsave(figure(4),'fig4');
%splinetool(apic2(1,:),apic2(2,:));
%splinetool(apic1(1,:),apic1(2,:));
%figure,image(rgbo1);
%figure,
%plot(apic1(1,:),apic1(2,:));
%axis([0, 720,0,480]);
%figure,image(rgbo2);
%figure,
%plot(apic2(1,:),apic2(2,:));
%axis([0, 720,0,480]);
```

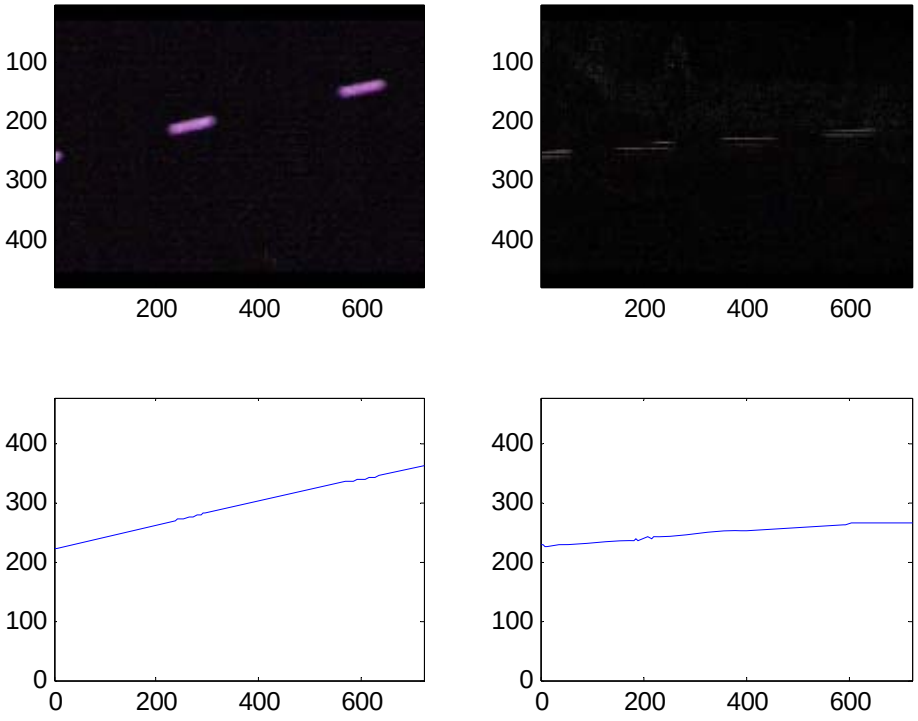
Eg. A MATLAB program of transforming an AVI file into several bmp files (by 張高德博士)

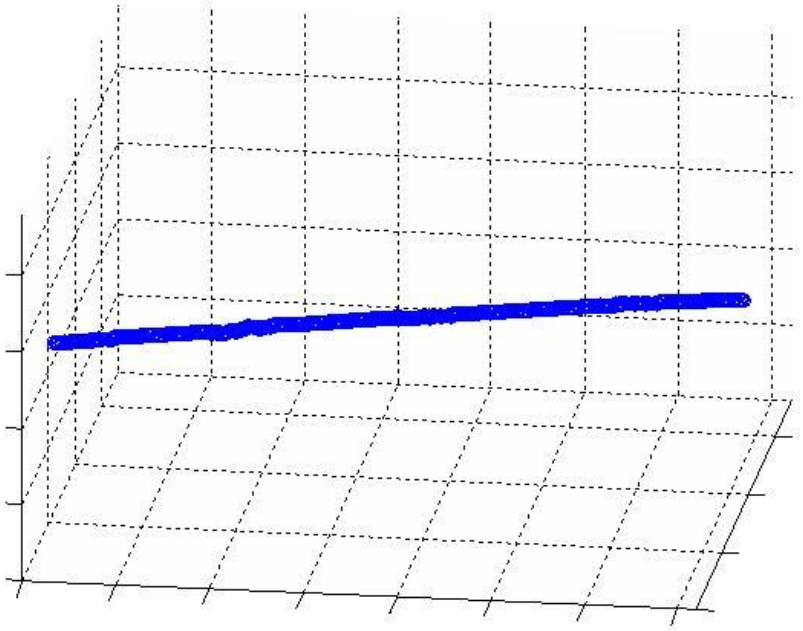
Source program:

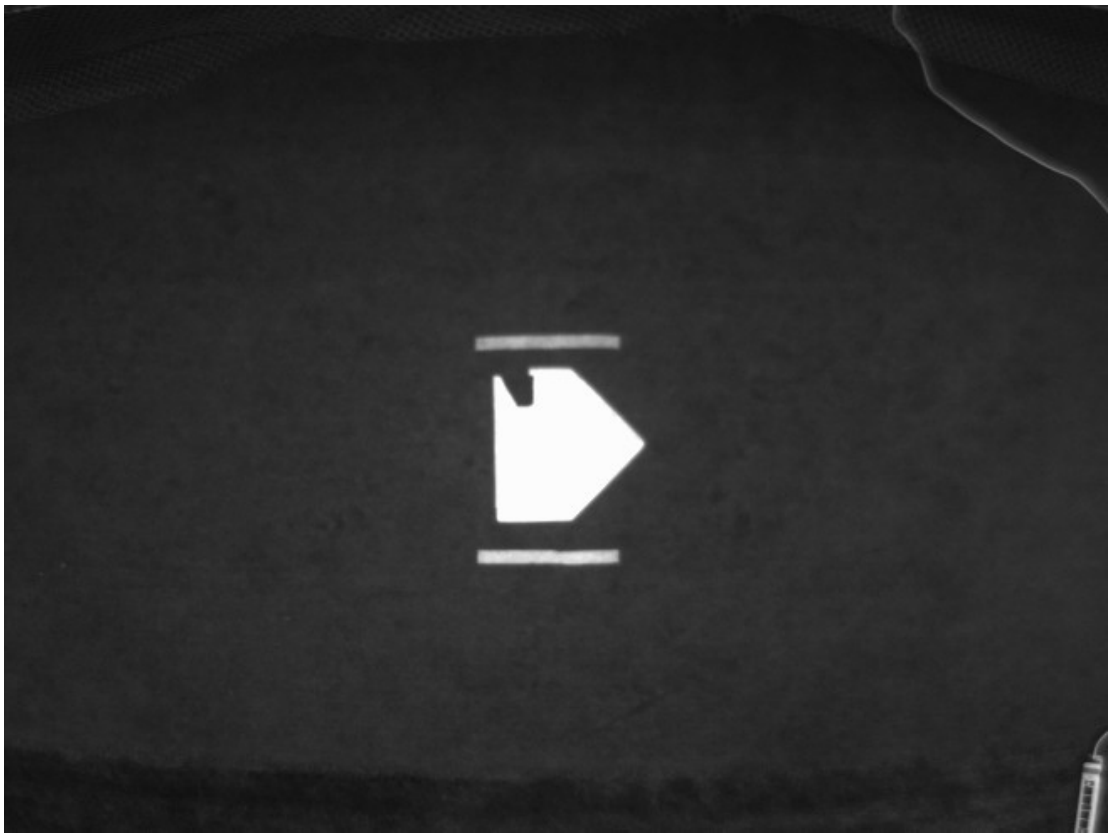
```
clear;
f_string=sprintf('d:\\kitty1.avi');
VideoInfo = aviinfo(f_string);
I_frame_stop=VideoInfo.NumFrames;

for ix=1:1:I_frame_stop
    Video=aviread(f_string,ix);
    image_string=sprintf('d:\\%d.bmp',ix);
    imwrite(Video.cdata,image_string,'bmp');
    disp(ix);
end
```

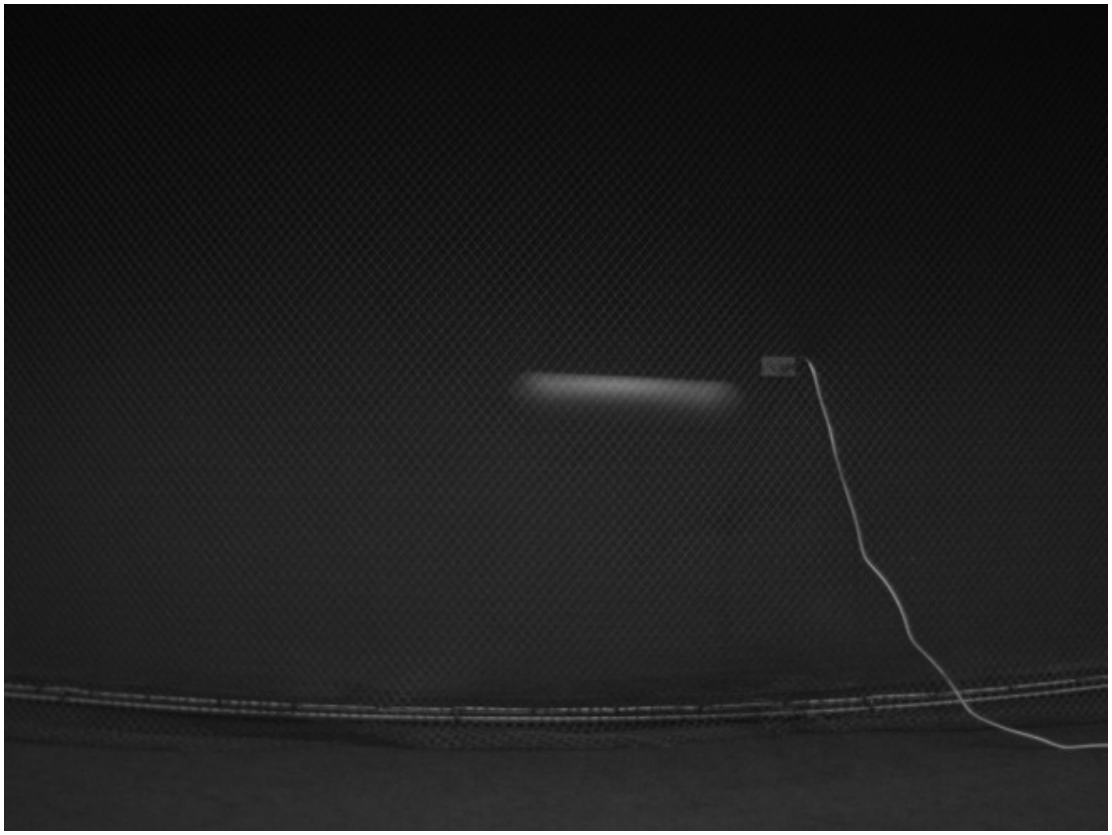
Experiment 2: Download AutoReadVideo.m (by 陳柏皓), AutoReadVideo3.m (by 黃建維), AutoReadVideo4.m and StrikeRegion.m (by 余信宏), down.jpg, up.jpg, dvdemocodecv2.1.exe, 1.avi, and 2.avi





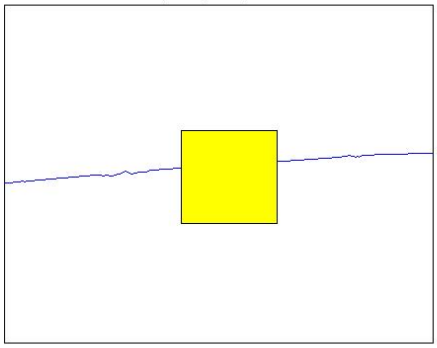


down.jpg

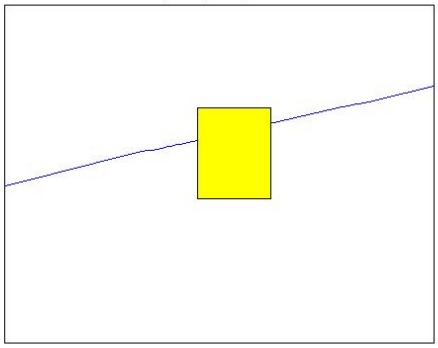


up.jpg

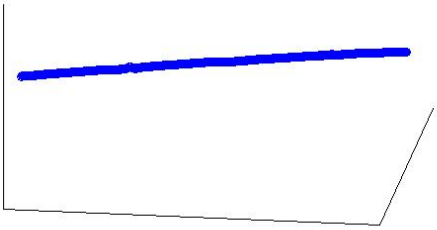
"""""""""""""""""""""""passing the region"""""""""""""""""""""""



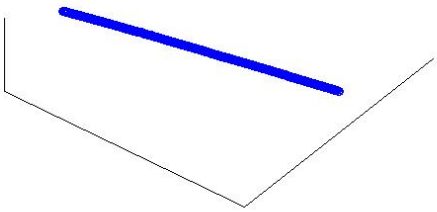
"""""""""""""""""""""""passing the region"""""""""""""""""""""""



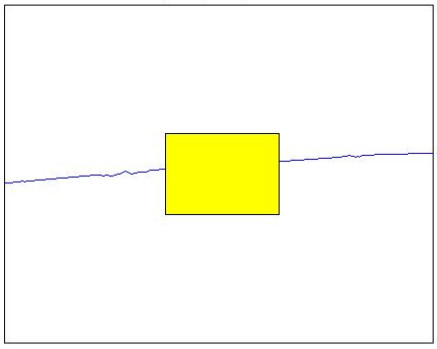
""""""""""""""""""""""""" Strike !! """""""""""""""""""""""""



""""""""""""""""""""""""" Strike !! """""""""""""""""""""""""



"""""""""""""""""""""""passing the region"""""""""""""""""""""""



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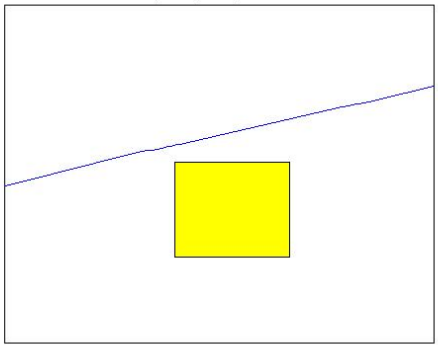
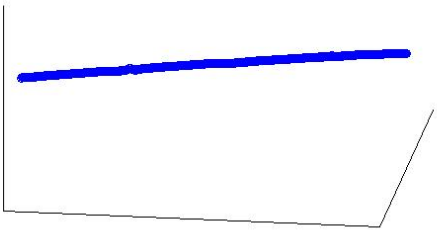


""""""""""""""""""""""""" Ball !..... """""""""""""""""""""""""""



""""""""""""""""""""""""" Ball !..... """""""""""""""""""""""""""