L14. Arrays and Functions

Functions with array parameters.

Row and column vectors

Built-Ins: `length, zeros, std`
Revisit: `rand, randn, max`

Row and Column Vectors

```
>> v = [1 2 3]
v =
   1    2    3

>> v = [1 ; 2 ; 3]
v =
   1
   2
   3
```

Observe semicolons

`zeros( , )`

```
>> x = zeros(3,1)
x =
     0
     0
     0
>> x = zeros(1,3)
x =
     0     0     0
```

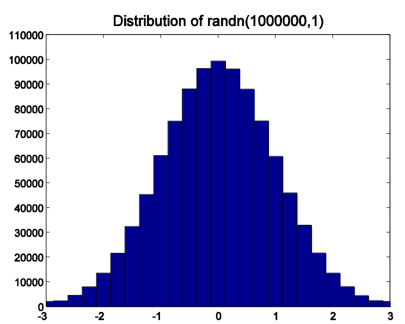
`rand( , )`

```
>> x = rand(3,1)
x =
    0.2618
    0.7085
    0.7839

>> x = rand(1,3)
x =
    0.9862    0.4733    0.9028
```

`randn( , )`

```
>> x = randn(1,3)
x =
    0.2877   -1.1465    1.1909
>> x = randn(3,1)
x =
    1.1892
   -0.0376
    0.3273
```

Normal Distribution with Zero Mean and Unit STD



Affirmations

```
>> n = 1000000;
>> x = randn(n,1);

>> ave = sum(x)/n
ave =
   -0.0017

>> standDev = std(x)
standDev =
    0.9989
```

length

```
>> v = randn(1,5);
>> n = length(v)
n =
     5

>> u = rand(5,1);
>> n = length(u)
n =
     5
```

The length function doesn't care about row or column orientation.

Augmenting Row Vectors

```
>> x = [10 20]
x =
    10    20

>> x = [x 30]

x =
    10    20    30
>>
```

Augmenting Column Vectors

```
>> x = [10;20]
x =
    10
    20
>> x = [x ; 30]
x =
    10
    20
    30
```

Observe semicolons!

"Concatenating" Row Vectors

```
>> x = [10 20]
x =
    10    20
>> y = [30 40 50]
y =
    30    40    50
>> z = [x y]
z =
    10    20    30    40    50
```

"Concatenating" Column Vectors

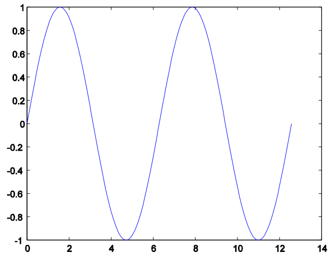
```
>> x = [10 ; 20];
>> y = [30 ; 40 ; 50];
>> z = [ x ; y ]
z =
      10
      20
      30
      40
      50
```

Observe semicolons!

Application

Plot sine across [0,4*pi] and use the fact that it has period 2pi.

```
x = linspace(0,2*pi,100);
y = sin(x);
x = [x x+2*pi];
y = [y y];
plot(x,y)
```




```
x = linspace(0,2*pi,100);
x = [ x    x+2*pi   ];
```

`linspace(2*pi,4*pi,100)]`

The Empty Vector

```
x = [ ];
for k=1:50
   if floor(sqrt(k))==sqrt(k
      x = [x; k];
   end
end
x = x
```

```
x =
    1
    4
    9
   16
   25
   36
   49
```

Array Hints & Errors

Dimension Mismatch

```
>> x = [1;2]
x =
     1
     2

>> y = [3 4]
y =
     3     4

>> z = x+y
??? Error using ==> plus
 Matrix dimensions must agree.
```

Can't add a row vector to a column vector

Not a Syntax Error

```
>> x = rand(3)
x =
    0.9501    0.4860    0.4565
    0.2311    0.8913    0.0185
    0.6068    0.7621    0.8214
```

You probably meant to say `x = rand(1,3)` or `x = rand(3,1)`.

A Style Hint

Assume n is initialized.

```
a = zeros(1,n)
for k=1:n
  a(k) = sqrt(k);
end
```

```
a = [ ];
for k=1:n
  a = [a sqrt(k)];
end
```

Better because it reminds you of the size and shape of the array you set up.

Error: Out-ofRange Subscript

```
>> x = [10 20 30]

x =
    10     20     30

>> c = x(4)

??? Index exceeds matrix
  dimensions.
```

This is OK…

```
>> x = [ 10 20 30]
x =
    10     20     30

>> x(4) = 100
x =
    10     20     30    100
```

Forgot the Semicolon?

```
>> x = randn(1000000,1)
```

Forgot the Semicolon?

```
>> x = randn(1000000,1)
```

Remember: ctrl-C

Question Time

```
A = [ 1 ];
while(length(A) < 5)
    A = [length(A)+1 ; A];
end
A = A
```

Is this the same as

```
A = linspace(1,5,5)   ?
```

A. Yes B. No

No!

```
Linspace:
            1 2 3  4 5

Fragment:
           5
           4
           3
           2
           1
```

Question Time

```
x = zeros(1,1);
for k=1:3
    x = [x x];
end
y = x(7)
```

Will this cause a subscript out of bounds error?

A. Yes B. No

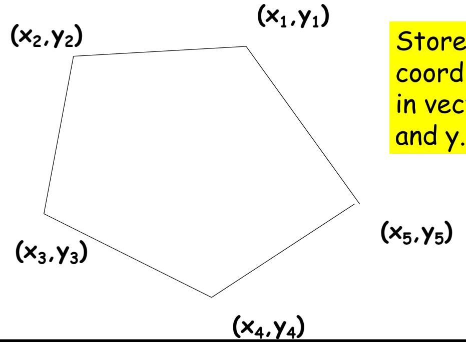
No!

```
How x changes:

After 1st pass:  [0 0]
After 2nd pass: [ 0 0 0 0 ]
After 3rd pass: [0 0 0 0 0 0 0 0]

So y = x(7) makes sense.
```

Polygon Transformations

Functions & arrays

A Polygon

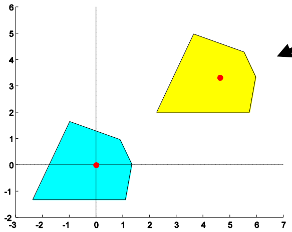


Store xy-coordinates in vectors x and y.

Operation 1: Centralize

Move a polygon so that the centroid of its vertices is at the origin.

Centralize



Before

After

Centralize

```
function [xNew,yNew] = Centralize(x,y)
n = length(x);
xBar = sum(x)/n;
yBar = sum(y)/n;
xNew = x-xBar;
yNew = y-yBar;
```

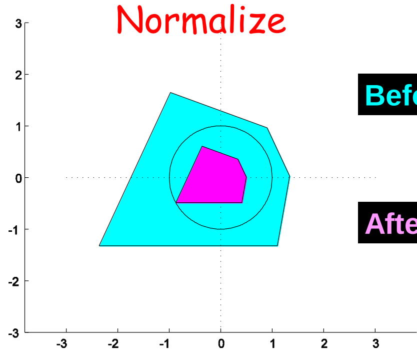
Computes the vertices of the new polygon

Notice how length is used to figure out the size of the incoming vectors.

Operation 2: Normalize

Shrink (enlarge) the polygon so that the vertex furthest from the (0,0) is on the unit circle.

Normalize



Before

After

Normalize

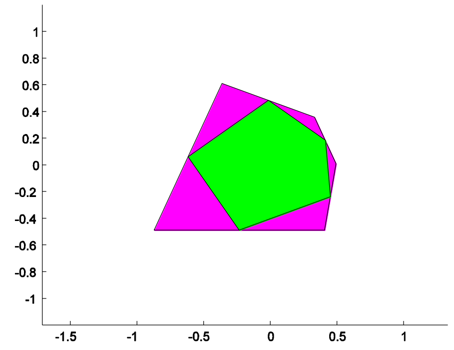
```
function [xNew,yNew] = Normalize(x,y)

d = max(sqrt(x.^2 + y.^2));
xNew = x/d;
yNew = y/d;
```

Applied to a vector, max returns the largest value in the vector.

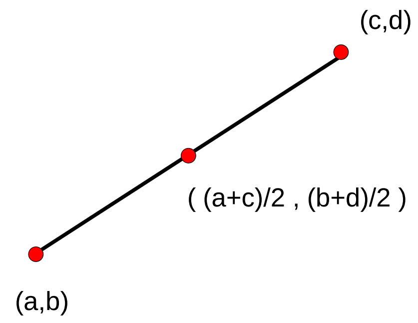
Operation 3: Smooth

Obtain a new polygon by connecting the midpoints of the edges

Smooth



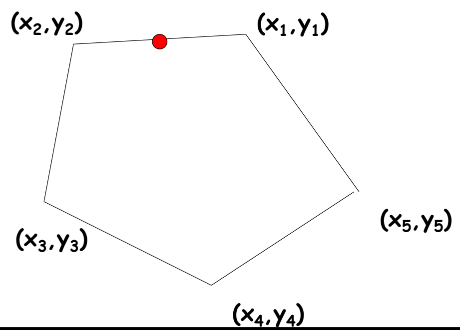
Midpoints



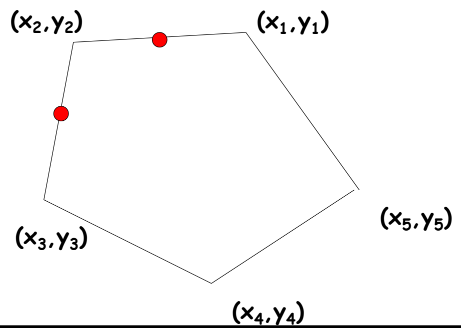
Smooth

```
function [xNew,yNew] = Smooth(x,y)

n = length(x);
xNew = zeros(n,1);
yNew = zeros(n,1);

for i=1:n
   Compute the mdpt of ith edge.
   Store in xNew(i) and yNew(i)
end
```

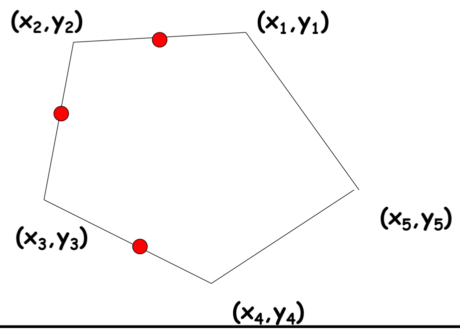
```
xNew(1)  =  (x(1)+x(2))/2
yNew(1)  =  (y(1)+y(2))/2
```



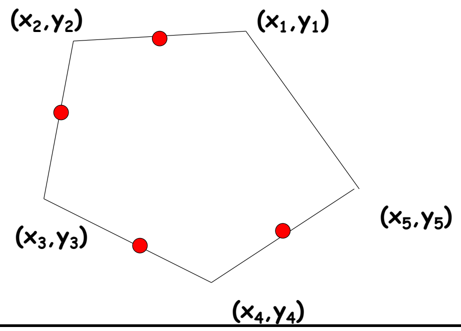

```
xNew(2)  =  (x(2)+x(3))/2
yNew(2)  =  (y(2)+y(3))/2
```



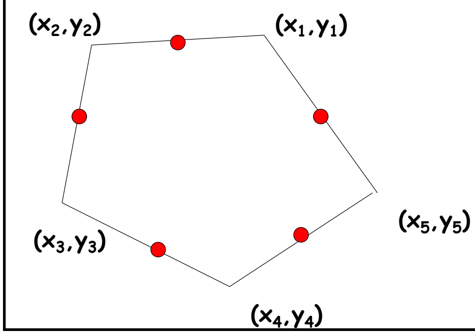

```
xNew(3)  =  (x(3)+x(4))/2
yNew(3)  =  (y(3)+y(4))/2
```



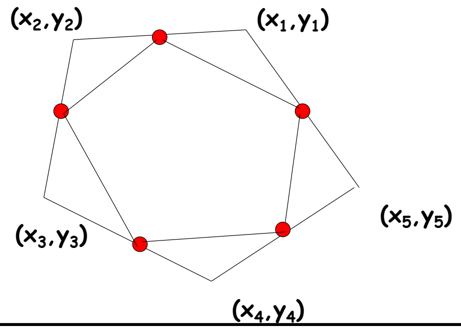
```
xNew(4) = (x(4)+x(5))/2
yNew(4) = (y(4)+y(5))/2
```




```
xNew(5) = (x(5)+x(1))/2
yNew(5) = (y(5)+y(1))/2
```




```
xNew(5) = (x(5)+x(1))/2
yNew(5) = (y(5)+y(1))/2
```



Smooth

```
for i=1:n
     xNew(i) = (x(i) + x(i+1))/2;
     yNew(i) = (y(i) + y(i+1))/2;
end
```

Will result in a subscript out of bounds error when i is n.

Smooth

```
for i=1:n
   if i<n
     xNew(i) = (x(i) + x(i+1))/2;
     yNew(i) = (y(i) + y(i+1))/2;
   else
     xNew(n) = (x(n) + x(1))/2;
     yNew(n) = (y(n) + y(1))/2;
   end
end
```

Smooth

```
for i=1:n-1
     xNew(i) = (x(i) + x(i+1))/2;
     yNew(i) = (y(i) + y(i+1))/2;
end
xNew(n) = (x(n) + x(1))/2;
yNew(n) = (y(n) + y(1))/2;
```

Proposed Simulation

Create a polygon with randomly located vertices.

Repeat:

- Centralize
- Normalize
- Smooth