L8. Iteration and Graphics

Introduce Matlab Graphics

More practice with iteration and boolean-type thinking

Warm-up for functions and arrays.

We will Draw Pictures Using Three User-Defined* Graphics Functions

DrawRect      Rectangles
DrawDisk      Circles
DrawStar      5-pointed Stars

*As opposed to built-in functions like sqrt and rem.
Why?

- Get more practice with loops and if.
- Warm-up to using Matlab's graphics functions which use arrays
- Warm-up to writing your own user-defined functions

DrawRect

```
DrawRect(-1,-2,6,3,'y')
```

A Simple 3-line Script

Draw a black square.

Then a magenta disk.

Then a yellow star.

Solution

```
close all
figure
axis equal off
hold on

DrawRect(-1,-1,2,2,'k')
DrawDisk(0,0,1,'m')
DrawStar(0,0,1,'y')

hold off
```
A General Framework

close all
figure
axis equal off
hold on

Fragment involving DrawRect's, DrawDisk's and/or DrawStar's

hold off
shg

Some Matlab Graphics Commands

% Close all figure windows...
close all
% Open a new figure window
figure
% Set x and y scaling to be the same and do not display axes
axis equal off
% "Add-in mode" is on...
hold on

IGNORE FOR NOW

Some Matlab Graphics Commands

% Exit the add-in mode...
hold off
% Bring the figure window to the front...
shg

IGNORE FOR NOW

Syntax

Let's look at the rules associated with using DrawRect, DrawDisk, and DrawStar.

IGNORE FOR NOW

DrawRect(-1,-2,6,3,’y’)
**Color Options**

- White: 'w'
- Black: 'k'
- Red: 'r'
- Blue: 'b'
- Green: 'g'
- Yellow: 'y'
- Magenta: 'm'
- Cyan: 'c'

**Question Time**

What is the area of the red region?

```matlab
for k=1:3
    if rem(k,2)==1
        DrawRect(0,0,k,k,'r')  % red
    else
        DrawRect(0,0,k,k,'w')  % white
    end
end
```

A. 1     B. 3     C. 6       D. 9

**DrawDisk**

- Input: A magenta disk with radius 6 & center at (-1,-2)
- Output: DrawDisk(-1,-2,6,'m')

**DrawStar**

- Input: A green star with radius 6 and center at (-1,-2)
- Output: DrawStar(-1,-2,6,'g')
Now Let's Solve 3 Problems

Star Array  Nested Stars  PaintBall

The Framework (Again)

close all
figure
axis equal off
hold on

Fragment involving DrawRect's, DrawDisk's and/or DrawStar's

hold off
shg

Problem 1: Star Array

Blue 12-by-6 rectangle with lower left corner at (0,0).

White radius-1 stars with centers at
(2,4), (4,4), (6,4), (8,4) (10,4)
(2,2), (4,2), (6,2), (8,2) (10,2)

Preliminary Notes

Blue rectangle with top row at y = 4
Top Row: y = 4
Bot Row: y = 2
1 2 3 4 5 ← column
2 4 6 8 10 ← x-value

The x-value in the k-th column is 2k

Pseudocode

Draw the blue rectangle
for k = 1:5
    Draw the kth star in the top row
end
for k = 1:5
    Draw the kth star in the bottom row
end
Refinement

Draw the blue rectangle

Draw the blue 12-by-6 rectangle with lower left corner at (0,0).

DrawRect(0,0,12,6,’b’)

Refinement

Draw the k-th star in the top row

Draw a white star with radius 1 and center (2k,4)

DrawStar(2*k,4,1,’w’)

Refinement

Draw the k-th star in the bottom row

Draw a white star with radius 1 and center (2k,2)

DrawStar(2*k,2,1,’w’)

Solution

DrawRect(0,0,12,6,’b’)

for k = 1:5
    DrawStar(2*k,4,1,’w’)
    DrawStar(2*k,2,1,’w’)
end

Problem 2: Nested Stars

Draw black square with center (0,0) & side 2.1

Draw a radius 1 magenta star with center (0,0)

Draw nested sequence of yellow and magenta stars, each with center (0,0) and radius reduced by a factor of 1.2.

Stop when radius <= .1

Preliminary Notes

Star #1: DrawStar(0,0,1,’m’)

Star #2: DrawStar(0,0,1/1.2,’y’)

Star #3: DrawStar(0,0,1/(1.2)^2,’m’)

Star #4: DrawStar(0,0,1/(1.2)^3,’y’)

Preliminary Notes

R = 1
Star #1: DrawStar(0,0,R,'m')
R = R/1.2
Star #2: DrawStar(0,0,R,'y')
R = R/1.2
Star #3: DrawStar(0,0,R,'m')
R = R/1.2
Star #4: DrawStar(0,0,R,'y')

Refinement

Draw the black square

Draw a black square with side 2.1
And center (0,0)

s = 2.1;
DrawRect(-s/2,-s/2,s,s,'k')

Refinement

Draw the kth star

if k is odd
Magenta, radius R, center (0,0)
else
Yellow, radius R, center (0,0)

Refinement

R = 1; k = 1;
Repeat while R > 0.1
Draw the k-th star
Update R and k

R = 1; k = 1;
while R >.1
Draw the k-th star
R = R/1.2; k= k+1;
end

if rem(k,2)==1
DrawStar(0,0,R,’m’)
else
DrawStar(0,0,R,’y’)
end
Solution

\[ R = 1; \ k = 1; \]
while \( R > .1 \)
    if \( \text{rem}(k,2) == 1 \)
        \text{DrawStar}(0,0,R,'m')
    else
        \text{DrawStar}(0,0,R,'y')
    end
    \( R = R/1.2; \ k = k+1; \)
end

Problem 3: Paintball

Draw a black unit square with lower left corner at (0,0).
Draw a radius .03 disk with center randomly located in square.

Problem 3: Paintball

If the disk is entirely in square, randomly color it 'c', 'y', or 'm' with equal probability. Otherwise, color it White.
Repeat this process until 50 white disks drawn.

Preliminary Notes

Dot: radius \( r \), center \((x,y)\)

\[ y+r > 1 \]
\[ x+r > 1 \]
\[ x-r < 0 \]
\[ y-r < 0 \]

“Edge Hits”

Preliminary Notes

How we simulate a 3-way random event?

If \( \text{ink} = \text{rand}(1) \), then
\[ \frac{1}{3} \text{ the time we have: } 0 < \text{ink} < \frac{1}{3} \]
\[ \frac{1}{3} \text{ the time we have: } \frac{1}{3} \leq \text{ink} < \frac{2}{3} \]
\[ \frac{1}{3} \text{ the time we have: } \frac{2}{3} < \text{ink} < 1 \]

Check the inequalities and do the right thing.
Pseudocode

Draw black square.
Repeat until 50 white disks:
  Locate a random disk.
  If the disk is in the square then
    randomly color it 'c', 'y', or 'm'.
  Otherwise,
    color it 'w'
end

Refinement

“Draw the black square”
  Draw a unit black square
    With lower left corner at (0,0)
  DrawRect(0,0,1,1,’k’)

Pseudocode

DrawRect(0,0,1,1,’k’)
  EdgeHits = 0;
  while EdgeHits < 50
    Locate a random disk.
    If the disk is in the square then
      randomly color it 'c', 'y', or 'm'.
    Otherwise,
      color it 'w'
      EdgeHits = EdgeHits + 1;
  end
end

Variable Definition

We use a variable
  
  EdgeHits

to keep track of the number of disks that intersect the square’s boundary.

Refinement

“Locate a random disk”
  The center (x,y) satisfies 0<x<1 and 0<y<1.
  x = rand; y = rand;

Refinement

If the disk is in the square then
  randomly color it 'c', 'y', or 'm'.
Otherwise,
  color it 'w'
  EdgeHits = EdgeHits + 1;
end

How do we check that?
Dot: radius \( r \), center \((x,y)\)

None of these conditions hold.

\[
\begin{align*}
y+r &> 1 \\
x+r &> 1 \\
x-r &< 0 \\
y-r &< 0
\end{align*}
\]

All of these conditions hold.

\[
\begin{align*}
y+r &\leq 1 \\
x+r &\leq 1 \\
x-r &\geq 0 \\
y-r &\geq 0
\end{align*}
\]

Question Time

Want to count upper right corner hits. Which of these boolean conditions guarantees that \((1,1)\) is covered?

(i) \( x + r \geq 1 \) \&\& \( y + r \geq 1 \)  
(ii) \( x + y \geq 2 - 2*r \)

A. Neither  
B. (i) only  
C. Both  
D. (ii) only

Answer Time

(i) \( x + r \geq 1 \) \&\& \( y + r \geq 1 \)  
(ii) \( x + y \geq 2 - 2*r \)

A. Neither  
B. (i) only  
C. Both  
D. (ii) only

The case \( x = 1, y = 1 - r - .000001 \), fools Condition (ii).

Refinement

If the disk is in the square then

\text{randomly color it 'c', 'y', or 'm'}

Otherwise,

\text{color it 'w'}

\text{EdgeHits = EdgeHits + 1;}

end

How do we do that?
Refinement

randomly color it 'c', 'y', or 'm'

1/3 of the time the disk should be 'm'
1/3 of the time the disk should be 'y'
1/3 of the time the disk should be 'c'

ink = rand(1);
if ink < 1/3;
   DrawDisk(x,y,r,'m')
elseif 1/3 <= ink && ink < 2/3
   DrawDisk(x,y,r,'y')
else
   DrawDisk(x,y,r,'c')
end