L17. Structures

Simple Structures
Structure Arrays
Structures with Array Fields
Other Possibilities

Data is Often Related
A point in the plane has an x coordinate and y coordinate.

If a program manipulates lots of points, there will be lots of x's and y's.

Anticipate clutter. Is there a way to "package" the two coordinate values?

Packaging Affects Thinking
Our Reasoning Level:
P and Q are points. Compute the midpoint M of the connecting line segment.

Behind the scenes we do this:
\[ M_x = (P_x + Q_x)/2 \quad M_y = (P_y + Q_y)/2 \]

Seen This Before
Functions are used to "package" calculations.
Elevates the level of our reasoning.
Critical for problem solving.

Packaging
Functions "package" calculations.
Structures "package" data.

Simple Example
\[ P1 = \text{struct}(\text{'x',3,'y',4}); \]
\[ P2 = \text{struct}(\text{'x',-1,'y',7}); \]
\[ D = \sqrt{(p1.x-p2.x)^2 + (p1.y-p2.y)^2}; \]
Distance between two points.
p1.x, p1.y, p2.x, p2.y participating as variables—because they are.
Initialization

\[ P1 = \text{struct}('x',3,'y',4); \]

\( p1 \) is a structure.
The structure has two fields.
Their names are \( x \) and \( y \).
They are assigned the values 3 and 4.

How to Visualize \( p1 \)

\[ P1 = \text{struct}('x',3,'y',4); \]

Accessing a Field

\[ A = p1.x + p1.y \]

Assigns the value 7 to \( A \).

Assigning to a Field

\[ p1.x = p.y^2 \]

Will assign the value 16 to \( p1.x \).

Another Example

\[ A = \text{struct}('name','New York',... 'capital','Albany',... 'Pop',15.5) \]

Can have combinations of string fields and numeric fields.

Legal/Illegal Maneuvers

\[ P = \text{struct}('x',3,'y',4) \]
\[ Q = \text{struct}('x',5,'y',6) \]
\[ R = Q \quad \% \text{Legal. } R \text{ is copy of } Q \]
\[ S = (Q+R)/2 \quad \% \text{Illegal.} \]
Legal/Illegal Maneuvers

% Illegal...
P = struct('x',3,'y')
P.y = 4

% Legal
P = struct('x',3,'y',[[]])
P.y = 4

Using the Empty array as a place holder

A Function Can Have Inputs that are Structures

function d = dist(P,Q)
% P and Q are points.
% d is the distance between them
D = sqrt((P.x-Q.x)^2 + ... (P.y-Q.y)^2);

A Function Can Return a Structure

function P = MakePoint(x,y)
% P is a point with P.x and P.y
% assigned the values x and y.
P = struct('x',x,'y',y);

Good Style.
Highlights the structure's definition.

Functions and Structures

function DrawLS(P,Q,c)
% P and Q are points.
% Draws a line segment connecting
% P and Q. Color specified by c
plot([P.x Q.x],[P.y Q.y],c)

Pick Up Sticks Script

s = 'rgbmcy';
for k=1:100
    P = MakePoint(randn(1),randn(1));
    Q = MakePoint(randn(1),randn(1));
    c = s(ceil(6*rand(1)));
    DrawLS(P,Q,c)
end

Generates two random points and chooses one of six colors randomly.
Structure Arrays

An array whose components are structures.
And all the structures are the same.

Example: An array of points...

Use this “Make” Function

function P = MakePoint(x,y)
% P is a point with P.x and P.y
% assigned the values x and y.
P = struct('x',x,'y',y);

P(1) = MakePoint(.50,.86)
P(2) = MakePoint(-.50,.86)
P(3) = MakePoint(-1.0,0.0)
P(4) = MakePoint(-.50,-.86)
An Array of Points

$P(5) = \text{MakePoint}(0.50, -0.86)$

$P(6) = \text{MakePoint}(1.00, 0.00)$

A Function that Returns an Array of Points

```matlab
function P = CirclePoints(n)

theta = 2*pi/n;
for k=1:n
    c = cos(theta*k);
    s = sin(theta*k);
    P(k) = MakePoint(c,s);
end
```

Structures with Array Fields

Let’s develop a structure that can be used to represent a colored disk.

Four fields:
- $xc$: x-coordinate of center
- $yc$: y-coordinate of center
- $r$: radius
- $c$: rgb color vector

Examples

$D1 = \text{struct}('xc',1,'yc',2,'r',3,...
    'c',[1 0 1])$

$D2 = \text{struct}('xc',4,'yc',0,'r',1,...
    'c',[0.2 0.5 0.3])$

Problem

Assume $D1$ and $D2$ are colored disks. Let’s compute their "average".

$r = (D1.r + D2.r) /2;
xc = (D1.xc + D2.xc)/2
yc = (D1.yc + D2.yc)/2
c = (D1.c + D2.c) /2;
D = \text{struct}('xc',xc,'yc',yc,'r',r,'c',c)$
Example