- Previous lecture:
  - Introduction to objects and classes
  - Value vs. reference
  - Instantiating an object; accessing its properties and methods
- Today's lecture:
  - Objects are passed by reference to functions
  - Details on class definition
    - Constructor
    - Methods
    - Attributes for properties and methods
- Announcements:
  - Prelim 2 will be returned on Tues

To specify the properties & methods of an object is to define its class

- An interval has two endpoints
- We may want to perform these actions:
  - scale and shift individual intervals
  - Determine whether two intervals overlap
  - Add and subtract two intervals

```
classdef Interval < handle

  properties
    left
    right
  end

  methods
    function scale(self, f)
      …
    end

    function Inter = overlap(self, other)
      …
    end

    function Inter = add(self, other)
      …
    end

    …

  end

end
```

classdef syntax summary

A class file begins with keyword classdef:

classdef *classname* < handle

The class specifies handle objects

Constructor returns a reference to the class object

Each instance method's first parameter must be a reference to the instance (object) itself

Use keyword end for keywords classdef, properties, methods, function.

Properties

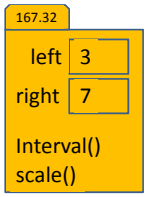
Constructor

Instance methods (functions)

```
classdef Interval < handle
% An Interval has a left end and a right end

  properties
    left
    right
  end

  methods
    function Inter = Interval(lt, rt)
    % Constructor: construct an Interval obj
      Inter.left= lt;
      Inter.right= rt;
    end

    function scale(self, f)
    % Scale the interval by a factor f
      w= self.right - self.left;
      self.right= self.left + w*f;
    end
  end
end
```

Simplified Interval class

To create an Interval object, use its class name as a function call: p = Interval(3,7)




```
classdef Interval < handle
% An Interval has a left end and a right end

  properties
    left
    right
  end

  methods
    function Inter = Interval(lt, rt)
    % Constructor: construct an Interval obj
      Inter.left= lt;
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    end

    function scale(self, f)
    % Scale the interval by a factor f
      w= self.right - self.left;
      self.right= self.left + w*f;
    end
  end
end
```
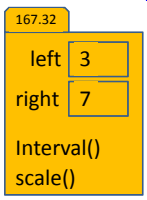

The *constructor* method

To create an Interval object, use its class name as a function call: p = Interval(3,7)



The *constructor* is a special method whose main jobs are to

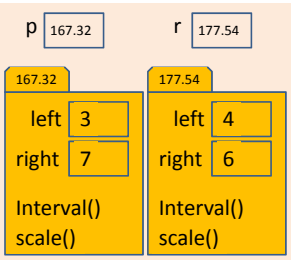
- compute the handle of the new object,
- execute the function code (to assign values to properties), and
- return the handle of the object.

Constructor has the name of the class

```
classdef Interval < handle
% An Interval has a left end and a right end

  properties
    left
    right
  end

  methods
    function Inter = Interval(lt, rt)
    % Constructor: construct an Interval obj
      Inter.left= lt;
      Inter.right= rt;
    end
```

A handle object is referenced by its handle

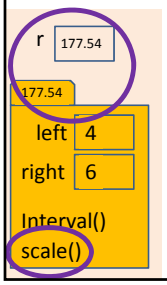
```
p = Interval(3,7);
r = Interval(4,6);
```



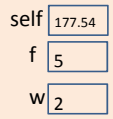
A handle, also called a reference, is like an address; it indicates the memory location where the object is stored.

Executing an instance method

```
r = Interval(4,6);
r.scale(5)
disp(r.right) %What will it be?
```



Function space of scale

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classdef Interval < handle
% An Interval has a left end and a rig

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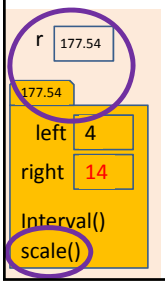
    right
  end

  methods
    function Inter = Interval(lt, rt)
    % Constructor: construct an Inte
       Inter.left= lt;
       Inter.right= rt;
    end

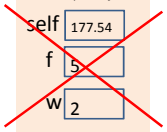
    function scale(self, f)
    % Scale the interval by a factor f
       w= self.right - self.left;
       self.right= self.left + w*f;
    end
  end
end
```

Object is passed to a function by reference

```
r = Interval(4,6);
r.scale(5)
disp(r.right) % updated value
```



Function space of scale

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    function Inter = Interval(lt, rt)
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       Inter.left= lt;
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    end

    function scale(self, f)
    % Scale the interval by a factor f
       w= self.right - self.left;
       self.right= self.left + w*f;
    end
  end
end
```
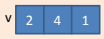
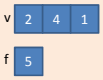

Objects are passed to functions by reference. Changes to an object's property values made through the local reference (self) stays in the object even after the local reference disappears when the function ends.

Non-objects are passed to a function by value

Command Window workspace



Function space of scale2

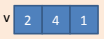



```
v= [2 4 1];
scale2(v,5)
disp(v) %???
```

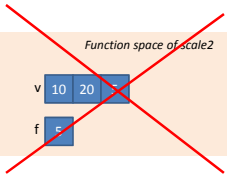
```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Non-objects are passed to a function by value

Command Window workspace



Function space of scale2




```
v= [2 4 1];
scale2(v,5)
disp(v) %NO CHANGE
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Objects are passed to a function by reference

```
r = Interval(4,6);
r.scale(5)
disp(r.right) % updated value
```

```
classdef Interval < handle
  :
  methods
    :
    function scale(self, f)
    % Scale the interval by a factor f
       w= self.right - self.left;
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    end
  end
end
```

```
v= [2 4 1];
scale2(v,5)
disp(v) %NO CHANGE
```

```
function scale2(v,f)
% Scale v by a factor f
v= v*f;
```

Non-objects are passed to a function by value

Syntax for calling an instance method:

<reference>.<method>(<arguments for 2nd thru last parameters>)

```
p = Interval(3,7);
r = Interval(4,6);
```

Better!

```
yesno= p.isIn(r);
% Explicitly call
% p's isIn method
```

```
yesno= isIn(p,r);
% Matlab chooses the
% isIn method of one
% of the parameters.
```

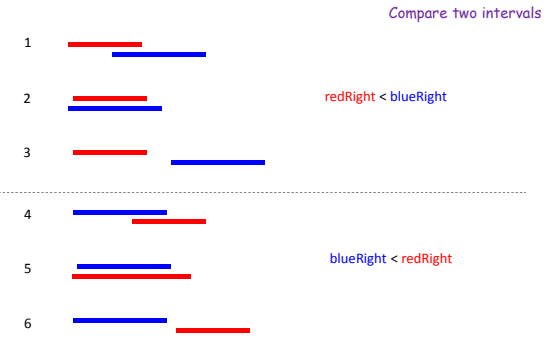
```
classdef Interval < handle
  :
  methods
    :
    function scale(self, f)
    % Scale self by a factor f
      w= self.right - self.left;
      self.right= self.left + w*f;
    end

    function tf = isIn(self, other)
    % tf is true if self is in other interval
      tf= self.left>=other.left && ...
          self.right<=other.right;
    end


  end
end
```

Method to find overlap between two Intervals

```
function Inter = overlap(self, other)
% Inter is overlapped Interval between self
% and the other Interval. If no overlap then
% self is empty Interval.
```



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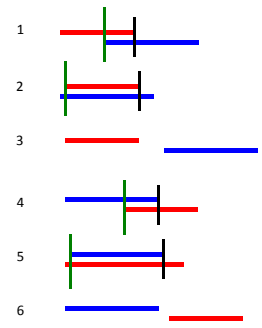

The overlap's left (OLeft) is the rightmost of the two original lefts

The overlap's right (ORight) is the leftmost of the two original rights

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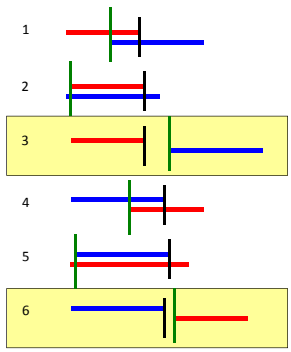

The overlap's left (OLeft) is the rightmost of the two original lefts

The overlap's right (ORight) is the leftmost of the two original rights

No overlap if OLeft > ORight

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```
function Inter = overlap(self, other)
% Inter is overlapped Interval between self
% and the other Interval. If no overlap then
% self is empty Interval.

  Inter= Interval.empty();
  left= max(self.left, other.left);
  right= min(self.right, other.right);
  if right-left > 0
      Inter= Interval(left, right);
  end
end
```

Built-in function to create an empty object of the specified class

Built-in function isempty

```
% Example use of overlap function
A= Interval(3,7);
B= Interval(4,9);
X= A.overlap(B);
if ~isempty(X)
    fprintf('(%f,%f)\n', X.left,X.right)
end
```

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Overloading built-in functions

- You can change the behavior of a built-in function for an object of a class by implementing a function of the same name in the class definition
- Called "overloading"
- A typical built-in function to overload is **`disp`**
  - Specify which properties to display, and how, when the argument to **`disp`** is an object
  - Matlab calls **`disp`** when there's no semi-colon at the end of an assignment statement

See `Interval.m`