- Previous lecture:
  - Array of objects
  - Methods that handle a variable number of arguments
  - Using objects of a class in other functions
- Today's lecture:
  - Using objects of a class in other functions
  - Why use OOP?
  - Attributes for properties and methods (**`private`** vs. **`public`**)
- Announcements:
  - Discussion this week in classrooms, not the lab
  - Pick up prelim 2 at ACCEL Green Rm during consulting hrs
  - Final exam for both lectures on Dec 7th at 2pm. There will not be a separate exam for lec2 on Dec 15th.
  - Check your final exam schedule now and notify us by emailing Randy Hess (rbh27) if you have an exam conflict. Include the times of all your final exams.

A weather object can make use of Intervals …

- Define a class LocalWeather to store the weather data of a city, including monthly high and low temperatures and precipitation
  - Temperature: low and high → an Interval
    - For a year → length 12 array of Intervals
  - Precipitation: a scalar value
    - For a year → length 12 numeric vector
  - Include the city name: a string

```
classdef LocalWeather < handle

 properties
  city     % string
  temps    % array of Intervals
  precip   % numeric vector
 end

 methods
  ...
 end

end
```

Weather data file

```
//Syracuse
//Monthly temperature and precipitation
//Lows (cols 4-8), Highs (col 12-16), precip (cols 20-24)
//Units:  English
      14      31    3.07
      16      33    2.96
      23      42    3.09
      34      55    3.91
      43      67    3.86
      52      76    4.27
      58      80    4.03
      56      79    3.95
      48      70    3.79
      42      58    3.44
      31      47    3.19
      21      36    2.82
```

Class `LocalWeather` should be able to construct an object from such data files, given the known file format.

See `ithacaWeather.txt`, `LocalWeather.m`

Weather data file

```
//Ithaca
//Monthly temperature and precipitation
//Lows (cols 4-8), Highs (col 12-16), precip (cols 20-24)
//Units:  English
      15      31    2.08
      17      34    2.06
      23      42    2.64
      34      56    3.29
      44      67    3.19
      53      76    3.99
      58      80    3.83
      56      79    3.63
      49      71    3.69
     NaN      59     NaN
      32      48    3.16
      22      36    2.40
```

Class `LocalWeather` should be able to construct an object from such data files, given the known file format.

See `ithacaWeather.txt`, `LocalWeather.m`

```
classdef LocalWeather < handle

 properties
  city= '';
  temps= Interval.empty();
  precip
 end

 methods
  function lw = LocalWeather(fname)
   ...
  end

  ...
 end

end
```

Set property variable that will store an array of objects to the correct type, either under properties or in the constructor

```
classdef LocalWeather < handle
 properties
  city=''; temps=Interval.empty(); precip=0;
 end
 methods
  function lw = LocalWeather(fname)
   fid= fopen(fname,'r');
   s= fgetl(fid);
   lw.city= s(3:length(s));
   for k= 1:3
     s= fgetl(fid);
   end
   for k=1:12
     s= fgetl(fid);
     lw.temps(k)= Interval(str2double(s(4:8)), ...
                           str2double(s(12:16)));
     lw.precip(k)= str2double(s(20:24));
   end
   fclose(fid);
  end
  ...
 end  %methods
end  %classdef
```

```
//Ithaca
//Monthly temperature and p
//Lows (cols 4-8), Highs ((
//Units:  English
      15      31    2.08
      17      34    2.06
      23      42    2.64
      34      56    3.29
      44      67    3.19
      53      76    3.99
      58      80    3.83
      56      79    3.63
      49      71    3.69
     NaN      59     NaN
      32      48    3.16
      22      36    2.40
```

```
classdef LocalWeather < handle
  properties
    city=''; temps=Interval.empty();
    precip=0;
  end
  methods
    function lw = LocalWeather(fname)
      ...
    end

    function showCityName(self)

    end
    ...
  end  %methods
end  %classdef
```

Function to show data of a month of `LocalWeather`

```
function showMonthData(self, m)
% Show data for month m, 1<=m<=12.

 mo= {'Jan','Feb','Mar','Apr','May','June',...
      'July','Aug','Sep','Oct','Nov','Dec'};
 fprintf('%s Data\n', mo{m})
 fprintf('Temperature range: ')
 disp(self.temps(m))
 fprintf('Average precipitation: %.2f\n', ...
         self.precip(m))
end
```

See `LocalWeather.m`

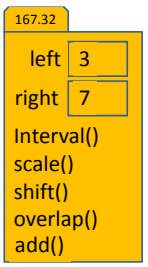
Observations about our class Interval

- We can use it (create Interval objects) anywhere
  - Within the Interval class, e.g., in method overlap
  - "on the fly" in the Command Window
  - In other function/script files – not class definition files
  - In another class definition
- Designing a class well means that it can be used in many different applications and situations

OOP ideas

- Aggregate variables/methods into an abstraction (a class) that makes their relationship to one another explicit
- Object properties (data) need not be passed to instance methods—only the object handle (reference) is passed. Important for large data sets!

Pass reference, not properties



When an instance method executes, the properties—data—are accessible through the handle (reference). No local copy of the data is needed in the method's memory space.

```
classdef Interval < handle

  properties
    left
    right
  end

  methods
    function scale(self, f)
      ...
    end

    function shift(self, s)
      ...
    end

    function Inter = overlap(self, other)
      ...
    end

    function Inter = add(self, other)
      ...
    end

    ...

  end

end
```

OOP ideas → Great for managing large projects

- Aggregate variables/methods into an abstraction (a class) that makes their relationship to one another explicit
- Object properties (data) need not be passed to instance methods—only the object handle (reference) is passed. Important for large data sets!
- Objects (instances of a class) are self-governing (protect and manage themselves)
  - Hide details from client, and restrict client's use of the services
  - Provide clients with the services they need so that they can create/manipulate as many objects as they need

Restricting access to properties and methods

- Hide data from "outside parties" who do not need to access that data—need-to-know basis
- E.g., we decide that users of Interval class cannot directly change `left` and `right` once the object has been created. Force users to use the provided methods—scale, shift, etc.—to cause changes in the object data
- Protect data from unanticipated user action
- Information hiding is very important in large projects

Constructor can be written to do error checking

```
classdef Interval < handle
 properties
  left
  right
 end

 methods
  function Inter = Interval(lt, rt)
   if nargin==2

        Inter.left= lt;
        Inter.right= rt;



   end
  end
  ...
 end
end
```

Constructor can be written to do error checking!

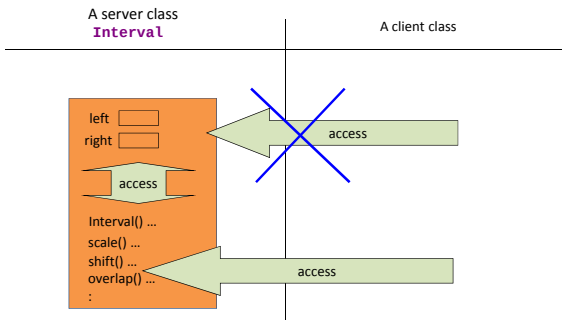
```
classdef Interval < handle
 properties
  left
  right
 end

 methods
  function Inter = Interval(lt, rt)
   if nargin==2
     if lt <= rt
        Inter.left= lt;
        Inter.right= rt;
     else
        disp('Error at instantiation: left>right')
     end
   end
  end
  ...
 end
end
```

Alternative: use built-in function error to halt program execution, e.g., error('Error at instantiation: left>right')

Should force users (clients) to use code provided in the class to create an Interval or to change its property values once the Interval has been created.

E.g., if users cannot directly set the properties left and right, then they cannot accidentally "mess up" an Interval.



Data that the client does not need to access should be protected: `private`
Provide a set of methods for `public` access.

The "client-server model"

```
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
```

Server

```
% Interval experiments
for k=1:5
   fprintf('Trial %d\n', k)
   a= Interval(3, 3+rand*5);
   b= Interval(6, 6+rand*3);
   disp(a)
   disp(b)
   c= a.overlap(b);
   if ~isempty(c)
      fprintf('Overlap is ')
      disp(c)
   else
      disp('No overlap')
   end
   pause
end
```

Example client code

Attributes for properties and methods

- **`public`**
  - Client has access
  - Default
- **`private`**
  - Client cannot access

```
% Client code
r= Interval(4,6);
r.scale(5); % OK
r= Interval(4,14); % OK
r.right=14; % error
disp(r.right) % error
```

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

 properties (SetAccess=private, GetAccess=private)
   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
```

Within the class, there is always access to the properties, even if private

Attributes for properties and methods

- **public**
  - Client has access
  - Default
- **private**
  - Client cannot access

```
% Client code
r= Interval(4,6);
r.scale(5); %OK
r= Interval(4,14); % OK
r.right=14; %error
disp(r.right) %error
```

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

 properties (Access=private)
    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
```

Both GetAccess and SetAccess are private

Public "getter" method

- Provides client the ability to get a property value

```
% Client code
r= Interval(4,6);
disp(r.left) % error
disp(r.getLeft()) % OK
```

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

 properties (Access=private)
    left
    right
 end

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

    function lt = getLeft(self)
    % lt is the interval's left end
       lt= self.left;
    end
    function rt = getRight(self)
    % rt is the interval's right end
       rt= self.right;
    end
    .
 end
end
```

Public "setter" method

- Provides client the ability to set a property value
- Don't do it unless really necessary! If you implement public setters, include error checking (not shown here).

```
% Client code
r= Interval(4,6);
r.right= 9; % error
r.setRight(9) % OK
```

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

 properties (Access=private)
    left
    right
 end

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

    function setLeft(self, lt)
    % the interval's left end gets lt
       self.left= lt;
    end
    function setRight(self, rt)
    % the interval's right end gets rt
       self.right= rt;
    end
    .
 end
end
```

Always use available methods, even when within same class

```
classdef Interval < handle
 properties (Access=private)
   left; right
 end
 methods
   function Inter = Interval(lt, rt)
     …
   end
   function lt = getLeft(self)
      lt = self.left;
   end
   function rt = getRight(self)
      rt = self.right;
   end
   function w = getWidth(self)
      w= self.getRight() – self.getLeft() ;
   end
   …
 end
end
```

In here… code that always uses the getters & setters

```
% Client code
…
A = Interval(4,7);
disp(A.getRight() )
…
% … lots of client code that uses
%     class Interval, always using the
%     provided public getters and
%     other public methods …
```

Always use available methods, even when within same class

```
classdef Interval < handle
 properties (Access=private)
   left; right
 end
 methods
   function Inter = Interval(lt, rt)
     …
   end
   function lt = getLeft(self)
      lt = self.left;
   end
   function rt = getRight(self)
      rt = self.right;
   end
   function w = getWidth(self)
      w= self.getRight() – self.getLeft() ;
   end
   …
 end
end
```

New Interval implementation

```
classdef Interval < handle
 properties (Access=private)
   left; width
 end
 methods
   function Inter = Interval(lt, w)
     …
   end
   function lt = getLeft(self)
      lt = self.left;
   end
   function rt = getRight(self)
      rt = self.getLeft() + self.getWidth();
   end
   function w = getWidth(self)
      w= self.width ;
   end
   …
 end
end
```

In here… code that always uses the getters & setters

Rewrite the getters/setters. Everything else stays the same! Cool! Happy clients!

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- Aggregate variables/methods into an abstraction (a class) that makes their relationship to one another explicit
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Rewrite the getters/setters. Everything else stays the same! Cool! Happy clients!