Today’s Lecture:
- 2-d array—matrix
- Function & subfunction
- Executing a function—function “scope” (see bleecture)
- Details on for-loop (see bleecture)

Announcements:
- Assignment 1a due tonight
- Friday: lab session in Hollister 464
- Assignment 1b due Tuesday 11:59pm
- Test 1 on Wednesday in class; review on Monday.
Pattern for traversing a matrix $M$

\[
[nr, nc] = \text{size}(M)
\]

\[
\text{for } r = 1:nr
\]

\[
\% \text{ At row } r
\]

\[
\text{for } c = 1:nc
\]

\[
\% \text{ At column } c \text{ (in row } r)\n\]

\[
\%
\]

\[
\% \text{ Do something with } M(r,c) \ldots
\]

\[
\text{end}
\]

\[
\text{end}
\]
Matrix example: Random Web

- N web pages can be represented by an N-by-N Link Array $A$.
- $A(i,j)$ is 1 if there is a link on webpage $j$ to webpage $i$.
- Generate a random link array and display the connectivity:
  - There is no link from a page to itself.
  - If $i \neq j$ then $A(i,j) = 1$ with probability $\frac{1}{1+|i-j|}$.
  - There is more likely to be a link if $i$ is close to $j$. 


function A = RandomLinks(n)
% A is n-by-n matrix of 1s and 0s
% representing n webpages

A = zeros(n,n);
for i=1:n
    for j=1:n
        r = rand(1);
        if i~=j && r<= 1/(1 + abs(i-j));
        A(i,j) = 1;
    end
end
end
Represent the web pages graphically…

100 Web pages arranged in a circle. Next display the links….
Bidirectional links are blue. Unidirectional link is black as it leaves page j, red when it arrives at page i.

See ShowRandomLinks.m
Somewhat inefficient: each blue line gets drawn twice.

See ShowRandomLinks.m
Transpose—like switching row and column indices
Accessing a submatrix

The matrix $M$ is shown below:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>-3</td>
<td>8.5</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>52</td>
<td>81</td>
<td>.5</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

The component $(2,3)$ is highlighted in red.

The neighborhood of component $(2,3)$ is shown in the submatrix $M(1:3,2:4)$.

$$M(2,3)$$

$$M(1:3,2:4)$$
Local minimum in a neighborhood

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>-1</th>
<th>.5</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td></td>
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<tr>
<td>5</td>
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<td>81</td>
<td>.5</td>
<td>7</td>
<td>2</td>
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</tr>
</tbody>
</table>

Component (3,5)

Neighborhood of component (3,5)
Local minimum in a neighborhood

- Write a function `minInNeighborhood`
- Input parameters:
  - `M`: matrix of numeric values
  - `loc`: location of the middle of the neighborhood
    - `loc(1)`, `loc(2)` are the row, column numbers
- Output parameter: `minVal`
  - The minimum value of the neighborhood
Ask yourself questions!

- Can you find the min of a (sub)matrix?
  - Yes! Our function \texttt{minInMatrix}(A)
- Given the indices \(r, c\) (representing element \(M(r, c)\)), is it easy to define the neighborhood?
  - Yes, for the general case the neighborhood is \(M(r-1:r+1, c-1:c+1)\)
  - But need to deal with the “border cases”
Local minimum in a neighborhood

Want to be able to use the general case, $m(r-1:r+1, c-1:c+1)$
Local minimum in a neighborhood

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>B</td>
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<td>B</td>
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<td>B</td>
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Create a border of values (B is some big number)

Want to be able to use the general case,
\( m(r-1:r+1,c-1:c+1) \)

Note: This is an exercise on manipulating a matrix. Method not suitable for a large matrix!
minInNeighborhood.m
minInNeighborhoodV2.m
minInNeighborhoodV3.m
Neighborhood of position \((i,j)\)

\[
\begin{array}{llllll}
2 & -1 & .5 & 0 & 1 \\
3 & 8 & 6 & 7 & 7 \\
5 & -3 & 8.5 & 9 & 10 \\
52 & 81 & .5 & 7 & 2 \\
\end{array}
\]

\[
\begin{align*}
i_{\text{Min}} &= i - r \\
i_{\text{Max}} &= i + r \\
j_{\text{Min}} &= j - r \\
j_{\text{Max}} &= j + r \\
\text{subM} &= M(i_{\text{Min}}:i_{\text{Max}},j_{\text{Min}}:j_{\text{Max}})
\end{align*}
\]
Neighborhood of position (i,j)

\[
M \ \\
\begin{array}{cccc}
2 & -1 & .5 & 0 & 1 \\
3 & 8 & 6 & 7 & 7 \\
5 & -3 & 8.5 & 9 & 10 \\
52 & 81 & .5 & 7 & 2
\end{array}
\]

\[\text{[nr,nc]} = \text{size}(M);\]
\[i\text{Min} = \text{max}(1,i-r);\]
\[i\text{Max} = \text{min}(nr,i+r);\]
\[j\text{Min} = \text{max}(1,j-r);\]
\[j\text{Max} = \text{min}(nc,j+r);\]
\[\text{subM} = M(i\text{Min}:i\text{Max},j\text{Min}:j\text{Max});\]
Subfunction

- There can be more than one function in an M-file
- top function is the main function and has the name of the file
- remaining functions are subfunctions, accessible only by the functions in the same m-file
- Each (sub)function in the file begins with a function header
- Keyword end is not necessary at the end of a (sub)function