Previous Lecture:
- Discrete vs. continuous; finite vs. infinite
- Linear interpolation
- Vectorized operations

Today’s Lecture:
- 2-d array—matrix

Announcements:
- Discussion this week in the classrooms as listed in the roster
- Prelim 1 tonight at 7:30pm
  - Last names A-O: Uris Auditorium (room G01)
  - Last names P-Z: Upson Auditorium (room B17)

Storing and using data in tables
A company has 3 factories that make 5 products with these costs:

<table>
<thead>
<tr>
<th>C</th>
<th>10</th>
<th>36</th>
<th>22</th>
<th>15</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>35</td>
<td>20</td>
<td>12</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>37</td>
<td>21</td>
<td>16</td>
<td>59</td>
</tr>
</tbody>
</table>

Connections between webpages

![Connections between webpages](image)

What is the best way to fill a given purchase order?

2-d array: matrix
- An array is a named collection of like data organized into rows and columns
- A 2-d array is a table, called a matrix
- Two indices identify the position of a value in a matrix, e.g.,
  \[ \text{mat}(r, c) \]
  refers to component in row \( r \), column \( c \) of matrix \( \text{mat} \)
- Array index starts at 1
- Rectangular: all rows have the same #of columns

Creating a matrix
- Built-in functions: ones, zeros, rand
  - E.g., zeros(2,3) gives a 2-by-3 matrix of 0s
  - “Build” a matrix using square brackets, \([ \ ]\), but the dimension must match up:
    - \([x \ y]\) puts \( y \) to the right of \( x \)
    - \([x; y]\) puts \( y \) below \( x \)
    - \([4 \ 0 \ 3; 5 \ 1 \ 9]\) creates the matrix
    - \([4 \ 0 \ 3; \text{ones}(1,3)]\) gives
    - \([4 \ 0 \ 3; \text{ones}(3,1)]\) doesn’t work

Example: minimum value in a matrix

function \( \text{val} = \text{minInMatrix}(\text{M}) \)
% \( \text{val} \) is the smallest value in matrix \( \text{M} \)

Working with a matrix:
- size and individual components

Given a matrix \( \text{M} \):

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

\[ [\text{nr}, \text{nc}] = \text{size}(\text{M}) \]  % \( \text{nr} \) is #of rows,
% \( \text{nc} \) is #of columns
\[ \text{nr} = \text{size}(\text{M}, 1) \]  % # of rows
\[ \text{nc} = \text{size}(\text{M}, 2) \]  % # of columns

\( \text{M}(2,4) = 1; \)
\( \text{disp}([\text{M}(3,1)] \)
\( \text{M}(1,\text{nc}) = 4; \)
Pattern for traversing a matrix $M$

```matlab
[nr, nc] = size(M)
for r= 1:nr
  % At row r
  for c= 1: nc
    % At column c (in row r)
    % Do something with $M(r,c)$ …
  end
end
```

% Given an nr-by-nc matrix M.
% What is A?
for r = 1: nr
  for c = 1: nc
    A(c, r) = M(r, c);
  end
end

A =
A is $M$ with the columns in reverse order
B. A is $M$ with the rows in reverse order
C. A is the transpose of $M$
D. A and $M$ are the same

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 $j$

```matlab
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
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.

% Given an n-by-m matrix A.
% What is this operation?
for g = 1: n
    for h = 1: floor(m/2)
        A(g,h) = A(g, m-h+1);
    end
end

A Reflect the right half of A onto the left half
B Reflect the bottom half of A onto the top half

Is there another way? See ShowRandomLinks.m