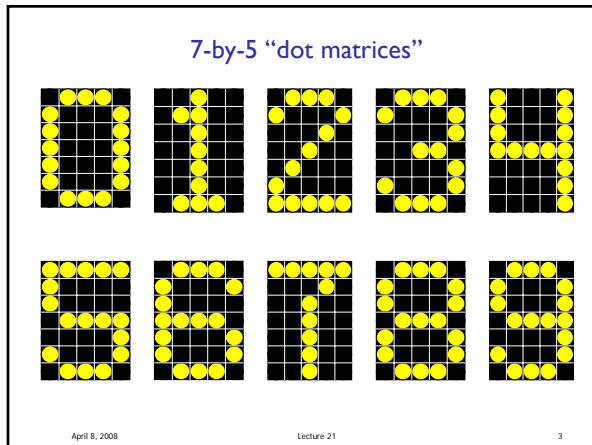
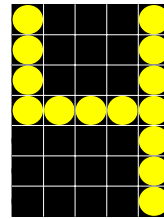


- Previous Lecture:
 - Working with large data files
 - Built-in `sort` function
- Today's Lecture:
 - Review matrix, cell array, structure array
- Announcement:
 - P5 due 4/11 at 3pm
 - Prelim 3 next Tues. We must know by now if you have an exam conflict.

Application: digital displays



A "bit map" for each digit



A "light" is either on or off.

A 7-by-5 matrix of zeros and ones can "tell the whole story."

Computing with these bitmaps

- What is a good scheme for storing the 10 bitmaps?
- How to draw one digit?
- How to display a number?
- Other interesting questions:
 - How to draw a mirror image of a digit?
 - Which "light bulb" switches on most often?

Design decisions...

How do we package a particular digit?

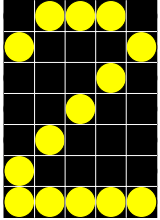
numerical array or character array

How do we package the collection of digits?

cell array or structure array

Can use a **numerical** array for each digit

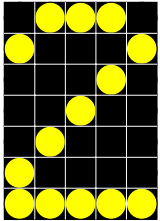
```
[ 0 1 1 1 0;...
  1 0 0 0 1;...
  0 0 0 1 0;...
  0 0 1 0 0;...
  0 1 0 0 0;...
  1 0 0 0 0;...
  1 1 1 1 1];
```



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Can use a **character** array for each digit

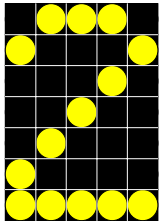
```
[ '01110';...
  '10001';...
  '00010';...
  '00100';...
  '01000';...
  '10000';...
  '11111'];
```



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Can use a **cell** array to keep the 10 bitmaps

```
M = [ 0 1 1 1 0;...
      1 0 0 0 1;...
      0 0 0 1 0;...
      0 0 1 0 0;...
      0 1 0 0 0;...
      1 0 0 0 0;...
      1 1 1 1 1];
```



`D{2} = M;`

Each cell of cell array **D** is a numerical matrix.

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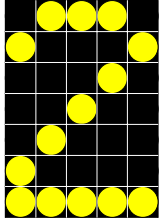
With $D\{1\}, \dots, D\{10\}$ set up as a cell array of numerical matrices, can do computation as follows:

```
% given 1<=k<=10
M = D{k};
if M(4,3)==1
    disp('Middle light is on')
end
```

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Still using a **cell** array to keep the 10 bitmaps

```
M = ['01110';...
      '10001';...
      '00010';...
      '00100';...
      '01000';...
      '10000';...
      '11111'];
```



`D{2} = M;`

Each cell of cell array **D** is a matrix of characters.

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With $D\{1\}, \dots, D\{10\}$ set up as a cell array of character matrices, can do computation as follows:

```
% given 1<=k<=10
M = D{k};
if strcmp(M(4,3), '1')
    disp('Middle light is on')
end
```

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Which do you prefer?

A Numerical matrix for each digit

```
[ 0 1 1 1 0;...
 1 0 0 0 1;...
 0 0 0 1 0;...
 0 0 1 0 0;...
 0 1 0 0 0;...
 1 0 0 0 0;...
 1 1 1 1 1];
```

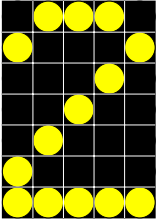
B Character matrix for each digit

```
[ '01110';...
  '10001';...
  '00010';...
  '00100';...
  '01000';...
  '10000';...
  '11111'];
```

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Can use a structure array to keep the 10 bitmaps

```
M = [ 0 1 1 1 0;...
      1 0 0 0 1;...
      0 0 0 1 0;...
      0 0 1 0 0;...
      0 1 0 0 0;...
      1 0 0 0 0;...
      1 1 1 1 1];
```



```
D(2) = struct('matrix', M);
```

Each component of array **D** is a structure, and the sole field in the structure is a **matrix of numbers**.

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Using a structure array to keep the 10 bitmaps...
The k-th component of array **D** encodes digit k.

```
% Example for the digit 2
A = [ 0 1 1 1 0;...
      1 0 0 0 1;...
      0 0 0 1 0;...
      0 0 1 0 0;...
      0 1 0 0 0;...
      1 0 0 0 0;...
      1 1 1 1 1];
D(2)= struct('matrix', A);
```

A

```
M = D(k);
if M(4,3)==1
    disp('Middle light on')
end
```

B

```
M = D(k).matrix;
if M(4,3)==1
    disp('Middle light on')
end
```

C

```
M = D{k};
if M(4,3)==1
    disp('Middle light on')
end
```

D

```
M = D{k}.matrix;
if M(4,3)==1
    disp('Middle light on')
end
```

Which fragment on the right is correct given $1 \leq k \leq 10$?

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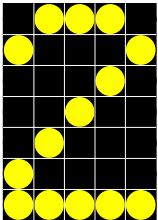
With $D\{1\}, \dots, D\{10\}$ set up as a structure array of numerical matrices, can do computation as follows:

```
% given 1<=k<=10
M = D(k).matrix;
if M(4,3)==1
    disp('Middle light is on')
end
```

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Can use a structure array to keep the 10 bitmaps

```
M = [ '01110';...
      '10001';...
      '00010';...
      '00100';...
      '01000';...
      '10000';...
      '11111'];
```



```
D(2) = struct('matrix', M);
```

Each component of array **D** is a structure, and the sole field in the structure is a **matrix of characters**.

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With $D\{1\}, \dots, D\{10\}$ set up as a structure array of character matrices, can do computation as follows:

```
% given 1<=k<=10
M = D(k).matrix;
if strcmp(M(4,3), '1')
    disp('Middle light is on')
end
```

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Choice for storing the bit maps

Cell array better than struct array

No point in having a structure with one field

Numerical array better than char array

Plan on doing numerical computations with the bit maps—char arrays not handy

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Lecture 21

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```
function D = TheDigits
% D is a 10-by-1 cell array where D{k} is a 7-by-5 matrix
% that encodes digit k. D{10} encodes 0.
```

```
D = cell(10,1);

D{1} = [0 0 1 0 0;...
        0 1 1 0 0;...
        0 0 1 0 0;...
        0 0 1 0 0;...
        0 0 1 0 0;...
        0 0 1 0 0;...
        0 1 1 1 0];

D{2} = [0 1 1 1 0;...
        1 0 0 0 1;...
        0 0 0 0 1;...
        0 0 0 1 0;...
        0 0 1 0 0;...
        0 1 0 0 0;...
        1 1 1 1 1];

:
```

Given this function, can write other functions to draw a single digit, multiple digits, etc.

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Lecture 21

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Produce a cell array of “reverse” digits



For every digit (matrix), need to reverse the order of the columns.

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Lecture 21

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```
function B = reverseCol(A)
% B is a matrix obtained by reversing
% the order of the columns in matrix A
```

```
[nr, nc]= size(A);
B= zeros(nr,nc);
for k= 1:nc
    B(:,k) = A(:,nc-k+1);
end
```

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Lecture 21

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```
function revD = reverseDigits
% revD is a 10-by-1 cell array.
% revD{k} is the reversed 7-by-5 bitmap
% of digit k. revD{10} encodes 0.
```

```
D= TheDigits;
revD= cell(10,1);
```

```
function revD = reverseDigits
% revD is a 10-by-1 cell array.
% revD{k} is the reversed 7-by-5 bitmap
% of digit k. revD{10} encodes 0.
```

```
D= TheDigits;
revD= cell(10,1);

for k= 1:length(D)
    M= D{k};
    revM= reverseCol(M);
    revD{k}= revM;
end
```

Digital display of a whole number

- Example: `showNumber(2008)`



- Need to convert the number to a vector of digits
 - 2008 → [2 0 0 8]
- Then display the digits in the vector side-by-side

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```
function showNumber(n)
% Digital display of integer n, n>0

hold on; axis equal off

% Convert n to a vector of digits

% Display the digits in v
D = TheDigits; % D{k} is matrix encoding digit k
```

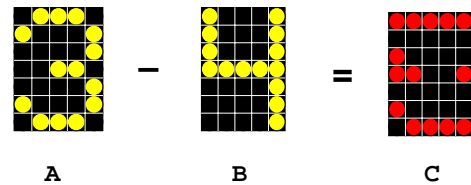
```
function showNumber(n)
% Digital display of integer n, n>0

hold on; axis equal off

% Convert n to a vector of digits
v = [];
while n>0
    v = [rem(n,10) v];
    n = floor(n/10);
end

% Display the digits in v
D = TheDigits; % D{k} is matrix encoding digit k
for k=1:length(v)
    index = v(k);
    if index==0
        index = 10;
    end
    drawDigit(k,1,1,D{index})
end
```

How to calculate the difference between 2 bitmaps?



$$C(i,j) = \text{abs}(A(i,j) - B(i,j))$$

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```
% A and B have same size
[nr,nc]= size(A);
B= zeros(nr,nc);
for r= 1:nr
    for c= 1:nc
        C(r,c)= abs(A(r,c)-B(r,c));
    end
end
```

```
% A and B have same size
C= abs(A-B);
```

C is a 0-1 matrix where 1 indicates that A(i,j) and B(i,j) are different.

Section exercise

If you have an extra-long-life light bulb for your 7-by-5 display board, at which position would you install this light bulb?

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