MATLAB EXPO 2019

Insights into MATLAB

Memory handling and data types

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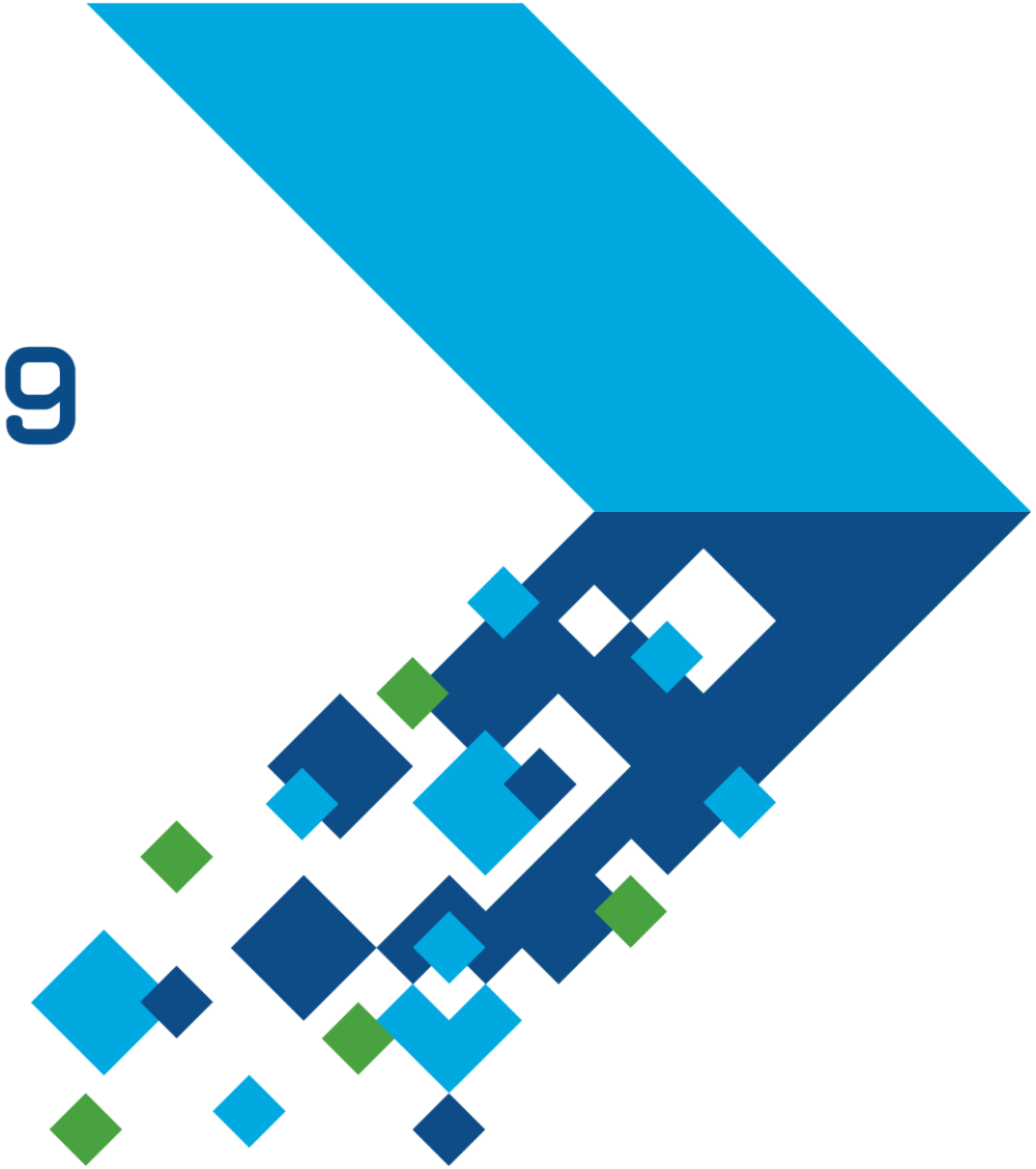


Agenda

MATLAB and memory implications

- Programming
  - Passing Arrays
  - In place calculations
- Datatypes
  - How structures/cells use memory
  - tables, categorical, string arrays

MATLAB and Memory

- Passing arrays to functions
  - When does MATLAB copy memory?

```
function y = foo(x,a,b)
a(1) = a(1) + 12;
y = a*x+b;
```

- Calling `foo`

```
y = foo(1:3,2,4)
```

  - i.e., **`x = 1:3, a = 2, b = 4`**

```
>> edit foo.m
```

In-place Optimizations

- When does MATLAB do calculations “**in-place**”?

```
x = 2*x + 3;
y = 2*x + 3;
```

In-place Optimizations

When does MATLAB do calculations “**in-place**”?

```
function showInPlace
xx = randn(n,1);
xx = myfunc(xx);            % vs. yy = myfunc(xx)
xx = myfuncInPlace(xx); % vs. yy = myfuncInPlace(xx)

function x = myfuncInPlace(x)
x = sin(2*x.^2+3*x+4);

function y = myfunc(x)
y = sin(2*x.^2+3*x+4);
```

```
>> edit myfuncInPlace myfunc showInPlace
%separate functions, separate files
```

Memory Used for Different Array Types

```
d = [1 2]          % Double array
dcell  = {d}       % Cell array containing
dstruct.d = d

whos
```

```
>> edit overhead
```

MATLAB and Memory

How does MATLAB store structures?

```
n = 10000;
s.A = rand(n,n);
s.B = rand(n,n);

sNew = s;

s.A(1,1) = 17;
```

```
>> edit structmem1
```

MATLAB and Memory

How does MATLAB store structures?

```
im1.red = redPlane;   % each plane is m x n
im1.green = greenPlane;
im1.blue = bluePlane;
```

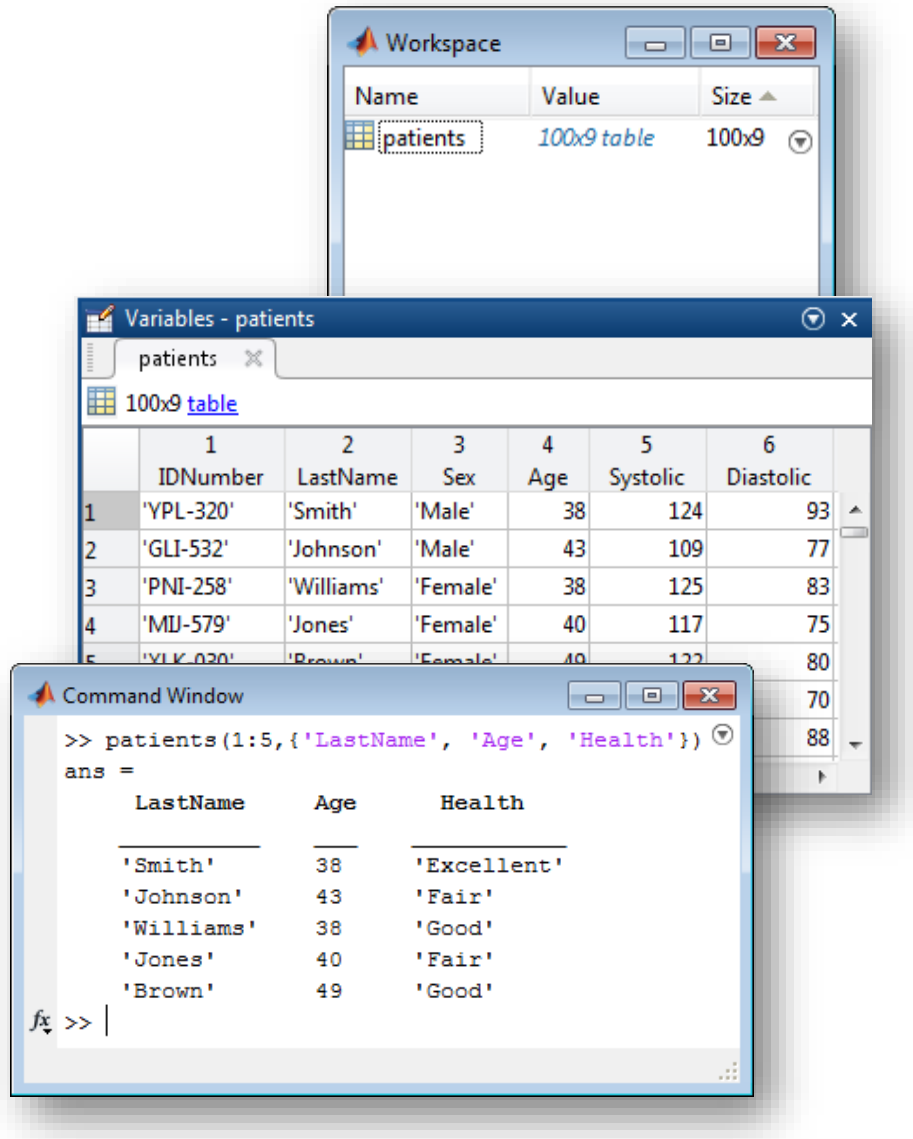
versus

```
% each 1x3
im2(1,1).pixel = [red(1) green(1) blue(1)];
im2(2,1).pixel = [red(2) green(2) blue(2)];
...
im2(m,n).pixel = [red(m*n) green(m*n) …
                  blue(m*n)];
```

```
>> edit structmem2
```

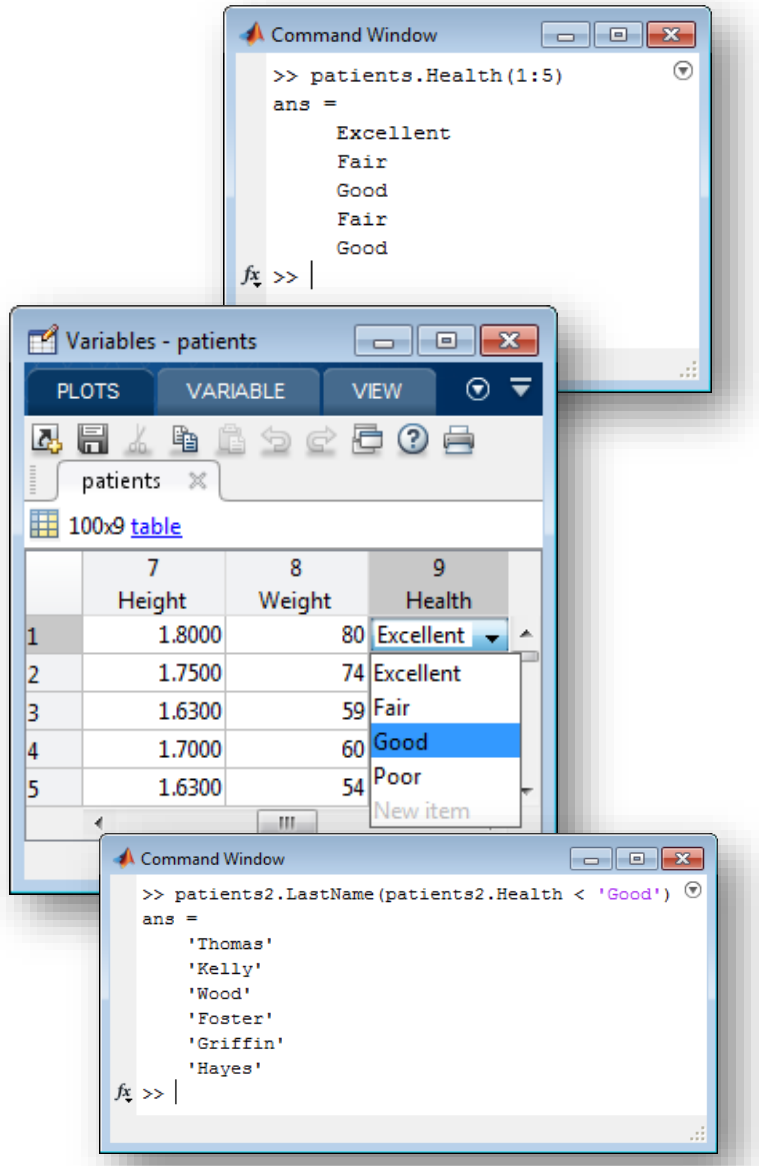
Tables

- New fundamental data type
- For mixed-type tabular data
  - Holds both data and metadata
- Supports flexible indexing
- Built-in functionality (merge, sort, etc.)



Categorical Arrays

- New fundamental data type
- For discrete non-numeric data
  - Values drawn from a finite set of possible values ("categories")
- More memory efficient than a cell array of strings
- Can be compared using logical operators
  - Similar to numeric arrays




```
>> edit showCategorical.m
```

Strings

The better way to work with text

- Manipulate, compare, and store text data efficiently

```
>> "image" + (1:3) + ".png"
    1×3 string array
      "image1.png"   "image2.png"   "image3.png"
```

- Simplified text manipulation functions
  - Example: Check if a string is contained within another string
    - Previously: `if ~isempty(strfind(textdata,"Dog"))`
    - Now: `if contains(textdata,"Dog")`

- Performance improvement
  - Up to 50x faster using **`contains`** with **`string`** than **`strfind`** with **`cellstr`**
  - Up to 2x memory savings using **`string`** over **`cellstr`**

Summary of MATLAB and Memory

- How MATLAB passes arrays to functions
  - By value, with “lazy” copy or copy on write
  - In-place optimization code pattern

- Memory use in array storage
  - Atomic types vs. cell arrays and structures
  - Array of structs vs. struct arrays
    - i.e., s(300,300).red vs. s.red(300,300)
  - Categorical arrays, tables, strings

Summary

MATLAB and memory implications

- Programming
  - Passing Arrays – when are copies made
  - In place calculations
- Datatypes
  - How structures/cells use memory
  - tables, categorical, string arrays