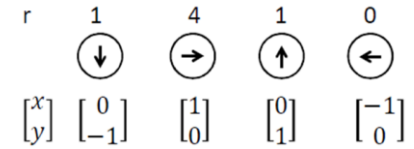
CISC 3250
Systems Neuroscience

Matlab, part 3:
Matrix math +
3D matrices

Professor Daniel Leeds
dleeds@fordham.edu
JMH 332

Matrices and weighted sums



$$1\begin{bmatrix}0\\-1\end{bmatrix}+4\begin{bmatrix}1\\0\end{bmatrix}+1\begin{bmatrix}0\\1\end{bmatrix}+0\begin{bmatrix}-1\\0\end{bmatrix}=\begin{bmatrix}4\\0\end{bmatrix}$$

$$\begin{bmatrix}0 & 1 & 0 & -1\\ -1 & 0 & 1 & 0\end{bmatrix}\begin{bmatrix}1\\4\\1\\0\end{bmatrix}=\begin{bmatrix}4\\0\end{bmatrix}$$

Left Matrix columns times
Right matrix numbers

$$\begin{bmatrix}| & | & |\\ v_1 & v_2 & v_3\\ | & | & |\end{bmatrix}\begin{bmatrix}x\\y\\z\end{bmatrix}=xv_1+yv_2+zv_3$$

3

Matrix math

$$\begin{bmatrix}| & | & |\\ v_1 & v_2 & v_3\\ | & | & |\end{bmatrix}\begin{bmatrix}x\\y\\z\end{bmatrix}=xv_1+yv_2+zv_3$$

Assuming right matrix is a single column

In general, # of left matrix columns must equal
# of right matrix rows

4

Matrices in matlab

```
A= [1 2; 3 4];
b= [4; 5];
```

What is `A*b`? **[14 ; 32]**

Transpose: `[4; 5]` == `[4 5]'`

`a'` flips rows and columns

6

"Solving for x"

$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ $\quad c = \begin{bmatrix} -2 \\ -2 \end{bmatrix}$

$Ax = c$

What is x? $x = A^{-1}c = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}^{-1} \begin{bmatrix} -2 \\ -2 \end{bmatrix} = \begin{bmatrix} \mathbf{2} \\ \mathbf{-2} \end{bmatrix}$

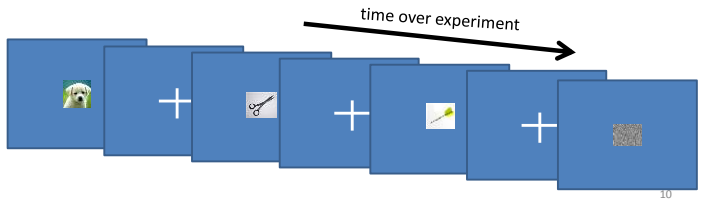
```
inv(A)*c
```

8

LOC localizer: experimental design

Each second:

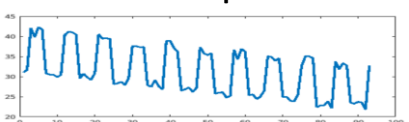
- new object OR
- new noise OR
- "blank screen" (fixation)



10

Building the voxel response

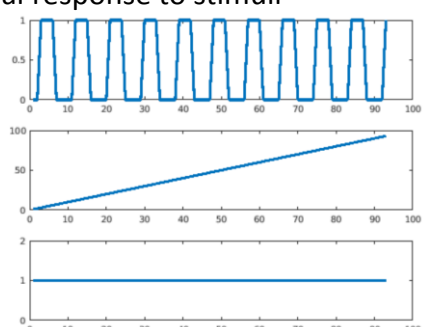
Voxel response `neuroData`



at each second neural response to stimuli

`timesObjs`, at each second:

- 0 for no-object, 1 for yes-object
- Drift and offset



Building the voxel response

Design matrix M

- On/off information O
- Constant offset C
- Linear drift L

Measured voxel output v $\quad [\, v_{t=1} \;\; v_{t=2} \ldots v_{t=93}]^T$

$$M = \begin{bmatrix} | & | & | \\ O & C & L \\ | & | & | \end{bmatrix} \qquad M \begin{bmatrix} \beta_o \\ \beta_c \\ \beta_L \end{bmatrix} = v \qquad B = M^{-1}v$$

12

Matlab code

```
% Want: k1*O+k2*C+k3*L=sigOut1;
% I.e.: M*kVec = sigOut1;
% Define M "design matrix"
M= [ blockPatt; driftL; driftC];
% M is 3 x 93, we want 93 x 3 matrix
Mtrans=M';
x=pinv(Mtrans)*sigOut1;
% inv only works on square mat -
%     num rows=num cols,
% pinv on any matrix
```

13

More Matlab code

```
% Find patterns in sigOut1
M= [ blockPatt; driftL; driftC];
Mtrans=M';
x=pinv(Mtrans)*sigOut1
```

9.9896 Block1
-0.1007 linDrift
30.4889 offset

```
% Patt-correct time blocks,
% Patt2-unrelated time blocks
M=[blockPatt;driftL;driftC; blockPatt2];
Mtrans=M';
x4=pinv(Mtrans)*sigOut1;
```

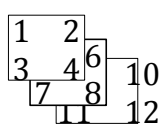
9.9773 Block1
-0.1006 linDrift
30.5045 offset
-0.0217 block2

Matrices in *n* dimensions

```
x=[1 2 3; 4 5 6]
```

$$\begin{bmatrix}1 & 2 & 3\\ 4 & 5 & 6\end{bmatrix}$$

```
y(:,:,1)=[1 2; 3 4]
y(:,:,2)=[5 6; 7 8]
y(:,:,3)=[9 10; 11 12]
size(y)  -> [2 2 3]
```



Typical brain data : location of neuron (x,y,z) + time

Heat-maps

imagesc(Data) – view 2D matrix of scaled data as image

- Red/yellow is highest value, blue is lowest value

Visualize a 2D slice of brain data (size(brainData) -> 128x128x88)

```
slice=squeeze(brainData(:,:,20))
```

-> slice 20 of brain

```
imagesc(slice)
```

Multiple plots

figure -> opens new plotting window

subplot(r,c,i) -> creates grid of plots with

- r rows
- c columns
- fill in position i

```
currSlice=squeeze(brainData(:,:,10));
subplot(1,3,1); imagesc(currSlice);
currSlice=squeeze(brainData(:,:,20));
subplot(1,3,2); imagesc(currSlice);
currSlice=squeeze(brainData(:,:,30));
subplot(1,3,3); imagesc(currSlice);
```

17

Multiple plots

With looping

```
for i=1:8,
  currSlice=squeeze(brainData(:,:,i*10));
  subplot(1,3,i), imagesc(currSlice);
end;
```

18

`squeeze` out 1-entry dimensions

```
currSlice=squeeze(brainData(:,60,:));

% currSlice has size 128x1x88
% won't be plotted by imagesc
%  - expects 2D matrix

currSlice=squeeze(currSlice);
% now currSlice has size 128x88
```

19

Distribution of matrix values

```
S1brainVec=S1brain(:);
 % convert entries to 1 long vector
hist(S1brainVec)
 % see distribution of values
 % see most values below 400,
 %    few outliers
S1brain(find(S1brain>400))=400;
 % pull outliers down to 400
imagesc(S1brain(:,:,40)) %replot
```

20

Scaling vs. not-scaling

`imagesc(Data)` – view 2D matrix of scaled data as image

- Red (or yellow) is highest value, blue is lowest value

`image(Data)` – view 2D matrix of data as image

- Red (or yellow) is 64 or higher, blue is 0 or lower

```
slice=squeeze(brainData(:,:,10));
figure; imagesc(slice);
```

vs

```
figure; image(slice)
```