# Lecture 04: Plotting I

## NENS 230: Analysis Techniques in Neuroscience

# Lecture 04 Outline

Questions?

Graphics Objects, Figures, Properties

Axes, Line Series, Legend

Limits, Line, Patch

3D Plotting

Subplot

Bar Graph, Tick and Tick Labels, Text

Assignment 4 Overview

# Lecture 04 Outline

**Questions?**

Graphics Objects, Figures, Properties

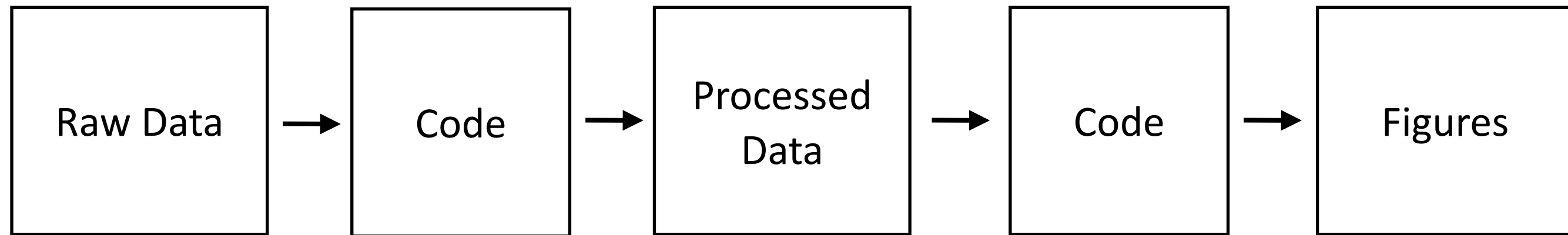Axes, Line Series, Legend

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# Why is plotting important?

Raw Data → Code → Processed Data → Code → Figures

Plotting data used for:

- Polished figures for analyzing and presenting results
- Quick visualization to get intuition about data in a variable

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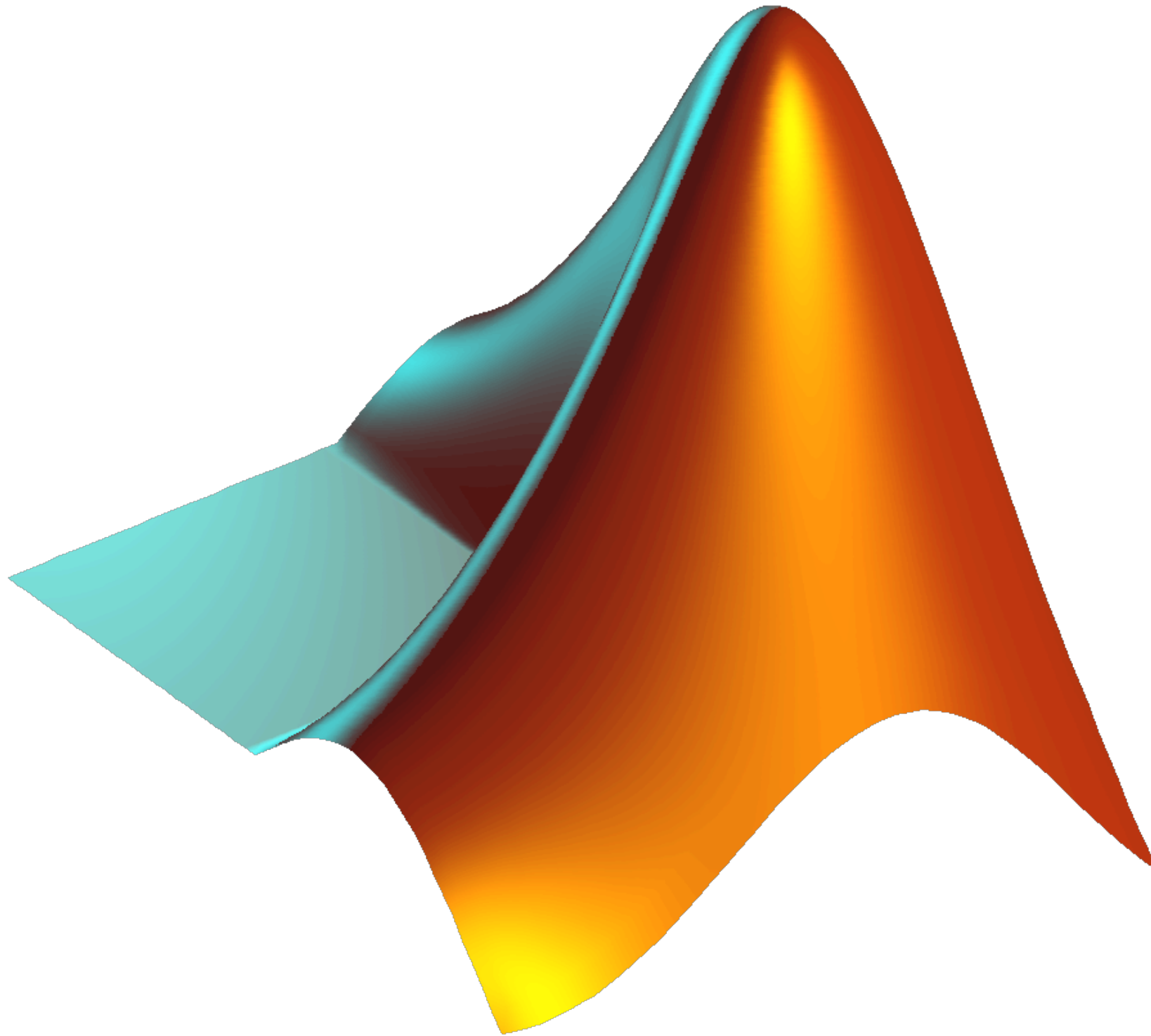Subplot

Bar Graph, Tick and Tick Labels, Text

Assignment 4 Overview

# Graphics Objects

All MATLAB graphics are represented by a **graphics objects**

Every object has a name, called a **handle.** You can put the handle into a variable and then use this to manipulate the object.

# Demo 1: Figure Handle and Its Properties

# Graphics Objects

All MATLAB graphics are represented by a **graphics objects**

Every object has a name, called a **handle.** You can put the handle into a variable and then use this to manipulate the object.

Handles appear in your workspace as just a double with some number; you need to remember that the number in this variable is special.

Check whether some number is a handle with `ishandle( h )`

Objects have **properties**. You can see them all with `get( handle )`

Each property has a corresponding **value**. You can query a property's value with `get( handle, 'PropertyName' )`

You can change a property with `set( handle, 'PropertyName', newValue )`

Most built-in functions that work on objects accept multiple **property-value pair** arguments `set( handle, 'Property1Name', value1, 'Property2Name', value2, ... )`

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Graphics Objects, Figures, Properties

**Axes, Line Series, Legend**

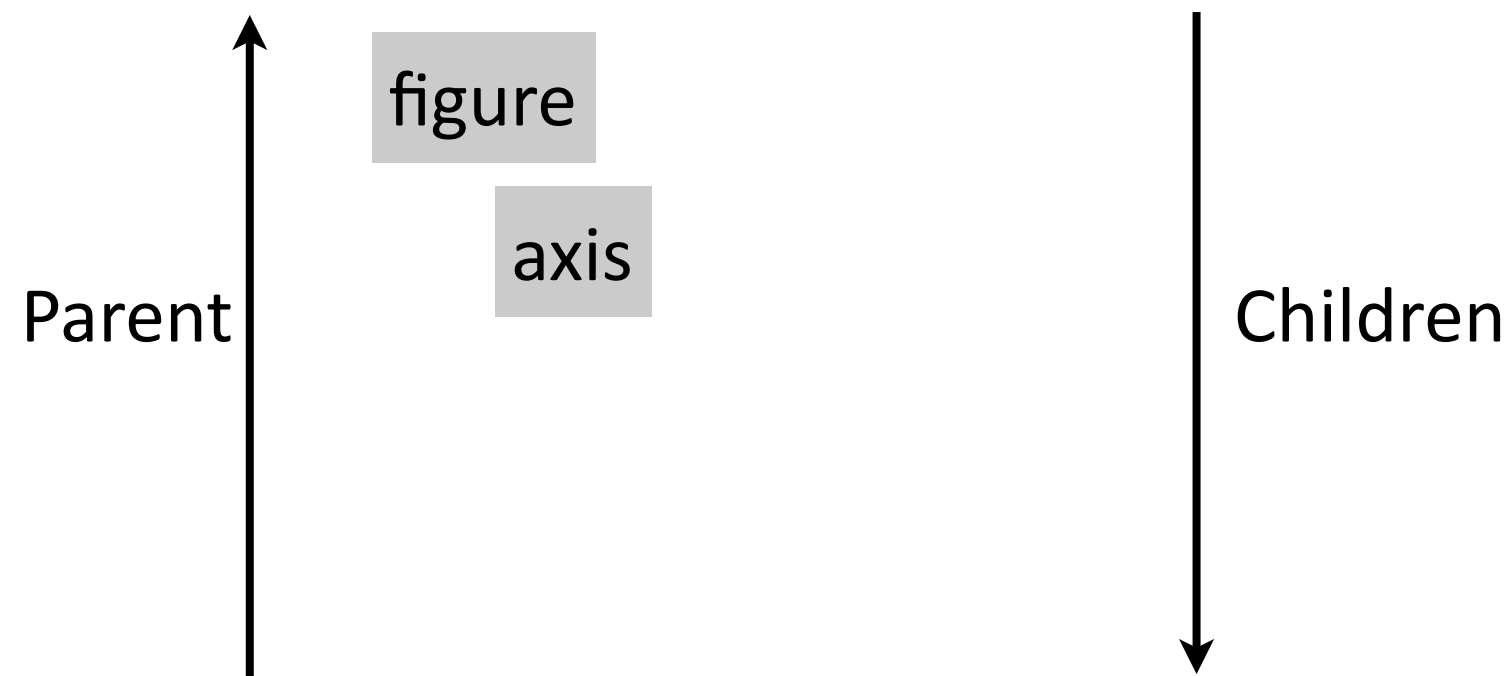Limits, Line, Patch

3D Plotting

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Bar Graph, Tick and Tick Labels, Text
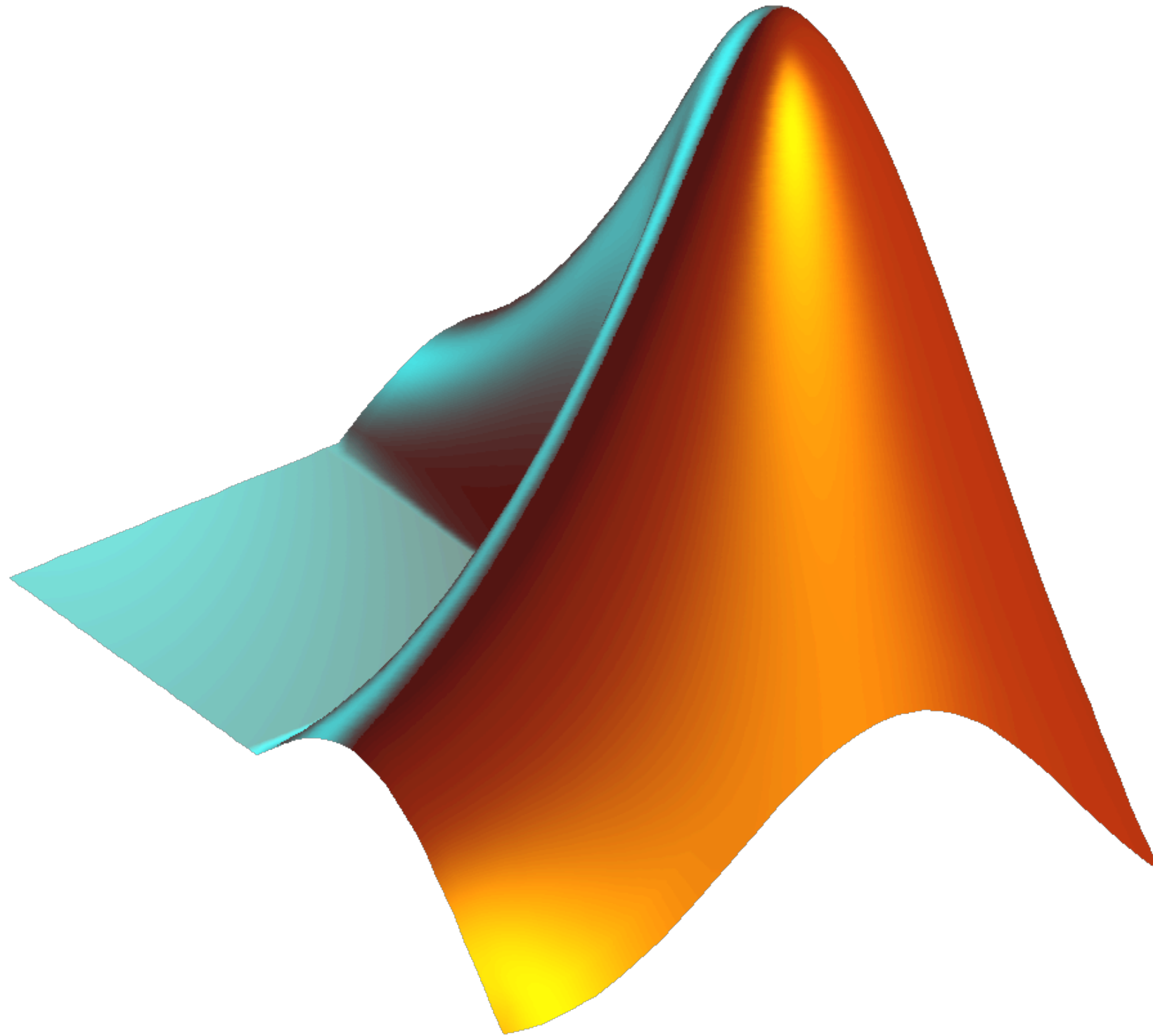
Assignment 4 Overview

# Axes

Objects can contain objects within them. These are called **children**

The most common child of a figure objects is an **axes object**

Parent

figure

axis

Children

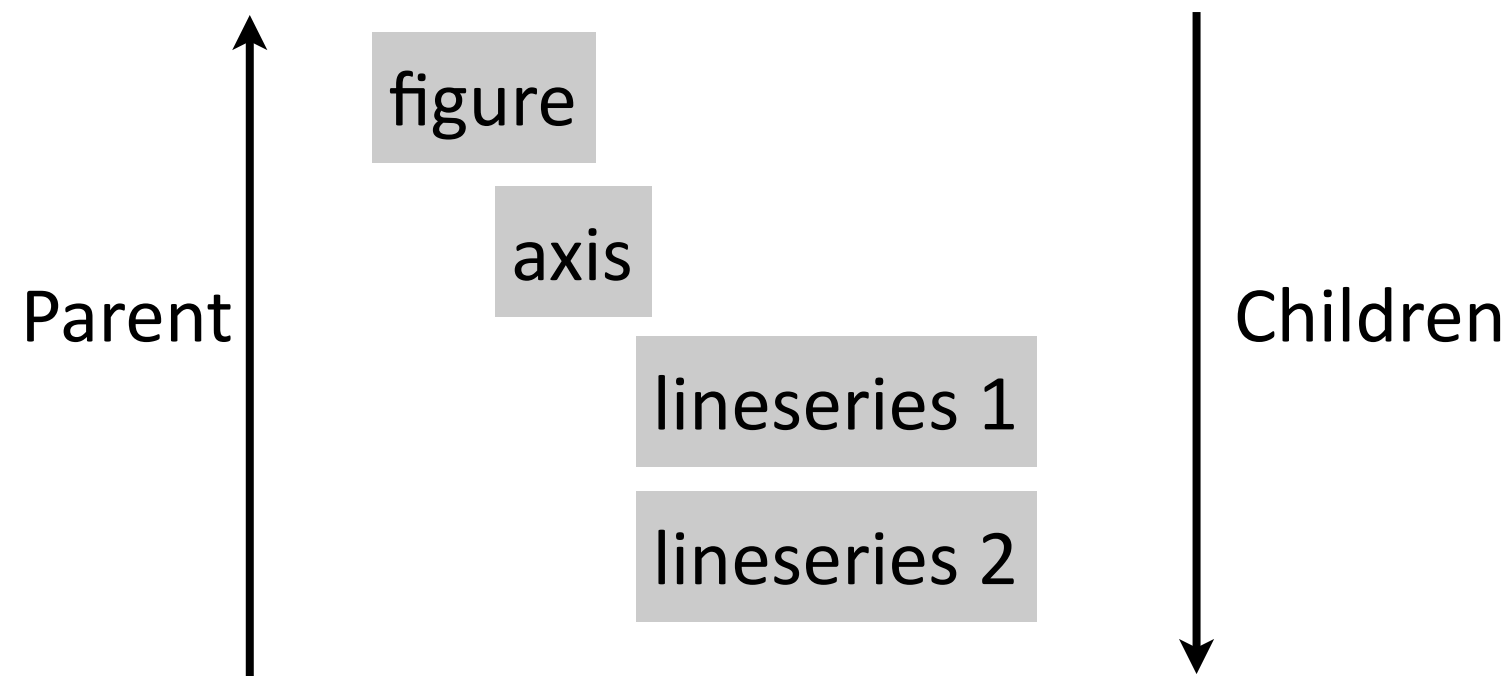# Demo 2: Axes, Lineseries, and Legend

# Axes

Objects can contain objects within them. These are called **children**

The most common child of a figure objects is an **axes object**

All plots, e.g. a lineseries created by plot( ), go inside of an axis, and are themselves graphics objects that are children of the axis

Parent

figure

axis

lineseries 1

lineseries 2

Children

Handles of children of an object are listed in its `'Children'` property

Handles of **parent** of an object is listed in its `'Parent'` property

# Plotting Functions Create Graphics Objects

`plot( )` creates a **lineseries** object which is a child of an axis. Its properties can be found in the "lineseries properties" help page

`'Color'`, `'LineWidth'`, `'LineStyle'` are a very useful properties of a lineseries object

Color can be specified either as a letter ('k' means black, 'r' means red) or as an **RGB vector**:
[**R**      **G**      **B**]   where each element is intensity ranging from 0 (none) to 1 (max)

Lineseries, along with every other graphics object, can be deleted with `delete( handle )`

You must do `hold on` before plotting multiple graphics objects in the same axis

Setting the `'DisplayName'` property of a graphics object prepares you to later create a **legend** with the command `legend_handle = legend(axis_handle, 'show')`

A useful property of a legend object is its `'Location'`. `'Best'` is a good initial **location**

# Lecture 04 Outline

Questions?

Graphics Objects, Figures, Properties
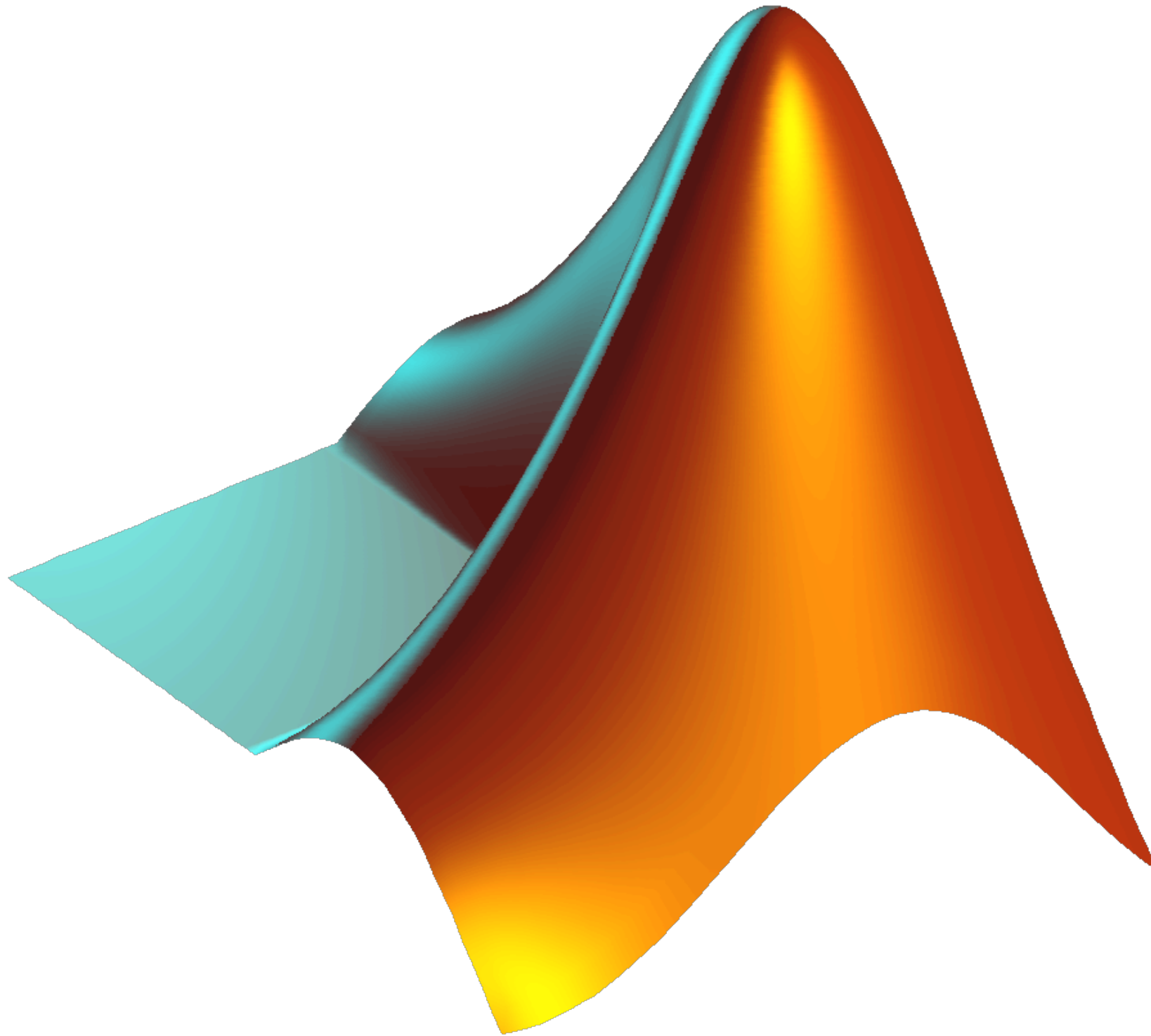
Axes, Line Series, Legend

**Limits, Line, Patch**

3D Plotting

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Assignment 4 Overview

# Demo 3: Limits, line( ), and patch( )

# Limits, Line, and Patch

The limits of an axis are queried and set through its ‘XLim’ and ‘YLim’ property

Axis direction can be reversed, e.g. set( axis_handle, ‘YDir’, ‘reverse’ )

Being able to draw a line is a very powerful tool. The syntax for a line from (x1,y1) to (x2,y2) is:
```
linehandle = line( [x1 x2], [y1 y2], ‘Property1’ , ‘Value1’ , ...
 ‘Property2’ , ‘Value2’ , ...)
```

You can draw polygons by creating a **patch** object:
```
patchHandle = patch( Xcoordinates, Ycoordinates, color, ‘Property1’ , ...
 ‘Value1’ , ...)
```

A useful property of a patch is its ‘FaceAlpha’ and ‘EdgeAlpha’ transparency.

Alpha can range from 0 (transparent) to 1 (opaque)

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Graphics Objects, Figures, Properties

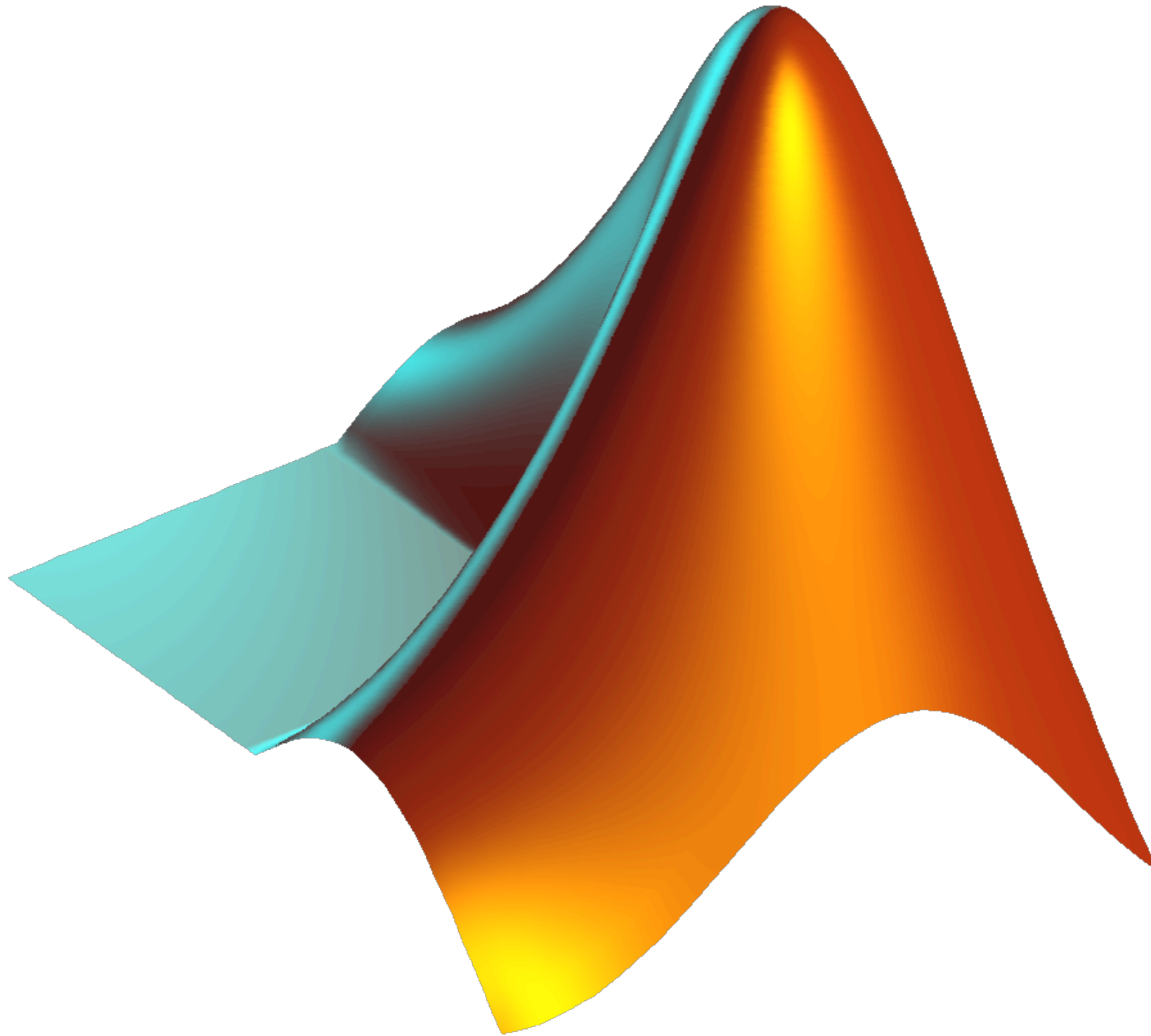Axes, Line Series, Legend

Limits, Line, Patch

**3D Plotting**

Subplot

Bar Graph, Tick and Tick Labels, Text

Assignment 4 Overview

# Demo 4: 3D Plotting

# 3D Plotting

You can make a 3d plot using the $\texttt{handle = plot3( X, Y, Z , ...)}$ command

There is also the analogous $\texttt{handle = scatter3(X, Y, Z, ... )}$ command with useful properties $\texttt{'MarkerFaceColor'}$ and $\texttt{'SizeData'}$

We see everything in a given axis through an imaginary **camera**. The 3d orientation of the camera is defined by the axis properties $\texttt{'CameraPosition'}$, $\texttt{'CameraTarget'}$, and $\texttt{'CameraUpVector'}$.

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Bar Graph, Tick and Tick Labels, Text
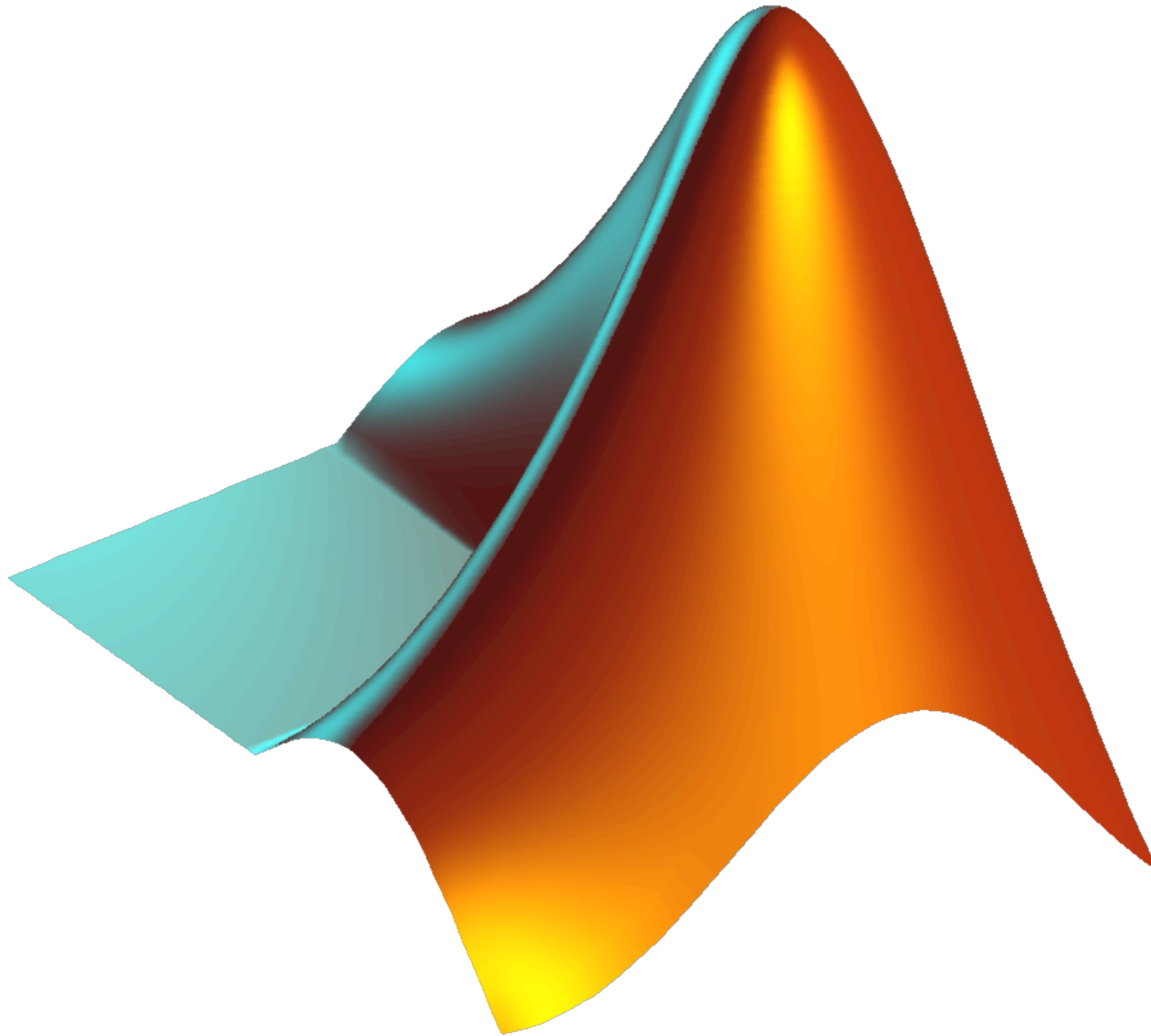
Assignment 4 Overview

# Subplot

When you want multiple axes in a figure, the easiest way to do this is by making each a **subplot**

Let's say we want a 3x2 grid of axes. Each axis can be created with
```
axis_handle = subplot( row, column, index )
```

|  | Column 1 | Column 2 |
|---|---|---|
| | figh | |
| Row 1 | topLefth = subplot(3, 2, 1) | topRighth = subplot(3, 2, 2) |
| Row 2 | midLefth = subplot(3, 2, 3) | midLefth = subplot(3, 2, 4) |
| Row 3 | botLefth = subplot(3, 2, 5) | botRighth = subplot(3, 2, 6) |

# Demo 5: Subplot

# Subplot

When you want multiple axes in a figure, the easiest way to do this is by making each a **subplot**:

Let's say we want a 3x2 grid of axes. Each axis can be created with
```
axis_handle = subplot( column, row, index )
```

Column 1                              Column 2

figh

Row 1    `topLefth = subplot(3,2,1)`        `topRighth = subplot(3,2,2)`

Row 2    `midLefth = subplot(3,2,3)`        `midLefth = subplot(3,2,4)`

Row 3    `botLefth = subplot(3,2,5)`        `botRighth = subplot(3,2,6)`

If a subplot already exists, calling `axh = subplot(cols, rows, idx)` gets you the axis handle of that subplot; it does not replace it

Axes can be linked using `linkaxes( [axis1_handle, axis2_handle, ...], 'xy' )` with the last parameter also able to take value 'x', 'y', and 'off' (to break the link)

# Lecture 04 Outline

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Graphics Objects, Figures, Properties
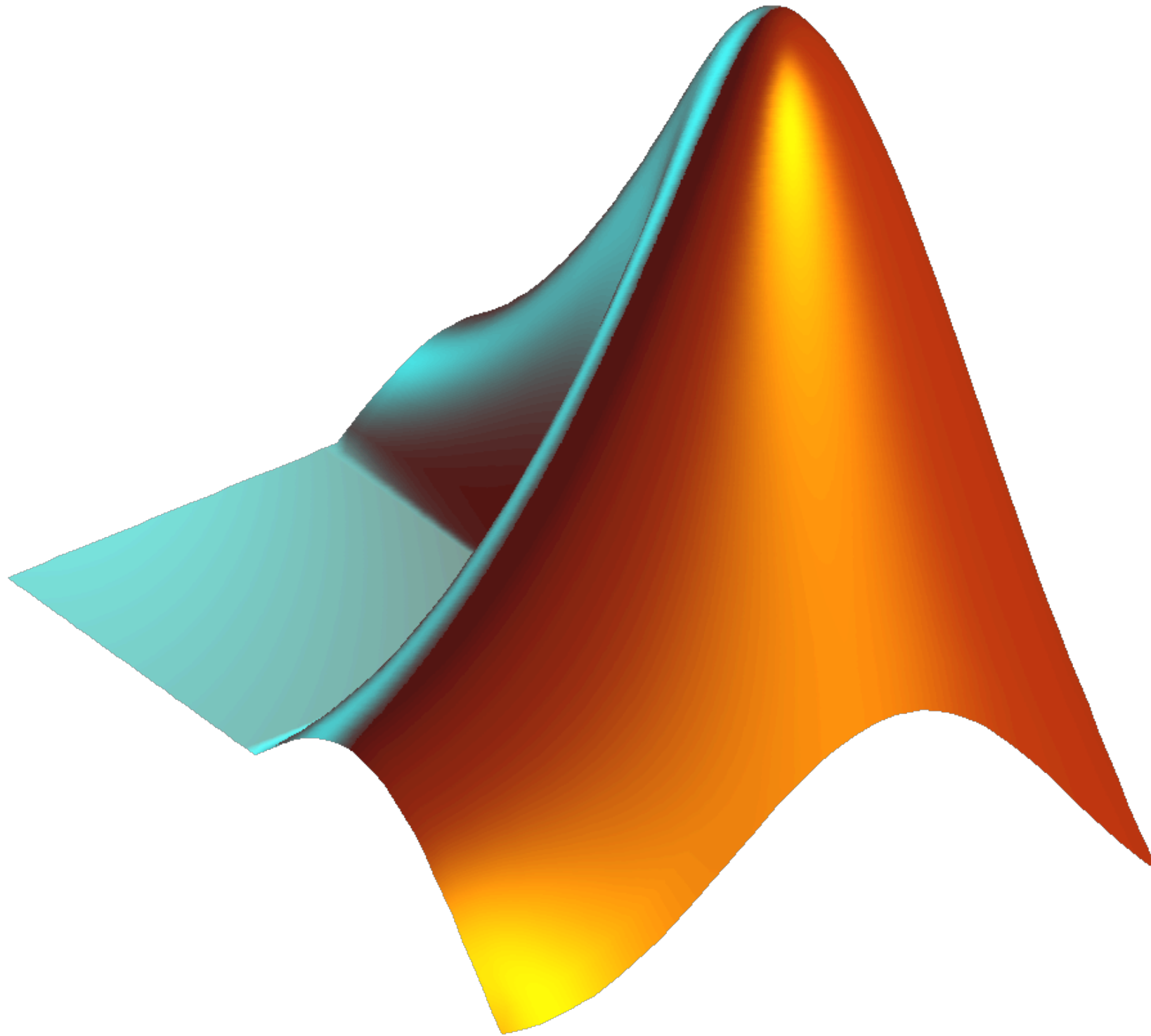
Axes, Line Series, Legend

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**Bar Graph, Tick and Tick Labels, Text**

Assignment 4 Overview

# Demo 6: Bar Graph, Tick Labels, and Text

# Bar Graph, Tick Labels, and Text

`bar( )` has a number of different modes, which you can read about in its help page.

If input is a matrix, by default it will treat it as Groups x Members and make a grouped bar plot

The location of tick marks on an axis are defined in the axis' `'XTick'` and `'YTick'` properties

The stings corresponding to these ticks can be set via the `'XTickLabel'` and `'YTickLabel'` properties; use a cell array of strings with same number of elements as the number of ticks

**text objects** can be created with the syntax
`text_handle = text( x, y, string, 'Property1', 'Value1', ... )`

The x and y coordinate of a text object is in the same coordinate system as the axis

All text objects (which actually include titles and labels) have **text properties.** Useful ones include: `'FontSize'`, `'FontWeight'`, `'Color'`, `'HorizontalAlignment'`, `'VerticalAlignment'`

# Lecture 04 Outline

Questions?

Graphics Objects, Figures, Properties

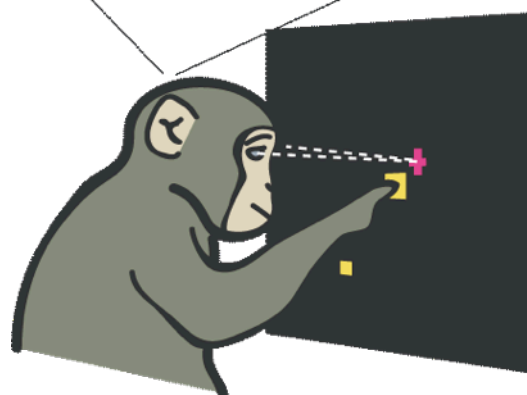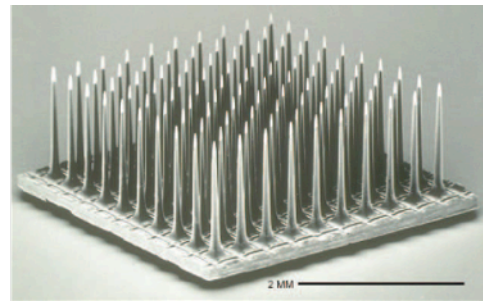Axes, Line Series, Legend

Limits, Line, Patch

3D Plotting

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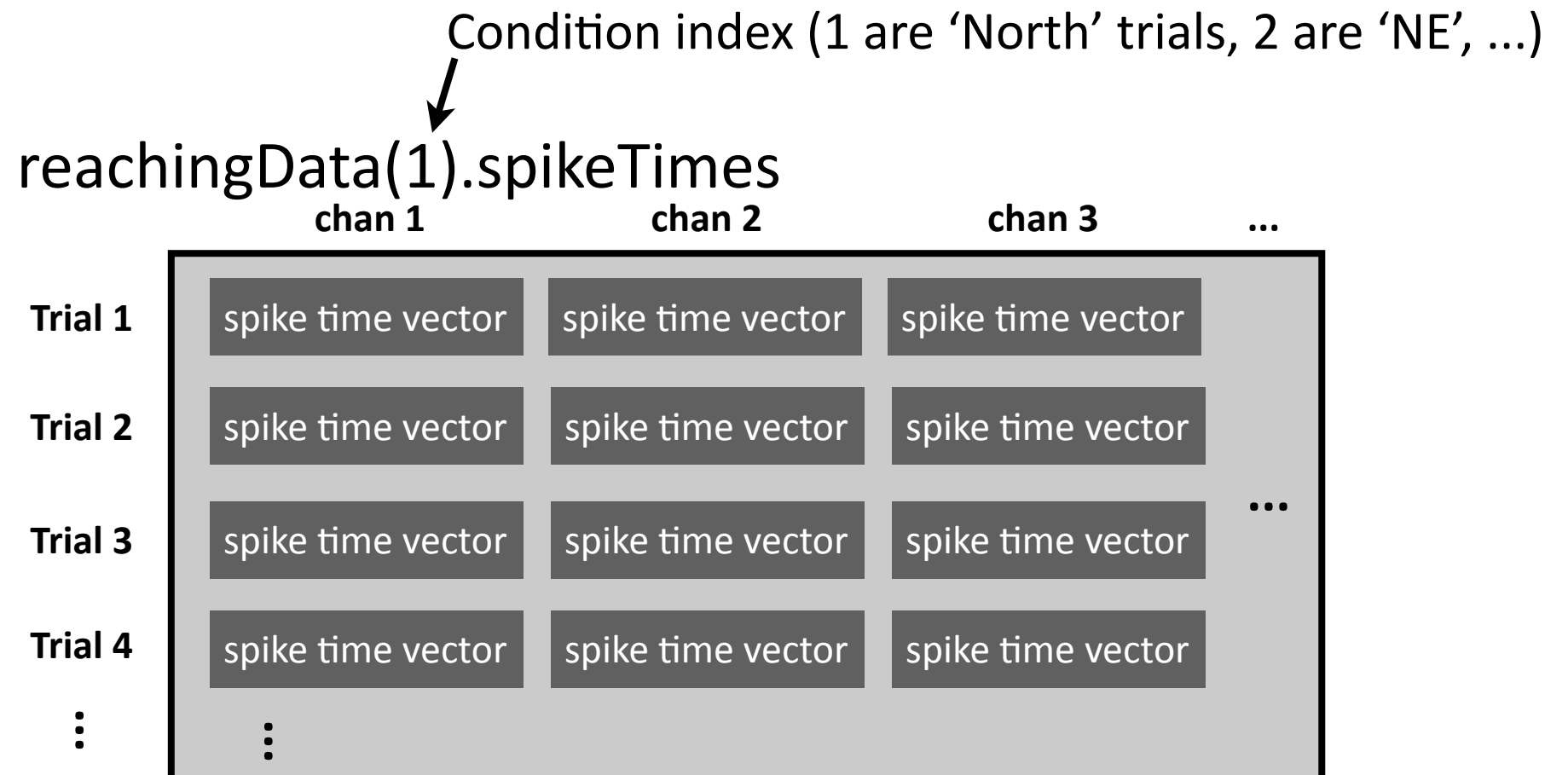
Bar Graph, Tick and Tick Labels, Text

**Assignment 4 Overview**

# Assignment Four: Reach Task Rasters and PSTHs

Dataset consists spike times recorded from an multielectrode array in primary motor cortex of a non-human primate

Condition index (1 are 'North' trials, 2 are 'NE', ...)

reachingData(1).spikeTimes



|  | chan 1 | chan 2 | chan 3 | ... |
|---|---|---|---|---|
| Trial 1 | spike time vector | spike time vector | spike time vector | |
| Trial 2 | spike time vector | spike time vector | spike time vector | |
| Trial 3 | spike time vector | spike time vector | spike time vector | ... |
| Trial 4 | spike time vector | spike time vector | spike time vector | |

**Task cartoon**[1]

For each trial, the animal is making a quick reach from a central hold location towards one of eight radially located targets

You are provided twelve trials for each of 8 directions, with a vector of spike times recorded on each of 96 electrodes

[1]Afshar et al, 2011, *Submitted*

Write a function which, given the data filename and a specific electrode number, makes a subplot for each reach direction condition
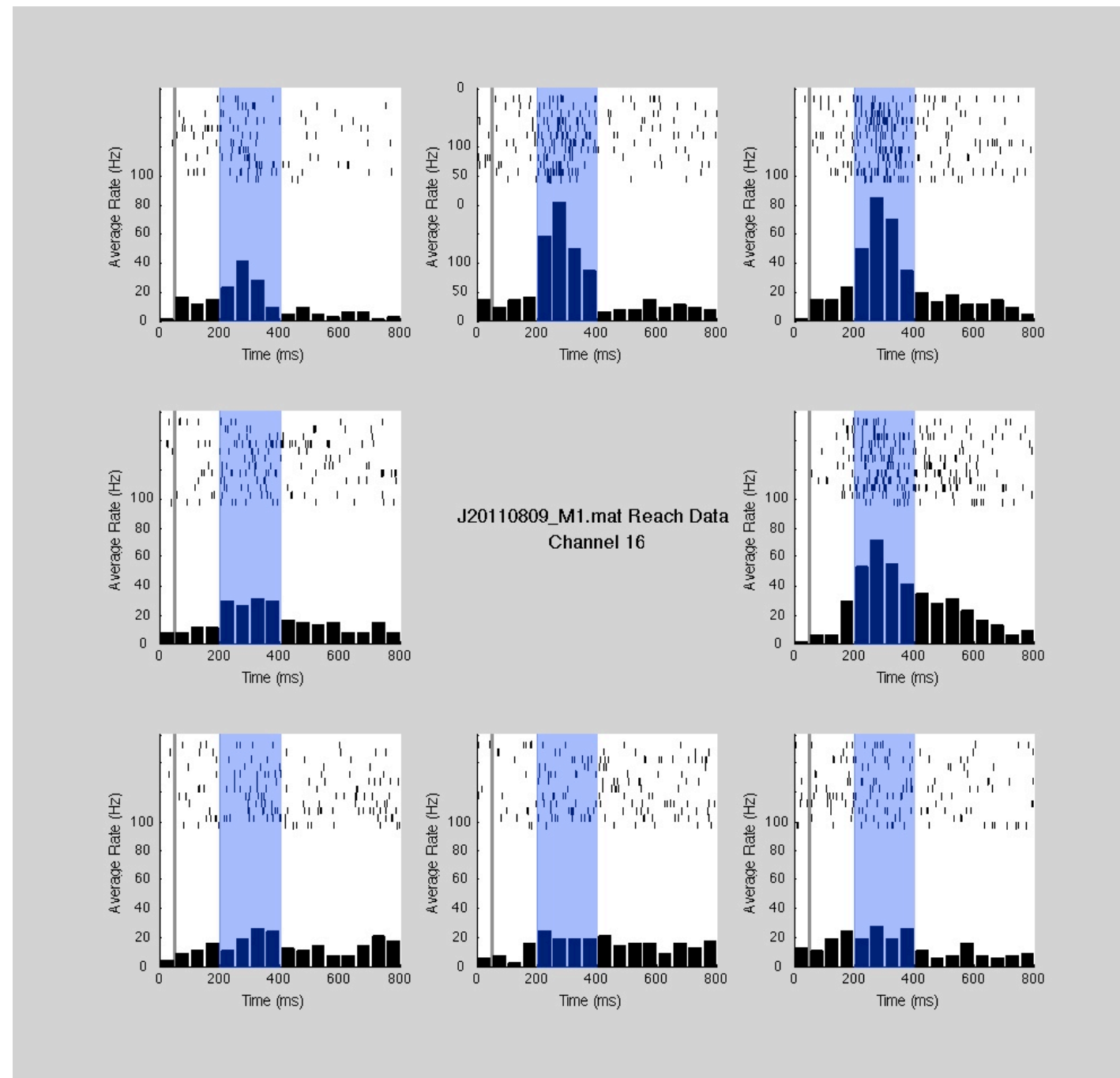


**Figure generated for chan 16**

Each subplot shows all of the data from this channel in the form of **spike rasters** *for each trial*

It also shows the average firing rate *averaged across trials* during a given time bin in a **peristimulus time histogram (PSTH)**

Finally, you will add a **line** marking the target onset, a semi-transparent **patch** showing the epoch of interest, and descriptive **text**

# Lecture 04 Review

## Key Concepts

**Graphics objects** are controlled via their **handle**, which can be stored in a variable

**Properties** of objects can be get and set through **property-value pair** syntax

Objects can have **children** and **parents**

**Position** property of a child (e.g. axes) is relative to the parent (e.g. figure)

**Color** is specified as a [R G B] vector

All axes are actually 3d; you can control the **camera properties** of the axis to see this

**subplot** creates a new axis in a specific tile of a grid.

Alternatively, manually create multiple axes in a figure and specify their positions

Conceptually related axes can be linked using **linkaxes**; changing one axis affects the rest

Axes have markings called **ticks**; these are labelled with **tickLabels**

**bar graph** objects have many grouping modes (vertical, horizontal, stacking, group)

**text objects** can be put anywhere in an axis and modified through their **text properties**.

Labels, titles, text, and others are all actually text objects with these same text properties

## Functions

```
figure
close
axis
get
set
ishandle
gca (get current axis)
gcf (get current figure)
line
patch
delete
legend
plot3
marker3
subplot
linkaxes
bar
text
```