Problem Set 03 · Plotting

Instructions

1. Read each problem carefully before starting your work. You are responsible for following all instructions within each problem. Remember that all code submissions must follow the course programming standards.
2. Below are the expected deliverables for each problem.
   - Name your files to match the format in the table below.
   - Publish your code for each problem. See PS02 for more information.
   - Do not forget to include any data files loaded into your code.

Item	Type	Deliverable to include in Submission
Problem 1: Matrix Manipulation	Paired	☐ PS03_matrix_magic_*login1*_*login2*.m ☐ PS03_matrix_magic_*login1*_*login2*_report.pdf
Problem 2: Headphone Volume	Individual	☐ PS03_volume_*yourlogin*.m ☐ PS03_volume_*yourlogin*_report.pdf ☐ Data file loaded into your m-file
Problem 3: Volcano Mapping	Individual	☐ PS03_volcano_maps_*yourlogin*.m ☐ PS03_volcano_maps_*yourlogin*_report.pdf ☐ Data file loaded into your m-file

3. Save all files to your Purdue career account in a folder specific to PS03.
4. When you are ready to submit your assignment,
   - Compress all the deliverables into one zip file and name it **PS03_yourlogin.zip**. Be sure that you
     - *i.* Only compress files using **.zip** format. No other compression format will be accepted.
     - *ii.* Only include deliverables. Do **not** include the problem document, blank templates, etc.
   - Submit the zip file to the Blackboard drop box for PS03 before the due date.
5. After grades are released for this assignment, access your feedback via the assignment rubric in the My Grades section of Blackboard.

Plotting Tips

Creating Plots of Data

- When analyzing bivariate (two variables) data, you must determine which is the independent variable and which is the dependent variable.
- A common way to phrase a request for a plot is to say, “Plot variable 1 versus variable 2.” Variable 1 refers to the y-axis variable; variable 2 refers to the x-axis variable.
- When plotting data, use data markers for each data point and do not connect the points with a line. A line implies a known or modelled relationship between the independent and dependent variable.

Creating Plots of Models

- When plotting models, use lines with no data markers. The points used to generate the plot are selected for convenience and do not refer to actual data.
- You can present a model with its raw data on the same plot. The model is a line with no data markers. The raw data are data markers and no connecting line.

Testing and Debugging Plot Code

- **Always close all figure windows before re-running your code.** Otherwise, your code will add or remove things from the existing plot displays. This can appear randomly in ways that may or may not reflect the presence of any coding problems.

Problem 1: Matrix Manipulation

Paired

Learning Objectives

Your work on this problem may be assessed using any of the following learning objectives:

- Assign and manage variables
- Manipulate arrays (vectors or matrices)
- Create and execute a script
- Manage text output

Problem Background

This problem will introduce you to Paired Programming and will review Matrix Manipulation concepts. Be sure to follow the Paired Programming guidelines presented in class.

Problem Steps

1. Download the script **PS03_matrix_magic_template.m** file.
2. Open template and complete the header information.
    a. Add the problem set number, your name, and your section-team number.
    b. Declare your partner in the paired programming area.
    c. List any additional contributors who work with you and your paired partner.
3. Save your script with the name format required by the deliverables list.
4. Use MATLAB to learn what these built-in functions do: `zeros` and `sum`.
5. In the `INITIALIZATION` section of your script file, create matrices A and `vals`, using the steps described below.
    a. Use the function `zeros` to create a 4x4 matrix named A.

```
A =

     0     0     0     0
     0     0     0     0
     0     0     0     0
     0     0     0     0
```

    b. Use MATLAB matrix creation commands to create a matrix, `vals`, that matches the matrix below. **Note:** The numbers are not sequential.

```
vals =

     1     3     2     4
     5     6     7     8
     9    10    11    12
    13    15    14    16
```

6. In the `COPY & CONCATENATE` section of your script file, perform the following:

   Note: Do not hardcode assignments unless told to do so.

   a. Copy the center 2x2 matrix of `vals` and assign it to `M`.

   b. Copy from `vals` a 2-element row vector `[3 2]` and assign it to `C`.

   c. Copy from `vals` a 2-element row vector `[15 14]` and assign it to `D`

   d. Create 1x4 row vector E that concatenates D between the first and fourth elements in the first row of `vals` to create the vector `[1 15 14 4]`, and uses square brackets to complete the concatenation in one line of code.

   e. Create 1x4 row vector F that concatenates C between the first and fourth elements in the fourth row of `vals` to create the vector `[13 3 2 16]`, and uses square brackets to complete the concatenation in one line of code.

   Hint: See PS01, Problem 5 "Useful MATLAB Commands" in the green box for help with array indexing.

7. In the `REPLACE MATRIX ELEMENTS` section of your script file, perform the following:

   a. Use only `M`, E, and F to replace the first row of A, the fourth row of A, and the center 2x2 matrix of A. Matrix A should look like the matrix below once these replacements are complete.

```
A =

     1    15    14     4
     0     6     7     0
     0    10    11     0
    13     3     2    16
```

   b. Complete the following replacements **without hardcoding values**:

      - Replace the 0 directly below the 1 in matrix A with the 12 from matrix `vals`.
      - Replace the 0 directly above the 13 in matrix A with the 8 from matrix `vals`.
      - Replace the 0 directly below the 4 in matrix A with the 9 from matrix `vals`.
      - Replace the 0 directly above the 16 in matrix A with the 5 from matrix `vals`.

8. In the `FINAL MATRIX` section of your script file, perform the following:

   a. Create a vector X that contains the sums of the columns of A.

   b. Concatenate vector X to the bottom of matrix A to create a new matrix, G. Concatenation requires the use of square brackets.

   c. Create a vector Y that contains the sums of the rows of G.

   d. Concatenate vector Y to the right of matrix G to create a new matrix, H. Concatenation requires the use of square brackets.

   e. Replace the lower right corner value of H with the sum of the first four values on the diagonal from the upper left corner and moving toward the lower right corner.

9. In the `FORMATTED TEXT DISPLAY` section of your script file, use three **`fprintf`** statements to display your results as shown:

Note: Do not hardcode the numerical values within your `fprintf` statements; use array indexing of H to identify the appropriate values of H to display.

```
After doing step 8.e, the value in the center of H is ___.

After doing step 8.e, the value in the upper left of H is ___,
and the value in the upper right of H is ___.

After doing step 8.e, the value in the lower left of H is ___,
and the value in lower right of H is ___.
```

10. Publish your script as **PS03_matrix_magic_*yourlogin1*_*yourlogin2*_report.pdf**.

Problem 2: Headphone Volume

Individual

Learning Objectives

Your work on this problem may be assessed using any of the following learning objectives:

- Create and execute a script
- Assign and manage variables
- Manipulate arrays (vectors or matrices)
- Manage text output
- Import numeric data stored in .csv and .txt files
- Create an x-y plot from a single data set
- Create multiple plots in separate figure windows
- Create an x-y plot with multiple data sets in a single figure window
- Format plots for technical presentation
- Interpret the shape of x-y plots

Problem Setup

Designing control systems for electronic devices requires an engineer to understand the relationships between power and device output, such as heat, light, or sound. You work for audio company that is designing two new headphone prototypes that need volume control systems. The company has collected experimental data in their testing lab for the two prototype designs (Design OEP4 and Design IEP3). The company sent you their data and their model for the power-volume relationship for the two designs.

The data is in a file named **Data_volume_power.csv**. The model equations are as follows:

OEP4: $v_{OEP4} = 67.1 \ \log_{10} P - 1.3$

IEP3: $v_{IEP3} = 77.7 \ \log_{10} P - 7.3$

Where v is the headphone's volume in decibels (dB) and P is the power necessary to produce the sound, in milliwatts (mW).

Use the data and the model equations to complete the steps below.

Problem Steps

1. Open the script **PS03_volume_template.m** file. Complete the header information. Save your script with the name format required by the deliverables list.
2. Open **Data_volume_power.csv** and review the information it contains.
3. In the `INITIALIZATION` section of the script, import the data into the script using the appropriate MATLAB built-in function for the provided data file format. Copy each data column into a separate variable.
4. In the `CALCULATIONS` section of the script, write the code to calculate the models' predicted volumes for OEP4 and IEP3.

5. In the `FORMATTED FIGURE` section of the script, write the code to
   a. Create a one figure that contains a single plot of the original data for both headphone designs.
   b. Overlay the model predictions for each headphone design.
   c. Format the plot with a descriptive title, useful axes labels with units, and gridlines. Each set of data points must have a different marker style and color. Each model line must be a different style but match the color of its corresponding data markers. Add a legend that has appropriate labels and control the location of the legend to ensure it does not cover plotted information.
6. In the `ANALYSIS` section of the script, answer the following questions. Justify your answer using the plots.
   Q1. Which model best fits its data?
   Q2. Headphone sensitivity is a measure of how the volume level changes as the power level changes. The headphone with the largest volume gain for the same power gain is the most sensitive. Using the model plots, which headphone design do you believe is more sensitive?
   Q3. Battery life is a function of power output over time. Which headphone design do you predict will have the best battery life if a listener consistently uses the headphones to produce a volume of 60 dB? At 30 dB?
7. Publish your script as a PDF and name it as required in the Deliverables List.

Problem 3: Volcano Mapping

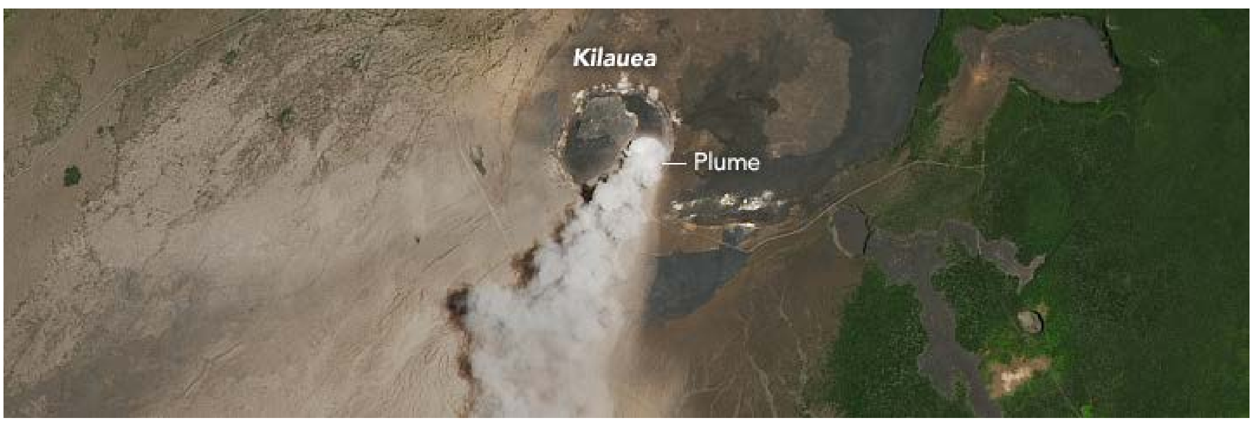
Individual

Learning Objectives

Your work on this problem may be assessed using any of the following learning objectives:

- Create and execute a script
- Assign and manage variables
- Manipulate arrays (vectors or matrices)
- Manage text output
- Import numeric data stored in .csv and .txt files
- Create an x-y plot from a single data set
- Create multiple plots in separate figure windows
- Create multiple plots in a single figure window
- Create an x-y plot with multiple data sets in a single figure window
- Format plots for technical presentation
- Interpret the shape of x-y plots
- Perform and evaluate relational and logical operations

Problem Setup



Re-read Problem Set 02, Problem 1 (Volcano Remote Sensing). You will continue your work identifying volcanos in old remote-sensing data. You have the same volcano list file and imaging limitations as in Problem Set 02.

Table 1. Imaging data limitations, listed by instrument that collected the data.

Instrument	Limitations
ACP-1	Images limited to latitudes within -39.5 to 39.5 decimal degrees, inclusive
VII	Images show elevations higher than 2500 m at latitudes less than or equal to 0 decimal degrees
MASC	Some images lost due to equipment malfunction. Recovered images in the following longitude ranges: • 100 to 145 decimal degrees, inclusive of 100 but not 145 • -140 to -120 decimal degrees, inclusive of -120 but not -140
PoLAR Viewer	Images limited to latitudes 50 decimal degrees or higher.

You need to plot the volcano locations using MATLAB. The plots should mimic a world map, so pay attention to the x and y axes. Your script will display plots to help you and the scientists visualize

- the locations of all the volcanoes in the data file,
- the locations of volcanoes visible to each instrument,
- the locations of all volcanoes visible to any instrument along with the locations of volcanoes not visible to an instrument

Be sure to format all your plots for technical presentation.

Problem Steps

1. Open the script **PS03_volcano_maps_template.m** file. Complete the header information. Save your script with the name format required by the deliverables list.
2. Import the volcano data into the script using the appropriate MATLAB built-in function for the provided data file format. Copy each data column into a separate variable.
3. Use relational and logical operators to create vectors of latitude and longitude values for all volcanoes that are
    a. visible in the ACP-1 images,
    b. visible in the VII images,
    c. visible in the MASC images,
    d. visible in the PoLAR Viewer images,
    e. visible in any instrument images, and
    f. not visible in any instrument images.
4. Create one figure that contains a single plot that displays the locations of all volcanoes in the data file.
    a. Format the plot for technical presentation.
5. Create a second figure that contains a 2x2 arrangement of subplots as follows:

Subplot A	Subplot C
Subplot B	Subplot D

    a. Subplot A must show the volcano locations visible to ACP-1 (which were identified in Step 3.a).
    b. Subplot B must show the volcano locations visible to VII (identified in Step 3.b).
    c. Subplot C must show the volcano locations visible to MASC (identified in Step 3.c).
    d. Subplot D must show the volcano locations visible to PoLAR Viewer (identified in Step 3.d).
    e. Format each subplot with a concise title, concise axes labels with units, and gridlines. Use unique data markers in each plot. Make sure that the axes on the subplots allows for comparisons.
6. Create a third figure that displays the volcano locations that are visible to any instrument (identified in Step 3.e) on the same plot as the volcano locations that are outside the instruments' ranges (identified in Step 3.f). Format for technical presentation. Control the location of the legend to ensure it does not cover the plotted data.

7. In the `ANALYSIS` section, answer the following question. Justify your answer using the plots.
    a. Indicate whether the four instruments might be sufficient for obtaining imaging of the volcanoes in the data file.

8. **Optional.** You will need to use Software Remote, an ITaP/ECN computer, or have the Mapping Toolbox installed on your version of MATLAB to complete this task.

    You would prefer to see the volcano locations displayed on a map. Test your plotting skills by combining these two MATLAB lines of code, in order,

```
landareas = shaperead('landareas.shp');
mapshow(landareas);
```

    with other MATLAB plotting commands to create a fourth figure that displays the locations from Step 6 on top of the world map.

9. Publish your script as a PDF and name it as required in the Deliverables List.

Reference: http://volcano.oregonstate.edu/volcano_table

Image: https://earthobservatory.nasa.gov/IOTD/view.php?id=92156