

CS1371: Assignment 6 - Version 1

You will need to know linear algebra operations and nested iteration to complete this assignment. Woody Allen tells us, “Life is divided into the horrible and the miserable.” The estimated time to completion for this assignment is five hours. Budget your time accordingly.

Corrections and revisions to this assignment should be sent to Titus Barik (barik@cc.gatech.edu). For general assistance, contact the Teaching Assistant for your section.

1 Warmup

1.1 System of Equations

Write a script, `sys.m`, which solves the following system of equations:

$$6x_1 + 3x_2 + 1x_3 + 2x_4 + 4x_5 = 70 \quad (1)$$

$$1x_1 + 9x_2 + 1x_3 + 2x_4 + 1x_5 = 56 \quad (2)$$

$$1x_1 + 1x_2 + 1x_3 + 6x_5 = 63 \quad (3)$$

$$1x_2 + 2x_3 + 3x_4 + 5x_5 = 69 \quad (4)$$

$$4x_1 + 3x_2 = 13 \quad (5)$$

1.2 Singularity

Given a square 2×2 matrix, determine the number of singular matrices containing only combinations of the values 1 and 0. A singular matrix is a square matrix that does not have an inverse. Compute this result using a MATLAB script and name your script `sing.m`.

2 Exercises

2.1 Multivariable Functions

Write a script, `multigraph.m`, which, when run, will simultaneously display three windows with graphs representing the following equations from the

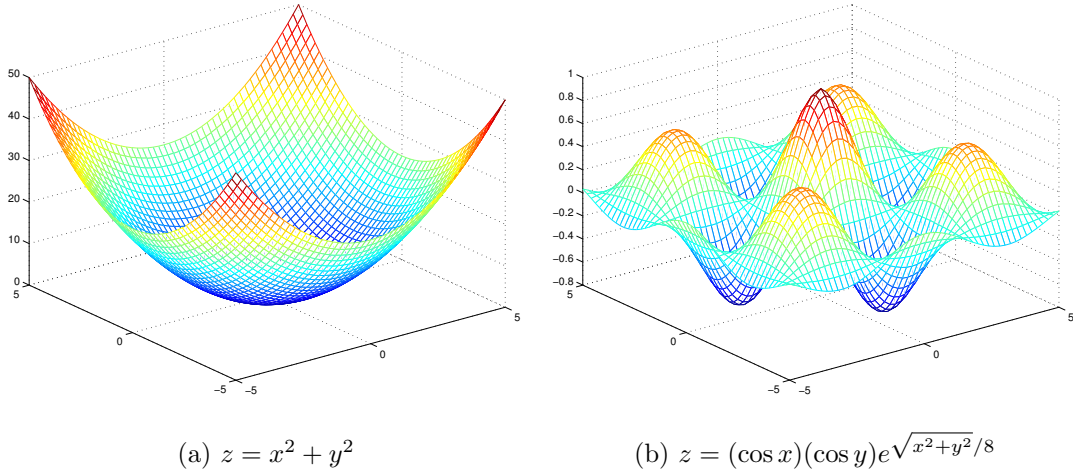


Figure 1: Example of mesh output.

range `[-5:0.2:5]` to `[-5:0.2:5]`:

$$z = x^2 + y^2 \tag{6}$$

$$z = (\cos x)(\cos y)e^{\sqrt{x^2+y^2}/8} \tag{7}$$

$$z = \frac{xy(x^2 - y^2)}{x^2 + y^2} \tag{8}$$

You will need the functions `mesh`, `meshgrid`, and `figure`. Examples of mesh graphs are shown in Figure 1.

2.2 Gravity

Consider the following $m \times n$ matrix, A , consisting of the values $V = \{0, 1, -1\}$, where 0 represents an open space, 1 represents a vertically falling object, and -1 represents a fixed block.

$$A = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 \\ 0 & -1 & 0 & 1 & 1 \\ 1 & 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 \end{bmatrix} \tag{9}$$

After time t , the array will settle to its final state, A_f :

$$A_f = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \end{bmatrix} \quad (10)$$

For example, the 1 at $A(2,5)$ moves to $A(4,5)$ as its final position; it cannot move any lower vertically. Similarly, the 1 at $A(1,3)$ halts at $A(2,3)$; the fixed -1 block prevents it from moving any lower vertically. Write a function $\mathbf{f} = \mathbf{gravity}(g)$ which returns the final state of the two dimensional array g using the gravity algorithm.

2.3 Cellular Automata

The Game of Life¹ was invented by the mathematician John Conway in 1970. It is an implementation of a cellular automata on a two dimensional array, where each cell is either occupied or not occupied by an organism, which we represent as a 1 or 0, respectively. For each cell, we count the number of live organism neighbors and apply a set of simple rules²:

death If an occupied cell has 0, 1, 4, 5, 6, 7, or 8 occupied neighbors, the organism dies (0, 1: of loneliness; 4 through 8: of overcrowding).

survival If an occupied cell has two or three neighbors, the organism survives to the next generation.

birth If an unoccupied cell has three occupied neighbors, it becomes occupied.

A turn of the game is then completed. **Note:** The number of live neighbors is always based on the cells before the rule was applied. That is, find all of the cells that change before changing any of them.

Write the function $\mathbf{y} = \mathbf{life}(x, n)$, where x is the starting state of the game, n is the number of turns, and y is the result.

¹*Scientific American* 223 (October 1970): 120-123

²<http://www.tech.org/~stuart/life/rules.html>

2.4 MATLAB Extras

Re-implement the MATLAB function `reshape(x, m, n)`, as specified in `help reshape`. That is, return the $m \times n$ matrix whose elements are taken column-wise from x . You may assume that the input is valid. Call your function `myreshape(x, m, n)`.

3 Turn In

You will need to turn in the following files: `sys.m`, `sing.m`, `multigraph.m`, `gravity.m`, `life.m`, `myreshape.m`. Be sure to include test scripts that test the functionality of the above problems. Finally, properly document all functions. For this assignment, functions with syntax errors will receive no credit.