Assignmnet 2 Part 1 a) - Andrew Paul 100996250

The first section of this assignment invlolved solving a simple case of the Laplace equation where one end of a 2D grid is fixed at a voltage V0 on the x-axis and is set to zero at the other end with a uniform charge distribution.

The finite difference method was used to solve for the given case using the matrix solution technique of $GV = F$, where V is the voltage solutions over the grid, G is the matrix which defines how each discrete votlage point is related to the neighbouring voltage values, and F is the matrix which sets the boundary conditions. A simplified version of Lapalce's equation is used in order to sovle for the voltages, discrete approximations are used in order to calculate finite values.

$$\frac{V_{x-1,y} - 2V_{x,y} + V_{x+1,y}}{(\Delta x)^2} + \frac{V_{x,y-1} - 2V_{x,y} + V_{x,y+1}}{(\Delta y)^2} = 0$$

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clear

% Set the length and width of the grid and the voltage V0
L = 3;
W = 2;
V0 = 1;

% Spacing and number of points of grid

dx = 0.1;
dy = 0.1;
nx = L/dx;
ny = W/dy;

% Parameters of Laplace equation

p1 = 1/(dx^2);
p2 = 1/(dy^2);
p3 = -2*(1/dx^2 + 1/dy^2);

% Generate "G" Matrix

G = zeros(nx*ny,nx*ny);

for i = 2:nx-1
    for j = 2:ny-1
        % set indicies for all neighbouring points
        n = i + (j-1)*nx;
        nym = i + (j-2)*nx;
        nyp = i + j*nx;
        nxm = (i-1) + (j-1)*nx;
        nxp = (i+1) + (j-1)*nx;

        % Define values of G matrix
        G(n,n) = p3;
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        G(n,nxm) = p1;
        G(n,nxp) = p1;
        G(n,nym) = p2;
        G(n,nyp) = p2;
    end
end

% Generate "F" Matrix

F = zeros(nx*ny,1);

% set boundary conditions

for j = 1:ny
    n = 1 + (j-1)*nx;
    G(n,n) = 1;

    F(n) = V0;

    n1 = nx + (j-1)*nx;
    G(n1,n1) = 1;
end

for i = 2:(nx-1)
    n = i;
    G(n,n) = 1;
    n1 = i + nx;
    G(n,n1) = -1;

    n = i + (ny-1)*nx;
    n1 = i + (ny-2)*nx;
    G(n,n) = 1;
    G(n,n1) = -1;
end

% Finding solution and reshaping the transpose

A = G\F;
solution = reshape(A,[],ny)';

xrange = linspace(0,L,nx);
yrange = linspace(0,W,ny);

figure(1)
surf(xrange,yrange,solution)
xlabel('x')
ylabel('y')
zlabel('Voltage')
title('Simple Finite Differences Solution')
view(0,90)
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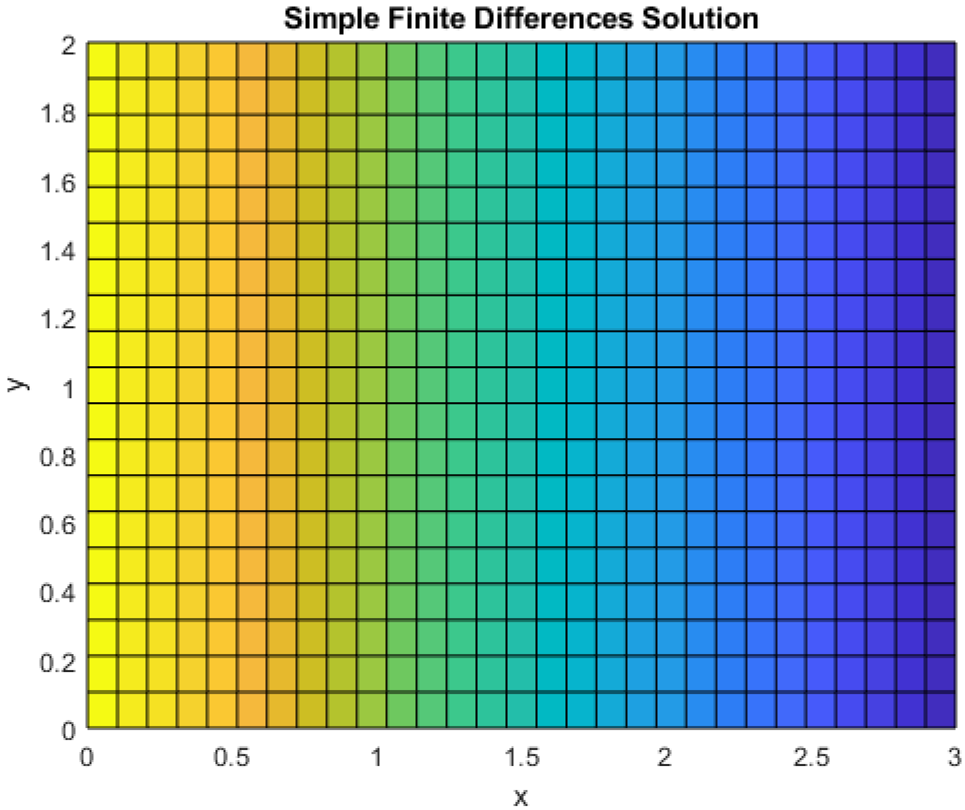

The figure above shows that the distribution of voltage satifies the given conditions

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