# Problem set 1b: MATLAB Fundamentals and Graphics

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**MATLAB release used: R2020a**

**Collaboration Info:**

- https://ch.mathworks.com/help/matlab/ref/title.html

- https://blogs.mathworks.com/loren/2011/07/18/a-mandelbrot-set-on-the-gpu/

- https://ch.mathworks.com/help/matlab/ref/colormap.html

## Exercise 4. Drawing the Mandelbrot fractal set.

### Explanation:

I first defined defined the area, the number of iterations and the step size between points. Then I computed the complex numbers similar to the way presented in the explanation pdf. The matrix of complex numbers was computed with meshgrid fuction. For plotting I used an already defined colormap and the function imagesc.

For the user interaction, the code is similar to the one provided in the tutorial. The user clicks two times on the figure to zoom in that part of the fractal. For characters "+" and "-", the number if iterations is modified accordingly. For 'q' or 'Q', the user interaction stops.

### MATLAB Code:

```
Niterations = 500;
Step = 1000;

Xmin = -2;
Xmax = 2;

Ymin = -2;
Ymax = 2;

RangeX = linspace(Xmin, Xmax, Step);
RangeY = linspace(Ymin, Ymax, Step);

[gridX,gridY] = meshgrid(RangeX, RangeY);
Z0 = gridX + gridY*1i;
Z = Z0;

C = zeros(size(Z0)); % vector of zeros

for n=1:Niterations
    Z = Z.*Z + Z0; % element computation
    B = abs(Z)<=2;
    C = C + B;
end
C = log( C+1 );

imagesc(RangeX, RangeX, C);
axis image;
axis off;
colormap hot;
title( "Mandelbrot fractal at [-2,2]x[-2,2]" );

userinteraction(Step, Niterations)

function drawing(Xmin, Xmax, Ymin, Ymax, Step, Niterations)

    RangeX = linspace(Xmin, Xmax, Step);
    RangeY = linspace(Ymin, Ymax, Step);

    [gridX,gridY] = meshgrid(RangeX, RangeY);
    Z0 = gridX + gridY*1i;
    Z = Z0;
```

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```matlab
    C = zeros(size(Z0)); %vector of zeros

    for n=1:Niterations
        Z = Z.*Z + Z0; %element computation
        B = abs(Z)<=2;
        C = C + B;
    end
    C = log( C+1 );

    imagesc(RangeX, RangeX, C);
    axis image;
    axis off;
    colormap hot;
    title(['Mandelbrot fractal at [',num2str(Xmin) ,',' ,num2str(Ymin), ']x[', num2str(Xmax), ',',
num2str(Ymax), ']']);

    userinteraction(Step, Niterations)
end

function userinteraction(Step, Niterations)
    [a1,b1,c]=ginput(1);
    if c<=3 %the mouse was clicked at point (a1,b1)
        [a2,b2]=ginput(1); %the second click point at (a2,b2)
        drawing(a1, a2, b1, b2, Step, Niterations)

    else %the keyboard was pressed instead

        switch c
            case "+"
                %increase the number of iterations and recompute
                Niterations = Niterations + 50;
                userinteraction(Step, Niterations)
            case "-"
                %decrease the number of iterations
                Niterations = Niterations - 50;
                userinteraction(Step, Niterations)

            case "q"
                %terminate the program
                quit

            case "Q"
                %terminate the program
                quit

        end
    end
end
```
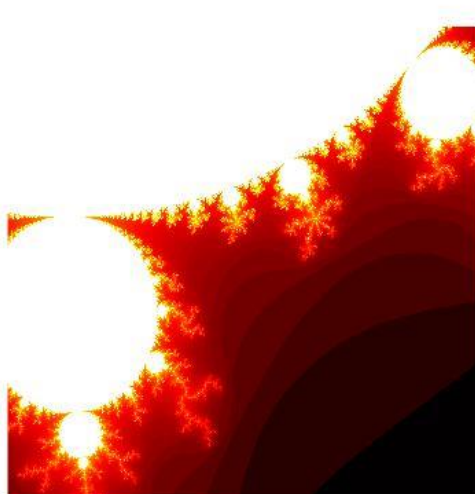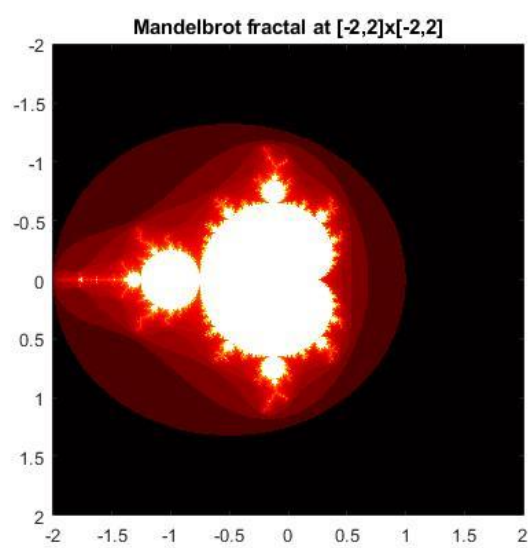
**Results:**

Mandelbrot fractal at [-2,2]x[-2,2]

Mandelbrot fractal at [-0.1109,0.63037]x[-0.040857,0.70041]