Basins of Attraction
Project 01
Graphical User Interface
MAT-63506 Scientific Computing

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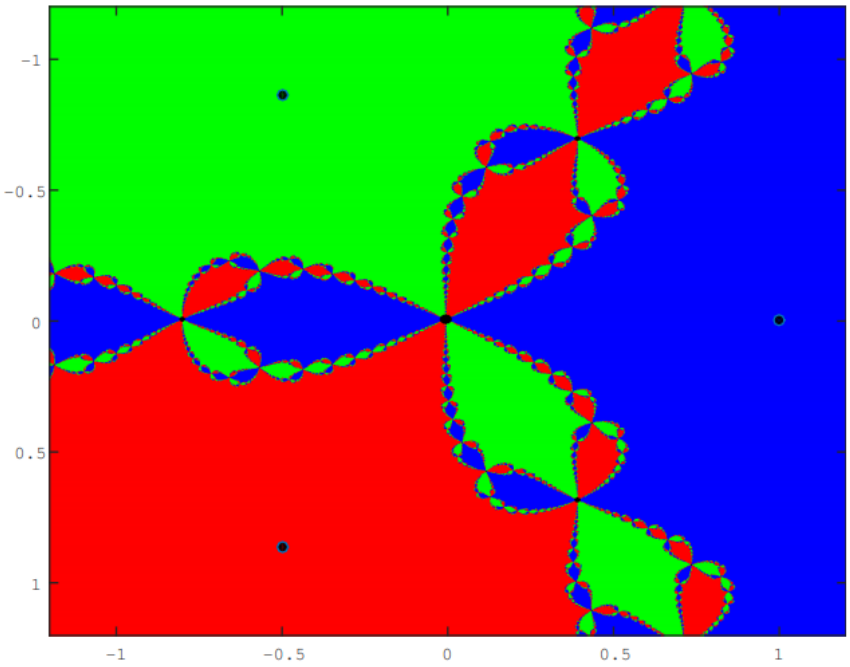
1 Introduciton

The complex roots of polynomial $p(z)$ with Newton's method can be obtained as follows:

$$z_{n+1} = z_n - \frac{p(z_n)}{p'(z_n)}, \quad n \geq 0 \tag{1}$$

An initial point $z_0 \in C$ must be used in equation (1). If the initial point z_0 is close enough to a root z^* of $p(z)$, the sequence (z_n) converges to z^* quadratically. The set of initial points $A(z^*) \subset C$ for which the iteration (1) converges to z^* is called the basin of attraction of z^* [1]. An example of a basin of attraction is given in Figure (1).



[1]

Figure 1: Basins of attraction of the roots of $z^3 - 1$.

2 Objective and Project Plan

The objective of the project was to make a graphical user interface in Matlab that plots the Basins of attraction for a given polynomial. The minimum requirement of our project was to include:

- Edit boxes for polynomial $p(z)$ given as a vector coefficients in descending order.
- The grid $[x_{min}, x_{max}] * [y_{min}, y_{max}]$ of initial values.
- The number of grid points m (for x data points) and n (for y data points).
- The tolerance for checking convergence to a root.

- A bound M for deciding if the iteration diverges.
- A plot button that starts the plotting.

While plainning the interface of our GUI, we made sure to include all the minimum requirements firstly. In addition to the minimum requirements, we also decided to add few more featurse in our GUI. Additional features that we decided to add were as follows:

- A check box for turning the grid on/off.
- A check box to show / hide the roots.
- A button to allow user to choose the color of the roots.
- A reset button to clear the figure and reset the values of the all the Edit boxes to default.

We also wanted our GUI to work for polynomials of degree ≤ 5. The colors to be used to plot the Basins of Attraction were red, blue and green . Moreover, the diverging initial values were to be plotted using black color.

3 Interface

The Interface of our program has an input panel which includes all the edit boxes that fulfills the basic requirements needed for the plot. The Coefficient of the polynomial is given to the program using a 'UITable' feature of matlab. The result is then plotted in 'UIAxes' once the 'Plot' button is pressed. The interface of our program is given in figure (2).

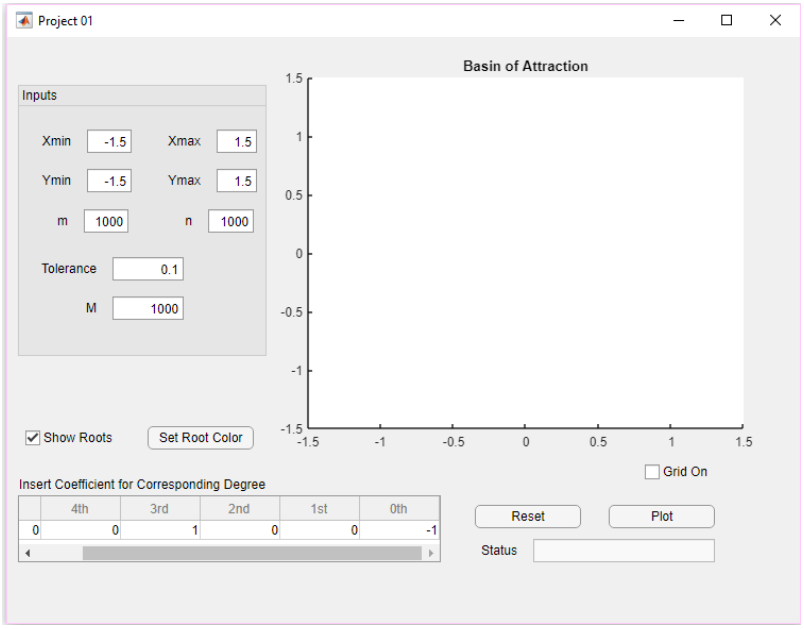


Figure 2: Interface of the GUI.

4 Components and Working Principle

The workings of our program can best be understood by understanding the features of the individual part. A brief detail about all the buttons and different fields used in our program is discussed below:

4.1 Inputs

The 'Inputs' panel includes Xmin, Xmax, Ymin, Ymax, m, n, M (bound) and Tolerance numeric Edit Fields. All Edit Fields have their own minimum and maximum limits. All the Edit Fields in 'Inputs' panel do not have a callback function and the value of each Edit Field is simply read at an instance required during program execution.

4.2 UITable

The coefficient of the polynomial is feed into the program using a 'UITable'. The table is editable and has 6 columns, assigned to different degree of polynomial in descending order.

4.3 UIAxes

The final graph is shown in 'UIAxes' window of the interface once the calculations are done. Its axis limit are set up by Xmin, Xmax, Ymin and Ymax Edit fields.

4.4 Plot and Stop Button

The 'Plot' button functions as both 'Plot' and 'Stop' button. It is a two state button and it changes during the execution of the program. After setting the parameter, 'Plot' button when pressed initiate plotting. The 'Plot' button during the plotting process then changes to 'Stop' button which when pressed stops the ongoing plotting. The 'Stop' button once pressed changes back into 'Plot' button. Also all other fields and buttons are diabled during the plotting process leaving only 'Stop' button active. If the 'Stop' button is not pressed during the plotting process and is let to finish then the 'Stop' button changes back into 'Plot' button once the plot is ready.

The intermediate state when 'Plot' button is pressed is shown in figure (3).

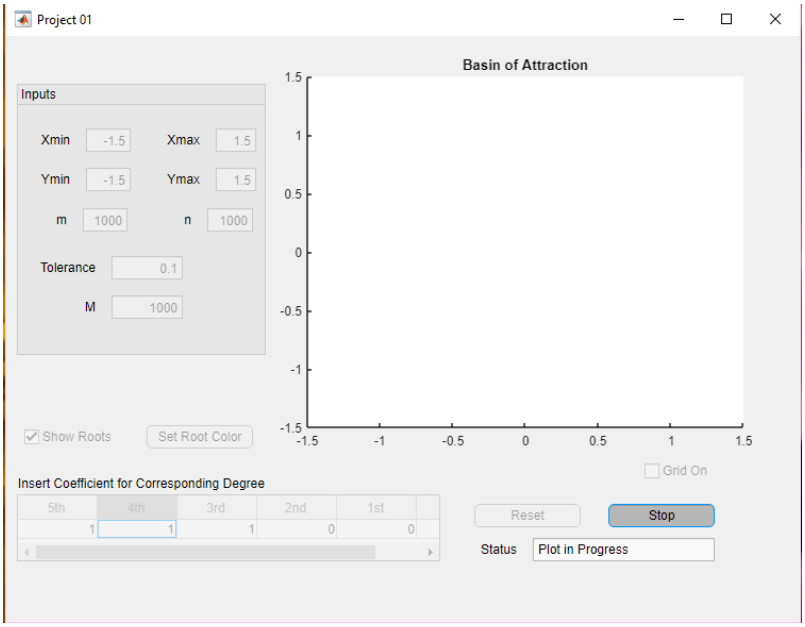


Figure 3: Plotting State of the GUI

The final state after a successful plot is shown in figure (4).

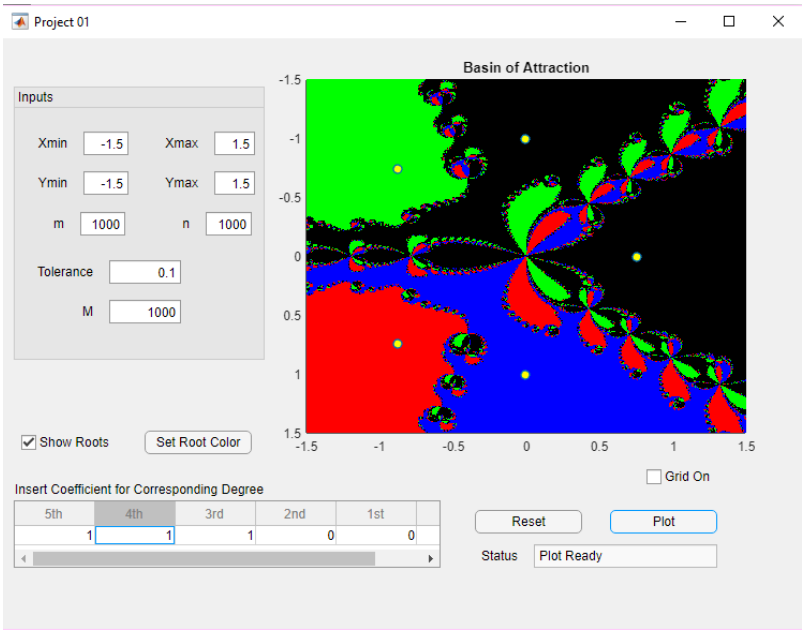


Figure 4: Successful plot phase of the GUI.

4.5 Reset Button

The 'Reset' button resets the whole program. Once pressed, this button clears the figure window and changes every edit fields, button state and check box value to their default setting.

4.6 Status Edit Field

The 'Status' edit field is non editable during all instances of the program. Its function is to display the plot status which are 'Plot in progress', 'Plot ready' and 'Plotting Stopped'. It also informs the user if the coefficient in the UITable has been changed.

4.7 Grid On

The function of 'Grid On' check box is to enable or disable grid in the figure window. It effects the window instantaneously.

4.8 Show Roots

This check box allows user to enable or disable the visibility of roots in the figure window. It effects the window instantaneously.

4.9 Set Root Color

The function of this button is to set the color of the roots in the figure window. It can only be pressed if the 'Show Roots' check box has been checked otherwise it is disabled. Once pressed a new window appears in the program where different choices are available.

5 Error Conditions and Invalid Inputs

The invalid inputs has been taken care of in the program by assigning an appropriate range to every edit fields. The condition when all the coefficients are '0' has been taken care of by disabling the 'Plot' button. If the user tries to feed in such scenario, a message 'Invalid Coefficient' is displayed in the 'Status' edit field.

6 Functions used

Apart from the obvious trigger functions of the interface. The program uses three additional functions, 'plot_data', 'enable_button' and 'disable_button'. The 'plot_data' function takes care of the plotting procedure.
The 'disable_button' function is used by the 'Plot' button to disable every other segment of the code during the 'plotting' process. Similarly 'enable_button' function enables the same buttons and fields once the plot is completed or interrupted.

7 References

[1] MAT-63506 2017-01 Scientific Computing(TUT). Programming projects handout for scientific computing. Available: `https://moodle2.tut.fi/mod/resource/view.php?id=378228`. Accessed: 14/05/2018.