

1. **Overview** The program will allow a user to view a graphical representation of a portion of the complex plane such that those numbers that are members of the Mandelbrot set are visually differentiated from those that are not. In short, the program will show colorful fractal images and allow the user to zoom into portions of the graphic that are of interest.
2. **Background Information** The essence of the program is that it calculates which complex numbers in a given set are members of the Mandelbrot set and colors a bitmap that represents the set according to whether each number belongs. We are not so much interested in the numbers that are in the set, but in the numbers that are not.

Each complex number that is *not* in the Mandelbrot set has the property that when a very simple algorithm is applied to it repeatedly, it grows without bound. We count the number of recursive applications of the algorithm are needed to reach an arbitrary ceiling value (2 and  $\sqrt{5}$  are commonly used values), and then color the pixel representing that complex number according to the number of applications.

Since we use a  $400 \times 400$  pixel display area, our graphic represents 160,000 discrete complex values. When the user selects a portion of the image to zoom into, our new image will then represent 160,000 new complex values, many of which are different than the original image, and which are spaced more closely to each other than those represented by the previous image. Because of the nature of the Mandelbrot set, this zooming in to a set of values whose difference is smaller and smaller with each zoom can continue until we run up against the limitations of floating point representation.

3. **User Interface** The user interface displays three major components:

- (a) *The display area for the fractal image.*

This portion of the interface displays a 600 by 600 pixel bitmap image. Each pixel of this image represents a complex number. The color of the pixel is as follows:

- i. those complex numbers that are members of the Mandelbrot set are colored black;
- ii. those complex numbers that are *not* members of the Mandelbrot set are colored according to the number of iterations required to reach the threshold value. Those with a relatively low number of iterations receive hues from one end of the color spectrum, while those with much more numerous required iterations are colored from the other end.

- (b) *The information area.* This portion of the interface displays information regarding the image being displayed; specifically, the location of the mouse pointer with respect to the  $600 \times 600$  pixel grid.

- (c) *The control area.* This portion of the interface presents buttons to allow the user to

- i. reset the interface to the original state,
- ii. return to the previous view before the latest zoom or move (with history back to the original state),
- iii. save the current view as a bitmap image,
- iv. zoom the current view, or
- v. exit the program.

#### 4. Further Details

- (a) **Inputs** The graphic display area will accept input from the mouse allowing the user to move the center of the view by clicking any area of the displayed image.
- (b) **Outputs** The program will display graphic images as detailed above.

The program will display information about the currently displayed image as detailed above.

The program will output images as device independent bitmap files. The specific file format for the images will follow the specification defined by the Microsoft company.