Xiaoxi Zhneg
CAP3027
Section 1925
10/23/15
HW09+Bonus

Cover Page

I, _*Xiaoxi Zheng*___ affirm that the work submitted is my own and that the Honor Code was neither bent nor broken.

The easiest part of this HW is the setup of this project, since the structure of code was quite straight forward implemented on top of HW9. The more difficult parts of the HW is buried within implementation of the recursion of calling the Mandelbrot and Julia methods when zooming. I spend some times to draft out the algebra behind zooming, and making sure the Cartesian coordinates and the complex coordinates line up after zooming. I also spend times debugging for Array out of bound exceptions when trying to convert coordinates back and forth between the Cartesian plane and the complex plane.

I believe the objective of this assignment was for us to understand the Timer object and implement Animation frame by frame using JPanel and JFrames. How these classes and objects call on each other, and making sure we understand the structural relationship between them.

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Code

```
import javax.swing.SwingUtilities;
import javax.swing.JFrame;
import javax.swing.JPanel;
import javax.swing.JOptionPane;
import javax.swing.JFileChooser;
import javax.swing.JMenuBar;
import javax.swing.JMenu;
import javax.swing.JMenuItem;
import javax.swing.JLabel;
import javax.swing.Timer;
import javax.imageio.ImageIO;
import java.awt.BorderLayout;
import java.awt.Dimension;
import java.awt.Color;
import java.awt.Graphics;
import java.awt.Graphics2D;
import java.awt.Point;
import java.awt.image.BufferedImage;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import java.awt.event.MouseEvent;
import java.awt.event.MouseAdapter;
import java.awt.event.MouseMotionAdapter;
import java.awt.event.KeyEvent;
import javax.swing.KeyStroke;
import java.io.File;
import java.io.IOException;


public class hw10{
	private static final int WIDTH = 600;
	private static final int HEIGHT = 450;

	public static void main( String[] args){
		new hw10();
	}
	public hw10() {
```

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```
                new ImageFrame(WIDTH,HEIGHT);
        }
//#########################################################################
private class ImageFrame extends JFrame {

        //private static final int INFINITE = 1000;
        private fractalDisplayPanel panel;
        private JLabel label;
        private Timer timer;


        private int width = 600;
        private int height = 450;

        private double x = 0;
        private double y = 0;

        //threashold for divergence test
        private int tmax = 100;
        public boolean mandelbrot;
        private BufferedImage image = null;
        private int [] colorSchema = new int [101];

        private double r0 = -2;
        private double r1 = 2;
        private double deltaR = r1-r0;
        private double i0 = -1.5;
        private double i1 = 1.5;
        private double deltaI = i1-i0;

        //Julia constant μ saved
        private double[] constant = new double[2];


        //=========================
        public ImageFrame(int width, int height){
                this.setTitle("CAP 3027 2015 - HW09 -XiaoxiZheng");
                this.setSize( width, height );
                this.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE);

                addMenu();////add a menu to the frame

                image = simulatedImage(width,height);

                panel = new fractalDisplayPanel( image);
```

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```
                this.getContentPane().add( panel, BorderLayout.CENTER );

                label = new JLabel("Click and hold to zoom (LMB to zoom in/RMB to zoom out)");
                this.getContentPane().add( label, BorderLayout.SOUTH );
                this.pack();
                this.setVisible( true );
        }
        private void addMenu(){
                JMenu fileMenu = new JMenu("File Menu");
                //load IFS description
                JMenuItem mandelbrot = new JMenuItem("Mandelbrot");
                mandelbrot.addActionListener( new ActionListener(){
                        public void actionPerformed( ActionEvent event){
                                //initial μ value @(-2 + 1.5i) ---> Top Left
                                r0 = -2;
                                r1 = 2;
                                deltaR = r1-r0;
                                i0 = -1.5;
                                i1 = 1.5;
                                deltaI = i1-i0;
                                produceDefaultMandelbrot(r0,i0,r1,i1);
                        }
                }   );
                fileMenu.add(mandelbrot);

                JMenuItem julia = new JMenuItem("Julia Set");
                julia.addActionListener( new ActionListener(){
                        public void actionPerformed(ActionEvent event){
                        //initial Z value @(-2 + 1.5i) ---> Top Left
                                constant = promptForMiu();
                                r0 = -2;
                                r1 = 2;
                                deltaR = r1-r0;
                                i0 = -1.5;
                                i1 = 1.5;
                                deltaI = i1-i0;
                                produceDefaultJulia(r0,i0,r1,i1, constant[0], constant[1]);
                        }
                }   );
                fileMenu.add(julia);

                //Save image
                JMenuItem saveImage = new JMenuItem("Save Image");
                saveImage.addActionListener( new ActionListener(){
                        public void actionPerformed( ActionEvent event){
```

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```
                                        saveImage();
                                }
                        }   );
                        fileMenu.add(saveImage);
                        //Exit
                        JMenuItem exitItem = new JMenuItem("Exit");
                        exitItem.addActionListener( new ActionListener(){
                                public void actionPerformed(ActionEvent event){
                                        System.exit( 0 );
                                }
                        }       );
                        fileMenu.add( exitItem);

                        //attach menu to a menu bar
                        JMenuBar menuBar = new JMenuBar();
                        menuBar.add( fileMenu);
                        this.setJMenuBar( menuBar);
                }

                public void mandelbrot(double ru, double iu,double ru1,double iu1){
                        //interpolate colors and store them in ColorSchema [] array
                        interpolateColor();
                        deltaR = ru1- ru;
                        deltaI = iu1 - iu;

                        double realIncr = (ru1- ru)/(width - 1);
                        double imagIncr = (iu1 - iu)/(height -1);

                        //initial μ value @(-2 + 1.5i) ---> Top Left
                        double real = ru;
                        //mandelbrot algorithm
                                //looping thru a 600*450 bounded region
                 for(int x=0; x< width-1; x++){
                        double img =  iu1;
                        for(int y=0; y<height-1; y++){
                                double [] complexZ = new double [2];
// temp variable to store real and img part of z when computing;
                                complexZ[0] = 0;
                                complexZ[1] = 0;
                                int t = 0;
                                while(t!=tmax){
                                        //z = (z*z) + u
                                        //update realZ, imgZ
                                        complexZ = zSquarePlusMiu(complexZ[0],complexZ[1],real,img);
```

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```
                                        if(sumOfSquare(complexZ[0],complexZ[1]) > 4.0) {
                                                break;//diverging
                                        }
                                        else{
                                                t++;
                                        }
                                }
                                if(t == tmax){
                                        //Plot black
                                        double [] bitmapCoord = new double [2];
//temp variable to store the converted bitmap interpretation of complex number
                                        bitmapCoord = toBitmapCoord(real,r0,r1,img,i0,i1);
                                if((int)bitmapCoord[0]< 0|| (int)bitmapCoord[1] < 0 ||(int)bitmapCoord[0] >
width-1 || (int)bitmapCoord[1] > height-1 ){
                                        //do nothing..out of bound
                                        }

                                        else{
                                                //System.out.println("(bitmapCoord(x,y): " +
(int)Math.round(bitmapCoord[0])+ ", " + (int)Math.round(bitmapCoord[1]));

        image.setRGB((int)(bitmapCoord[0]),(int)(bitmapCoord[1]),colorSchema[t]);
                                        }
                                }
                                else{
                                        //diverged and μ is not in Mandelbrot set
                                        //plot μ using colorSchema[t].
                                        double [] bitmapCoord = new double [2]; //temp variable to store the
converted bitmap interpretation of complex number
                                        bitmapCoord = toBitmapCoord(real,r0,r1,img,i0,i1);
                                        if((int)bitmapCoord[0]< 0|| (int)bitmapCoord[1] < 0
||(int)bitmapCoord[0]> width-1|| (int)bitmapCoord[1] > height-1 ){
                                                //do nothing..out of bound
                                        }
                                        else{
                                                //System.out.println("(bitmapCoord(x,y): " +
(int)Math.round(bitmapCoord[0])+ ", " + (int)Math.round(bitmapCoord[1]));

        image.setRGB((int)(bitmapCoord[0]),(int)(bitmapCoord[1]),colorSchema[t]);
                                        }
                                        //System.out.println("(bitmapCoord(x,y): " +
(int)Math.round(bitmapCoord[0])+ ", " + (int)Math.round(bitmapCoord[1]));
                                }
                                img -= imagIncr;
                        }
```

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```
                    real += realIncr;
                }

        }

        private void produceDefaultMandelbrot(double r0_,double i0_, double r1_ ,double i1_){
                //display default image
                new Thread(new Runnable() {
                        public void run(){
                                mandelbrot(r0_,i0_,r1_,i1_);
                                SwingUtilities.invokeLater(new Runnable() {
                                        public void run() {
                                        mandelbrot = true;
                                        panel.setImage(image);
                        }
                });
                                }
                }).start();
        }
        public void julia(double rz, double iz, double rz1, double iz1, double rMiu_, double iMiu_){

                double [] complexU = new double [2];
                complexU[0] = rMiu_;
                complexU[1] =  iMiu_;
                //interpolate colors and store them in ColorSchema [] array
                interpolateColor();
                deltaR = rz1- rz;
                deltaI = iz1 - iz;

                double realIncr = (rz1- rz)/(width - 1);
                double imagIncr = (iz1 - iz)/(height -1);

                //initial μ value @(-2 + 1.5i) ---> Top Left
                double real = rz;
                //imgU = iu;
                //Julia algorithm
                        //looping thru a 600*450 bounded region
         for(int x=0; x< width-1; x++){
                double img =  iz1;
                //realU = realU + 4/width;
                for(int y=0; y<height-1; y++){
                        double [] complexZ = new double [2]; // temp variable to store real and img part
of z when computing;
                        complexZ[0] = real;
                        complexZ[1] = img;
```

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```
                        int t = 0;
                        while(t!=tmax){
                                //z = (z*z) + u
                                complexZ =
zSquarePlusMiu(complexZ[0],complexZ[1],complexU[0],complexU[1]);
                                if(sumOfSquare(complexZ[0],complexZ[1]) > 4.0) {
                                        break;//diverging
                                }
                                else{
                                        ++t;
                                }
                        }
                        if(t ==tmax){
                                //Plot black
                                double [] bitmapCoord = new double [2]; //temp variable to store the
converted bitmap interpretation of complex number
                                bitmapCoord = toBitmapCoord(real,r0,r1,img,i0,i1);
                                if((int)bitmapCoord[0]< 0|| (int)bitmapCoord[1] < 0
||(int)bitmapCoord[0]> width-1|| (int)bitmapCoord[1] > height-1 ){
                                        //do nothing..out of bound
                                }
                                else{
                                        //System.out.println("(bitmapCoord(x,y): " +
(int)Math.round(bitmapCoord[0])+ ", " + (int)Math.round(bitmapCoord[1]));

        image.setRGB((int)(bitmapCoord[0]),(int)(bitmapCoord[1]),colorSchema[t]);
                                }
                        }
                        else{
                                //diverged and μ is not in Mandelbrot set
                                //plot μ using colorSchema[t].
                                double [] bitmapCoord = new double [2]; //temp variable to store the
converted bitmap interpretation of complex number
                                bitmapCoord = toBitmapCoord(real,r0,r1,img,i0,i1);
                                if((int)bitmapCoord[0]< 0|| (int)bitmapCoord[1] < 0
||(int)bitmapCoord[0]> width-1|| (int)bitmapCoord[1] > height-1 ){
                                        //do nothing..out of bound
                                }
                                else{
                                        //System.out.println("(bitmapCoord(x,y): " +
(int)Math.round(bitmapCoord[0])+ ", " + (int)Math.round(bitmapCoord[1]));

        image.setRGB((int)(bitmapCoord[0]),(int)(bitmapCoord[1]),colorSchema[t]);
                                }
                        }
```

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```
                        img -= imagIncr;
                    }
                    real += realIncr;
                }
        }
        public void produceDefaultJulia(double r0,double i0,double r1,double i1, double constant0,
double constant1){
                new Thread(new Runnable() {
                        public void run(){
                                julia(r0,i0,r1,i1, constant0, constant1);
                                SwingUtilities.invokeLater(new Runnable() {
                                        public void run() {
                                                mandelbrot = false;
                                                panel.setImage(image);
                                        }
                                });
                        }
                }).start();
        }
                private double [] zSquarePlusMiu(double rZ,double iZ,double rU,double iU){
                double [] answer = new double [2];
                //compute Z^2 + μ in complex form
                answer[0] = (rZ*rZ) - (iZ*iZ)+ rU;
                answer[1] = ((rZ*iZ) + (iZ*rZ)) + iU;
                //answer[1] = (2*rZ*iZ) + iU;
                return answer;
        }
        private double sumOfSquare(double realZ_,double imgZ_){
                double answer = 0.0;
                answer = realZ_*realZ_ + imgZ_*imgZ_;
                return answer;
        }
        private double [] toBitmapCoord(double realU_,double r0_,double r1_,double imgU_,double
i0_,double i1_){
                double answer [] = new double [2];

                double deltaR_ = r1_-r0_;
                double deltaI_ = i1_-i0_;

                answer[0] = ((realU_ - r0_ ) / deltaR_* (width-1));
                answer[1] = (imgU_ - i0_ ) / deltaI_ * (height-1);

                return answer;
        }
        private void interpolateColor(){
```

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```
int ARGBNewGeneral = 0;
double[] colorInfoLeft;
double[] colorInfoRight;

//ignores delta alpha bc in this hw has no changes in alpha
double deltaRGen;
double deltaGGen;
double deltaBGen;

double redGeneral; //start paiting @ left
double greenGeneral; //start paiting @ left
double blueGeneral; //starting paiting @ left

//color[0] = white, color[40] = red, color[100] = Blue

//interpolate from 0---50
//follows the rule of thumb of right hand side of canvas - left hand side of canvas
        colorInfoLeft = extraction(16711680);//extract white
        colorInfoRight = extraction(16747520);//extract orange

        //ignores delta alpha bc in this hw has no changes in alpha
        deltaRGen = (colorInfoRight[1] - colorInfoLeft[1])/(49); //[1]--
channel for red
        deltaGGen = (colorInfoRight[2] - colorInfoLeft[2])/(49); //[2]--
channel for green
        deltaBGen = (colorInfoRight[3] - colorInfoLeft[3])/(49); //[3]--
channel for blue

        redGeneral = colorInfoLeft[1]; //start paiting @ left
        greenGeneral = colorInfoLeft[2]; //start paiting @ left
        blueGeneral = colorInfoLeft[3]; //starting paiting @ left

        for(int x = 0; x<49;x++){
                redGeneral = redGeneral + deltaRGen;
                greenGeneral = greenGeneral + deltaGGen;
                blueGeneral = blueGeneral + deltaBGen;
                //clamping
                if(redGeneral>255){
                        redGeneral = 255;
                }
                if(redGeneral<0){
                        redGeneral = 0;
                }
                if(greenGeneral>255){
                        greenGeneral = 255;
```

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```
                                        }
                                        if(greenGeneral<0){
                                                greenGeneral = 0;
                                        }
                                        if(blueGeneral>255){
                                                blueGeneral = 255;
                                        }
                                        if(blueGeneral<0){
                                                blueGeneral = 0;
                                        }
                                        ARGBNewGeneral =
toIntARGB(255,redGeneral,greenGeneral,blueGeneral);
                                        colorSchema[x] =ARGBNewGeneral;//record the color
information in the colorArray for future use                                    }
                                }
                //50---100
                //follows the rule of thumb of right hand side of canvas - left hand side of canvas
                                colorInfoLeft = extraction(16747520);//extract orange
                                colorInfoRight = extraction(16711680);//extract red

                                //ignores delta alpha bc in this hw has no changes in alpha
                                deltaRGen = (colorInfoRight[1] - colorInfoLeft[1])/(49); //[1]--
channel for red
                                deltaGGen = (colorInfoRight[2] - colorInfoLeft[2])/(49); //[2]--
channel for green
                                deltaBGen = (colorInfoRight[3] - colorInfoLeft[3])/(49); //[3]--
channel for blue

                                redGeneral = colorInfoLeft[1]; //start paiting @ left
                                greenGeneral = colorInfoLeft[2]; //start paiting @ left
                                blueGeneral = colorInfoLeft[3]; //starting paiting @ left

                                for(int x = 49; x<100;x++){
                                        redGeneral = redGeneral + deltaRGen;  //bc red starts
from the left
                                        greenGeneral = greenGeneral + deltaGGen;
                                        blueGeneral = blueGeneral + deltaBGen;
                                        //clamping
                                        if(redGeneral>255){
                                                redGeneral = 255;
                                        }
                                        if(redGeneral<0){
                                                redGeneral = 0;
                                        }
                                        if(greenGeneral>255){
```

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```
                                                greenGeneral = 255;
                                        }
                                        if(greenGeneral<0){
                                                greenGeneral = 0;
                                        }
                                        if(blueGeneral>255){
                                                blueGeneral = 255;
                                        }
                                        if(blueGeneral<0){
                                                blueGeneral = 0;
                                        }
                                        ARGBNewGeneral =
toIntARGB(255,redGeneral,greenGeneral,blueGeneral);
                                        colorSchema[x] =ARGBNewGeneral;//record the color
information in the colorArray for future use                                    }
                                }

        }
        private double[] extraction(int ARGB_){
                double[] extractionArray;
                extractionArray = new double[4];
                //extractionArray -- extraction[0] = alpha values;
                                                //extraction[1] = red values; & etc with ARGB
                extractionArray[0] = ARGB_>>>24;
                extractionArray[1] = (ARGB_<<8) >>> 24;
                extractionArray[2] = (ARGB_<<16)>>>24;
                extractionArray[3] = (ARGB_<<24)>>>24;
                return (extractionArray);
        }
        private int toIntARGB(double alpha_, double red_, double green_, double blue_){
                //System.out.println((alpha_<<24)|(red_<<16)|(green_<<8)|(blue_));

                return ((((int)alpha_)<<24)|(((int)red_)<<16)|((int)(green_)<<8)|((int)blue_));
        }
        private void saveImage(){
                try
                        {
                                if(mandelbrot){
                                        File outputfile = new File("mandelbrot.png");
                                        javax.imageio.ImageIO.write(image, "png", outputfile );
                                }
                                else{
                                        File outputfile = new File("JuliaSet.png");
                                        javax.imageio.ImageIO.write(image, "png", outputfile );
                                }
```

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```
                        }
                        catch ( IOException e )
                        {
                          JOptionPane.showMessageDialog( ImageFrame.this,
                                                  "Error saving file",
                                                      "oops!",
                                                      JOptionPane.ERROR_MESSAGE );
                        }
        }
        private double [] promptForMiu(){
                double [] temp = new double[2];
                double [] error = new double[2];

                error[0] = -100000;
                error[1] = 100000;

                String input1 = JOptionPane.showInputDialog("Please enter the real part of Mu ");
                String input2 = JOptionPane.showInputDialog("Please enter the imaginary part of  Mu");
                if(valideInput(input1) && valideInput(input2)){
                        temp[0] = Double.parseDouble(input1);
                        temp[1] = Double.parseDouble(input2);

                        return temp;
                }
                else if (input1 == null || input2 == null){ //User clicked "Cancel"
             System.exit(0);
             return error;
              }
            else{
                return promptForMiu();
            }
        }
        private boolean valideInput(String input_){
                try{
                        double num = Double.parseDouble(input_);
                        if(num<-1000 || num > 1000){
                                JOptionPane.showMessageDialog(null, "Invalid Input", "alert",
JOptionPane.ERROR_MESSAGE);
                                return false;
                        }
                        return true;
                }
                catch(NumberFormatException e){
```

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```
                        JOptionPane.showMessageDialog(null, "Invalid Input", "alert",
JOptionPane.ERROR_MESSAGE);
                        return false;
                }
        }
        protected BufferedImage simulatedImage(int width_,int height_){
                while (true) {
                        if (width_ < 0 || height_ < 0)
                                return null;
                        try {
                                BufferedImage img = new
BufferedImage(width_,height_,BufferedImage.TYPE_INT_RGB);
                                return img;
                        } catch (OutOfMemoryError err) {
                                JOptionPane.showMessageDialog(this, "Ran out of memory! Try
using a smaller image size.");
                        }
                }
        }
//nested FractalDisplayPanel class
private class fractalDisplayPanel extends JPanel{
         // panel size
         private final int WIDTH, MAX_X;
         private final int HEIGHT, MAX_Y;
         // image displayed on panel
         private BufferedImage image;
         private Graphics2D g2d;
         private Timer timer;
         //[T]---zooming-In; [F]---zooming-OUT
         private boolean zoom;
         //the point in which the mouse clicked
         private Point mouseLoc;

        private final int MILLESECONDS_BETWEEN_FRAMES = 17;
        private final double ZOOM_PERCENTAGE = 0.05;
        private static final double MAXIMUM_ZOOM = 1E-11;

        private final double ZOOM_RATE = ZOOM_PERCENTAGE / 2;
        private final double LEFT_ZOOM_IN_BOUND = ZOOM_RATE;
        private final double RIGHT_ZOOM_IN_BOUND = 1.0 - ZOOM_RATE;
        private final double LEFT_ZOOM_OUT_BOUND = -ZOOM_RATE;
        private final double RIGHT_ZOOM_OUT_BOUND = 1.0 + ZOOM_RATE;


 //---------------------------------------------------------------------
```

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```
 // constructor
 public fractalDisplayPanel( BufferedImage image ){
        this.image = image;
        g2d = image.createGraphics();

        // define panel characteristics
        WIDTH = image.getWidth();
        HEIGHT = image.getHeight();
        Dimension size = new Dimension( WIDTH, HEIGHT );
        setMinimumSize( size );
        setMaximumSize( size );
        setPreferredSize( size );
        MAX_X = WIDTH - 1;
        MAX_Y = HEIGHT - 1;

        mouseLoc = null;
        zoom = true;

        //initialize Timer
        timer = new Timer(MILLESECONDS_BETWEEN_FRAMES, new ImageZoomer());

        this.addMouseListener( new MouseAdapter(){
                public void mousePressed( MouseEvent event ){
                        if(event.getButton() == MouseEvent.BUTTON1){
                                // zooming in stuff
                                zoom = true;
                                mouseLoc = event.getPoint();
                                timer.start();

                        }
                        else if(event.getButton() == MouseEvent.BUTTON3){
                                // zooming out stuff
                                zoom = false;
                                mouseLoc = event.getPoint();
                                timer.start();

                        }

                }
                public void mouseReleased(MouseEvent event){
                        timer.stop();
                }
        });

        this.addMouseMotionListener( new MouseMotionAdapter(){
```

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```
                public void mouseDragged(MouseEvent event){
                        mouseLoc = event.getPoint();
                        //claming mouse points within the border of display
                        int x = (int)mouseLoc.getX();
                        int y = (int)mouseLoc.getY();
                                if (x < 0)
                                        x = 0;
                                else if (x > width-1)
                                        x = width-1;
                                if (y < 0)
                                        y = 0;
                                else if (y > height-1)
                                        y = height-1;
                        mouseLoc.setLocation(x, y);
                }
        });
}
//---------------------------------------------------------------------

public void setImage( BufferedImage src ){
        g2d.drawImage( src,
                0, 0, MAX_X, MAX_Y,
                0, 0, (src.getWidth() - 1), (src.getHeight() - 1),
                null
         );
        repaint();
}
//---------------------------------------------------------------------
// behaviors

public void paintComponent( Graphics g ){
         super.paintComponent( g );
         g.drawImage( image, 0, 0, null );
}

private class ImageZoomer implements ActionListener{

        public void actionPerformed(ActionEvent evt){

                        new Thread(new Runnable() {
                                public void run() {

                                                        // precompute variables that will be used
multiple times
                                                double newX = 2 * (mouseLoc.getX() / MAX_X - 0.5);
```

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```
                                        double newY = 2 * (mouseLoc.getY() / MAX_Y - 0.5);
                                        double deltaR = r1 - r0;
                                        double deltaI = i1-i0;
                                        double xCoff = newX * ZOOM_RATE;
                                        double yCoff = newY * ZOOM_RATE;
                                // Zooming in portion
                                        if (zoom) {

                        double newr0 = r0 + (LEFT_ZOOM_IN_BOUND + xCoff) * deltaR;
                        double newr1 = r1 - (1.0 - (RIGHT_ZOOM_IN_BOUND + xCoff)) * deltaR;
                        double newi0 = i0 + (LEFT_ZOOM_IN_BOUND + yCoff) * deltaI;
                        double newi1 = i1 - (1.0 - (RIGHT_ZOOM_IN_BOUND + yCoff)) * deltaI;

        if (newr1 - newr0 <= MAXIMUM_ZOOM || newi1 - newi0 <= MAXIMUM_ZOOM) {
                        SwingUtilities.invokeLater(new Runnable() {
                                public void run() {

        JOptionPane.showMessageDialog(ImageFrame.this, "WARNING_CANNOT_ZOOM_FURTHER",
"ERROR!", JOptionPane.ERROR_MESSAGE);
                                                                        }
                                                                });
                                                                timer.stop(); // Make sure to
stop the timer
                                                                return;
                                                        }


                                                                r0 = newr0;
                                                                r1 = newr1;
                                                                i0 = newi0;
                                                                i1 = newi1;
                                                        }

                                // Zooming out portion
                                else {

                        r0 = r0 + (LEFT_ZOOM_OUT_BOUND - xCoff) * deltaR;
                        r1 = r1 - (1.0 - (RIGHT_ZOOM_OUT_BOUND - xCoff)) * deltaR;
                        i0 = i0 + (LEFT_ZOOM_OUT_BOUND - yCoff) * deltaI;
                        i1 = i1 - (1.0 - (RIGHT_ZOOM_OUT_BOUND - yCoff)) * deltaI;
                                                        }

                // If the panel currently has a Mandelbrot set
                                                        if (mandelbrot) {
                                                                //call mandelbrot
```

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```
                                                        mandelbrot(r0,i0,r1,i1);
                                                    }


        else{
                                                        julia(r0,i0,r1,i1,constant[0],constant[1]);
                                                    }
                                                    // Update the image
                                                    SwingUtilities.invokeLater(new Runnable() {
                                                        public void run() {
                                                            panel.setImage(image);
                                                        }
                                                    });
                                                }
                                            }).start();
        }//action performed
  }//image zoomer
 }//FractalPanel

}//Jframe
}//hw10
```

==========

Question

1. Does the program compile without errors?
Yes.
2. 2. Does the program compile without warnings?
Yes
3. 3. Does the program run without crashing?
Yes
4. 4. Describe how you tested the program.
I ran several test cases with different inputs for Julia. And make sure the default image for Mandelbrot set is displaying and zooming correctly.
5. Describe the ways in which the program does not meet assignment's specifications.
In the GIFs I provided, the image appear to be tearing a bit, and slow to update for every frame. I based on the assumption that could be the nature of my Graphics Card and the amount of other programs I had running on my laptop at the time.
6. Describe all known and suspected bugs.
There are no known bugs.
7. Does the program run correctly?
Yes

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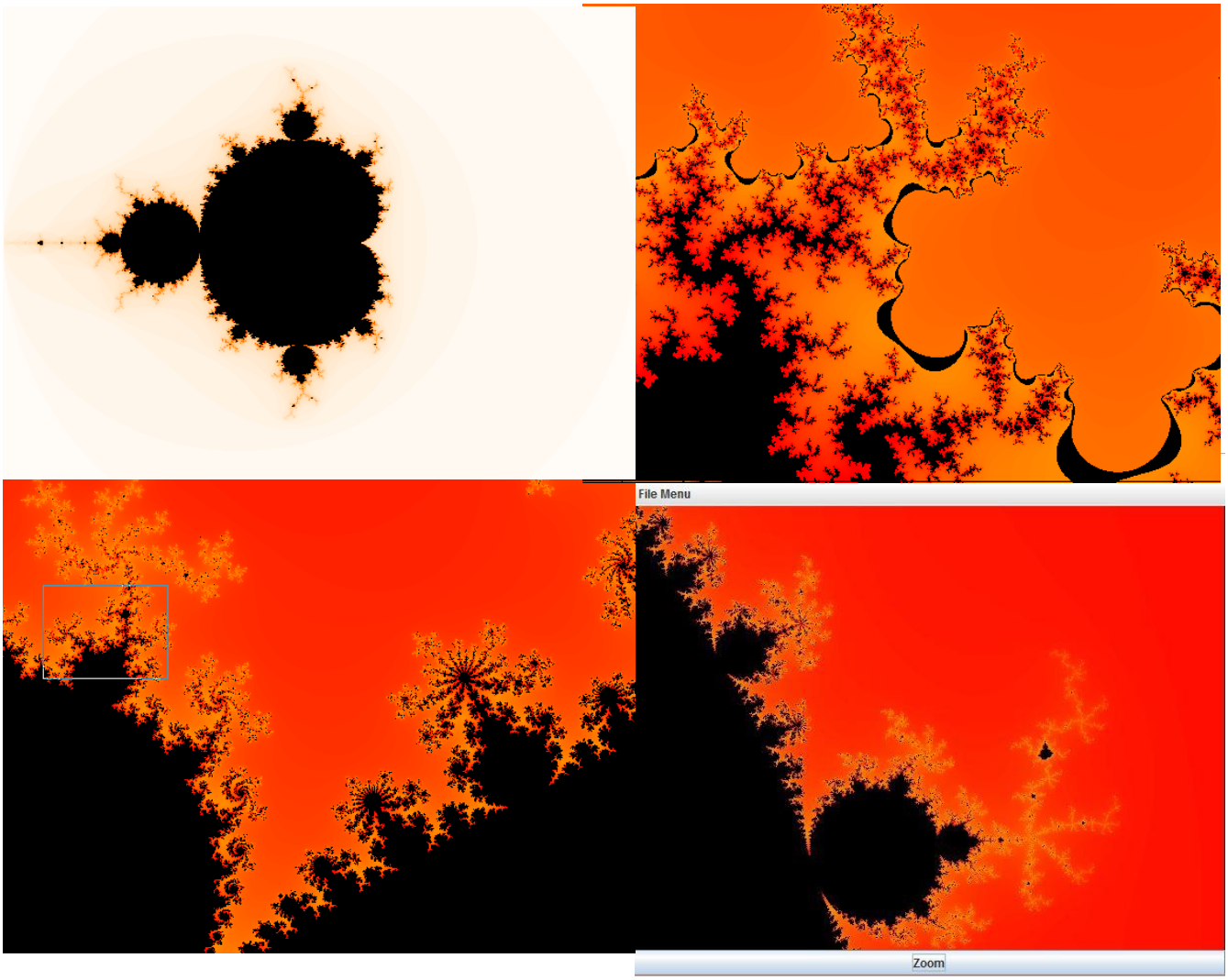
Screenshots

Mandelbrot set



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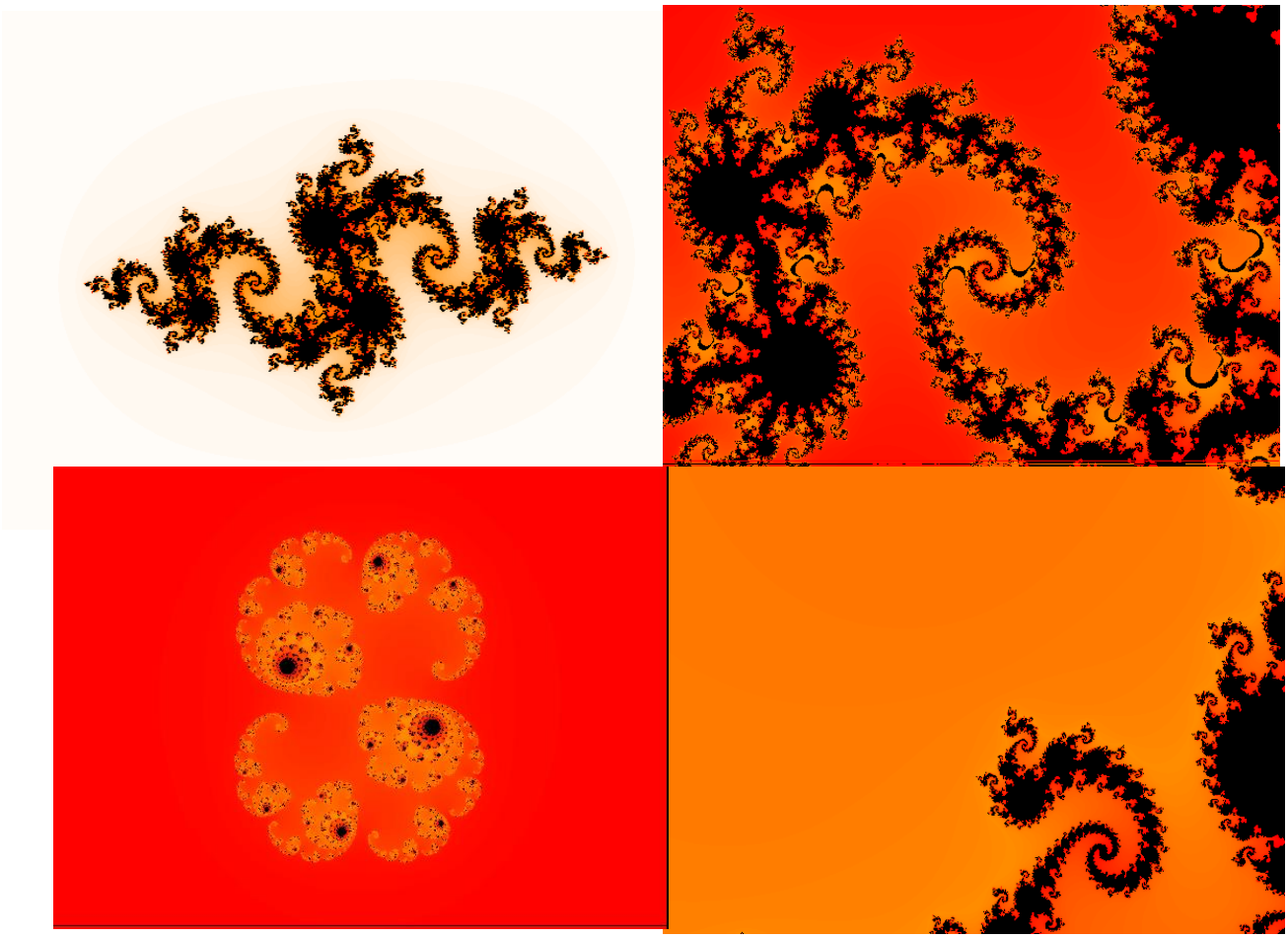
Julia Set



****Please see folder for the animated GIFs****