Computer Programming Fundamentals

CS 152
Professor: Leah Buechley
TAs: Melody Horn, Noah Garcia, Andrew Geyko, Juan Ormaza
Time: MWF 10:00-10:50am
https://handandmachine.cs.unm.edu/classes/CS152_Fall2021/

QUIZ 5

90 minutes

24 hour window

11am today - 11am tomorrow

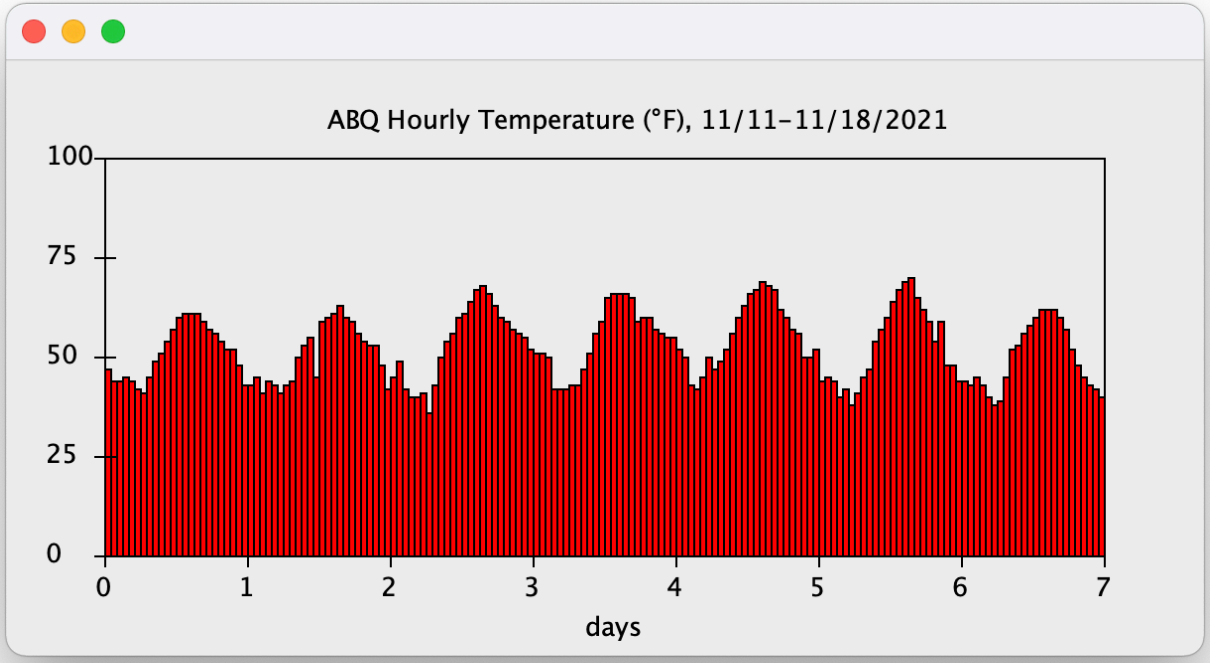
ASSIGNMENT 7

https://handandmachine.cs.unm.edu/classes/CS152_Fall2021/assignments/assignment7.html

questions?

WHERE WE ARE

(FINALLY) A NICE BAR GRAPH!



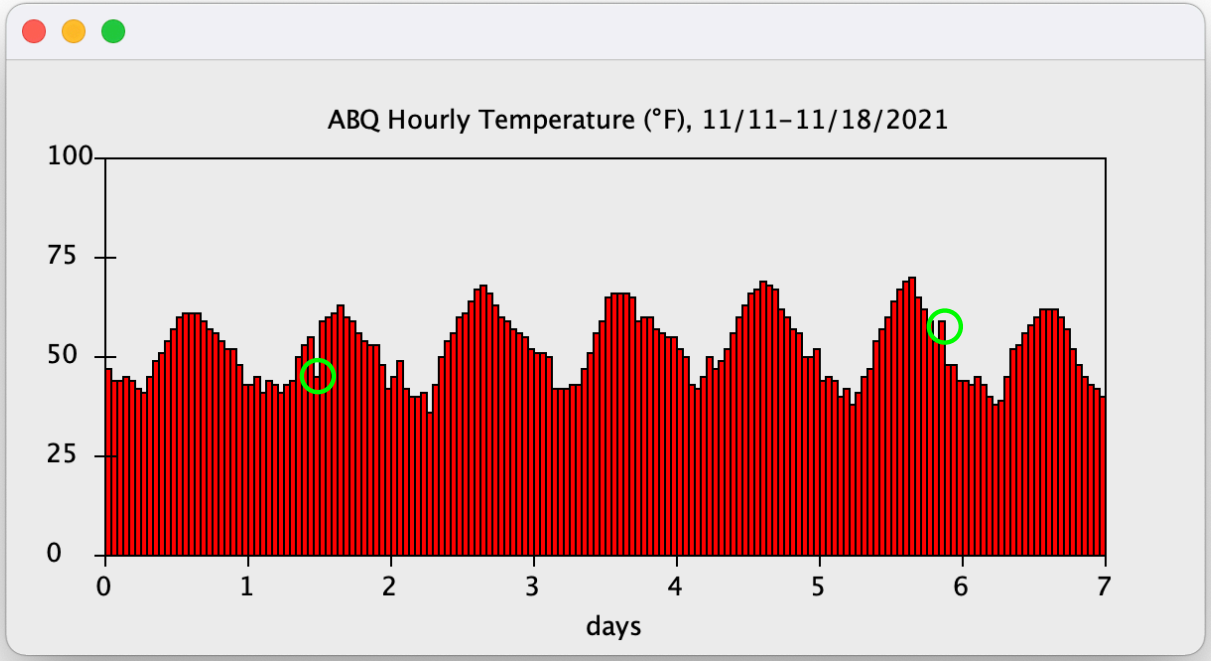
TODAY: DATA SMOOTHING

DATA SMOOTHING

- Capture or clarify patterns in data
- Remove/minimize noise
- Emphasize large scale trends over short term fluctuations
- Better big picture
- Can over-smooth, accidentally hide or eliminate important patterns
- Appropriate level of smoothing depends on analysis goal

WHY WOULD WE WANT TO SMOOTH OUR DATA?

QUESTIONABLE DATA POINTS



hourly temperature readings
these points are likely
measurement errors

ONE SMOOTHING TECHNIQUE: MOVING AVERAGE

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

Our data array

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

average = (47 + 44 + 44 + 45 + 44)/5

average = 44.8

average a 5 hour window

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

average = (44 + 44 + 45 + 44 + 42)/5

average = 43.8

move window down

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

average = (44 + 45 + 44 + 42 + 41)/5

average = 43.2

move window down

questions?

THINKING ABOUT THE CODE

temperature	
47	
44	
44	i = 2
45	
44	
42	
41	
45	
49	
51	
54	
57	
60	
61	i = end - 2
61	
61	

what is size of window? 5

what row can I start averaging for? 2 (5-1)/2

what row should I stop averaging for? end - 2

questions?

WRITING CODE

A MOVING AVERAGE BAR GRAPH

- Separate drawing labels from drawing bar graph
- Create a moving average bar graph method
- Calculate and graph the moving average, based on a windowSize variable

SEPARATING GRAPH LABELING FROM ACTUAL PLOTTING

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
    g.drawString("days", width/2-10, height-spacer+40);

    //draw title
    g.drawString("ABQ Hourly Temperature (°F), 11/11-11/18/2021", width/2-140, spacer-15);
}
```

labeling code

METHOD 1: barGraph

```
void barGraph(Graphics g) {
    int maxY = 100;
    int scale = graphHeight/maxY;
    Color graphColor = Color.GRAY;
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
}
```

METHOD 2: graphWindow

```
void graphWindow(Graphics g) {
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
    g.drawString("days", width/2-10, height-spacer+40);

    //draw title
    g.drawString("ABQ Hourly Temperature (°F), 11/11-11/18/2021", width/2-140, spacer-15);
}
```

CHANGE maxY & scale TO CLASS VARIABLES

DELETE FROM barGraph METHOD

```
void barGraph(Graphics g) {
    int maxY = 100;
    int scale = graphHeight/maxY;
    Color graphColor = Color.GRAY;
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
}
```

ADD TO CLASS

```
public class DataVisualizationTest extends BasicPanel {
    int[][] data;
    int rows;
    final String FILENAME = "abq_weather_cleaned.csv";
    final int rectangleWidth = 3;
    final int graphHeight = 200;
    final int spacer = 50;
    final int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
```

ADD COLOR TO BEGINNING OF NEW graphWindow METHOD

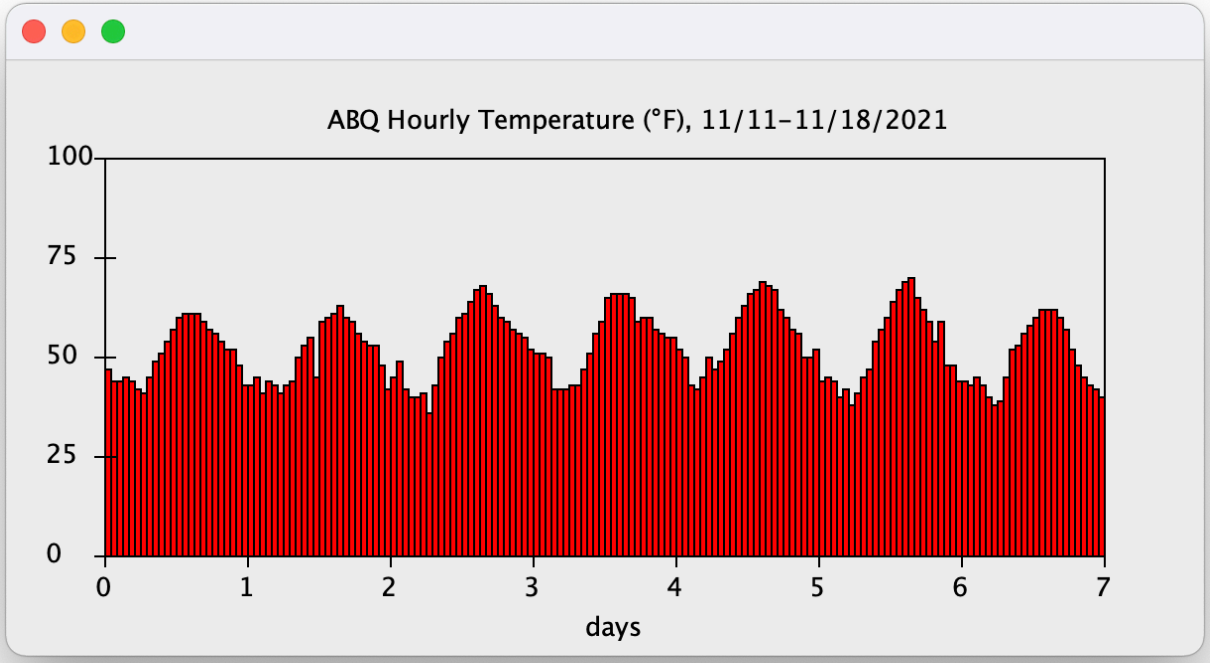
graphWindow

```
void graphWindow(Graphics g) {
    g.setColor(Color.BLACK);
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
    g.drawString("days", width/2-10, height-spacer+40);

    //draw title
    g.drawString("ABQ Hourly Temperature (°F), 11/11-11/18/2021", width/2-140, spacer-15);
}
```

CALL NEW FUNCTIONS

```
@Override
protected void paintComponent(Graphics g) {
    barGraph(g);
    graphWindow(g);
}
```

COMPILE & RUN


ABQ Hourly Temperature (°F), 11/11-11/18/2021
100
75
50
25
0
0
1
2
3
4
5
6
7
days

questions?

MOVING AVERAGE METHOD

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {

}
```

window = size of averaging window

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
}
```

add color

add variables to calculate average

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

i = 2

what is size of window? 5

can we have even windows?

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

i = 2

thinking about a size 4 window

temperature
47
44
44
45
44
42
41
45
49
51
54
57
60
61
61
61

i = 2

thinking about a size 4 window

even windows are unbalanced

let's prevent them

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;

}
```

if value of window is even,
add one to it to make it odd

questions?

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (    ) {
        //calculate average
        //draw the rectangle
    }
}
```

loop through array

temperature	
47	
44	
44	i = 2
45	
44	
42	
41	
45	
49	
51	
54	
57	
60	
61	i = end - 2
61	
61	

what is size of window? 5

what row can I start averaging for? 2 (5-1)/2

what row should I stop averaging for? end - 2

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        //draw the rectangle
    }
}
```

loop through array

note starting and stopping conditions

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
    }
}
```

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for ( ) {
        }
    }
}
```

temperature	
47	i - 2
44	
44	i
45	
44	i + 2
42	
41	

want to add up all numbers in the window

loop through window

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for (int j=i-window/2; j<=i+window/2; j++) {
        }
    }
}
```

temperature	
47	i - window/2
44	
44	i
45	
44	i + window/2
42	
41	

loop through window

note starting and stopping conditions

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for (int j=i-window/2; j<=i+window/2; j++) {
            sum = sum+data[j][0]*scale;
        }
    }
}
```

add up data points

remember to scale

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for (int j=i-window/2; j<=i+window/2; j++) {
            sum = sum+data[j][0]*scale;
        }
        averageTemp = sum/window;
    }
}
```

calculate average

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10);
    int averageTemp, sum;
    if (window%2==0)
        window = window+1;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for (int j=i-window/2; j<=i+window/2; j++) {
            sum = sum+data[j][0]*scale;
        }
        averageTemp = sum/window;
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-averageTemp-spacer, rectangleWidth, averageTemp);
    }
}
```

draw rectangle

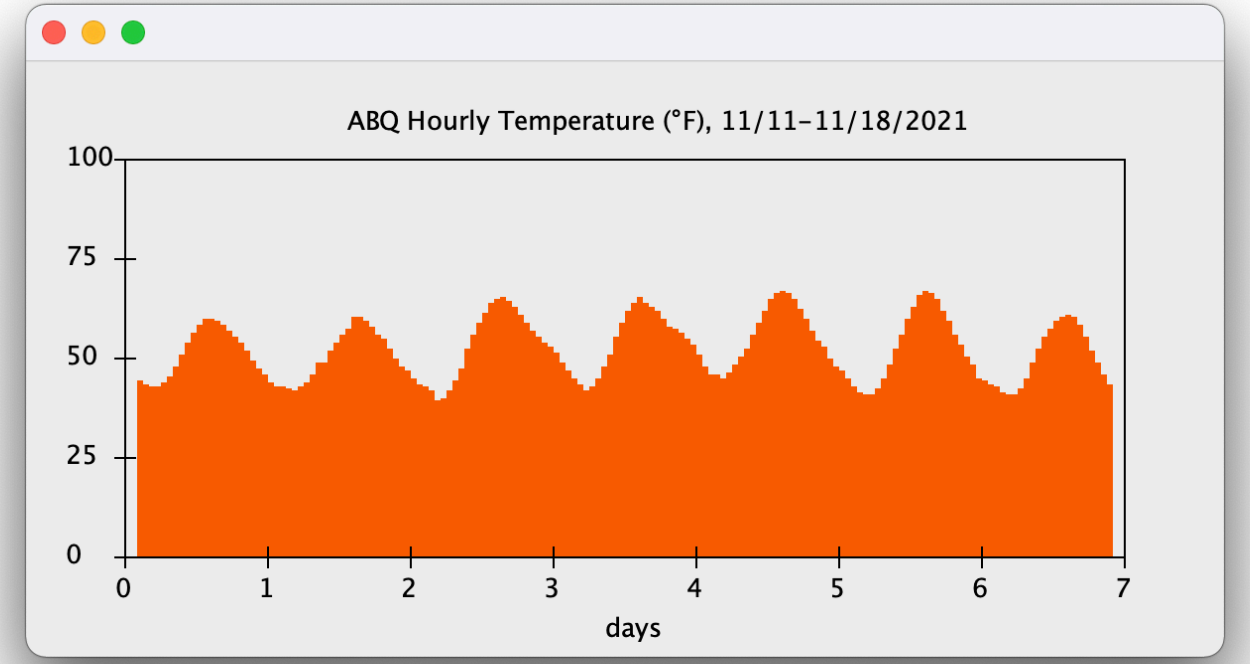
CALL NEW FUNCTION

```
@Override
protected void paintComponent(Graphics g) {
    //barGraph(g);
    barMovingAverage(g, 5);
    graphWindow(g);
}
```

window = 5

SMOOTHED GRAPH

window = 5



why the space at the edges?

averaging window

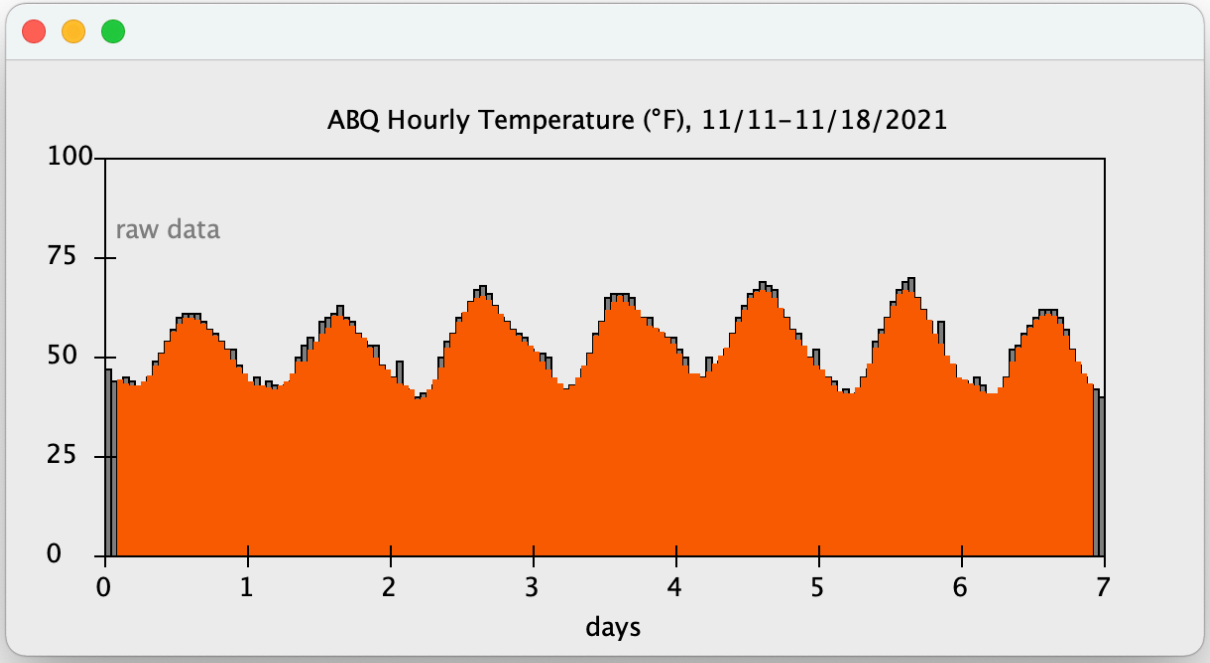
WOULD BE USEFUL TO BE ABLE TO COMPARE TO ORIGINAL GRAPH

LET'S GRAPH BOTH!

GRAPH BOTH

```
@Override
protected void paintComponent(Graphics g) {
    barGraph(g);
    barMovingAverage(g, 5);
    graphWindow(g);
}
```

BOTH GRAPHS


ABQ Hourly Temperature (°F), 11/11–11/18/2021
raw data
100
75
50
25
0
0
1
2
3
4
5
6
7
days

CAN’T REALLY SEE ORIGINAL GRAPH
LET’S MAKE SMOOTH GRAPH TRANSPARENT

MOVING AVERAGE

```
void barMovingAverage(Graphics g, int window) {
    Color graphColor = new Color(232, 103, 10, 120);
    if (window%2==0)
        window = window+1;
    int averageTemp, sum;
    for (int i=window/2; i<rows-window/2; i++) {
        //calculate average
        sum = 0;
        for (int j=i-window/2; j<=i+window/2; j++) {
            sum = sum+data[j][0]*scale;
        }
        averageTemp = sum/window;
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-averageTemp-spacer, rectangleWidth, averageTemp);
    }
}
```

add transparency

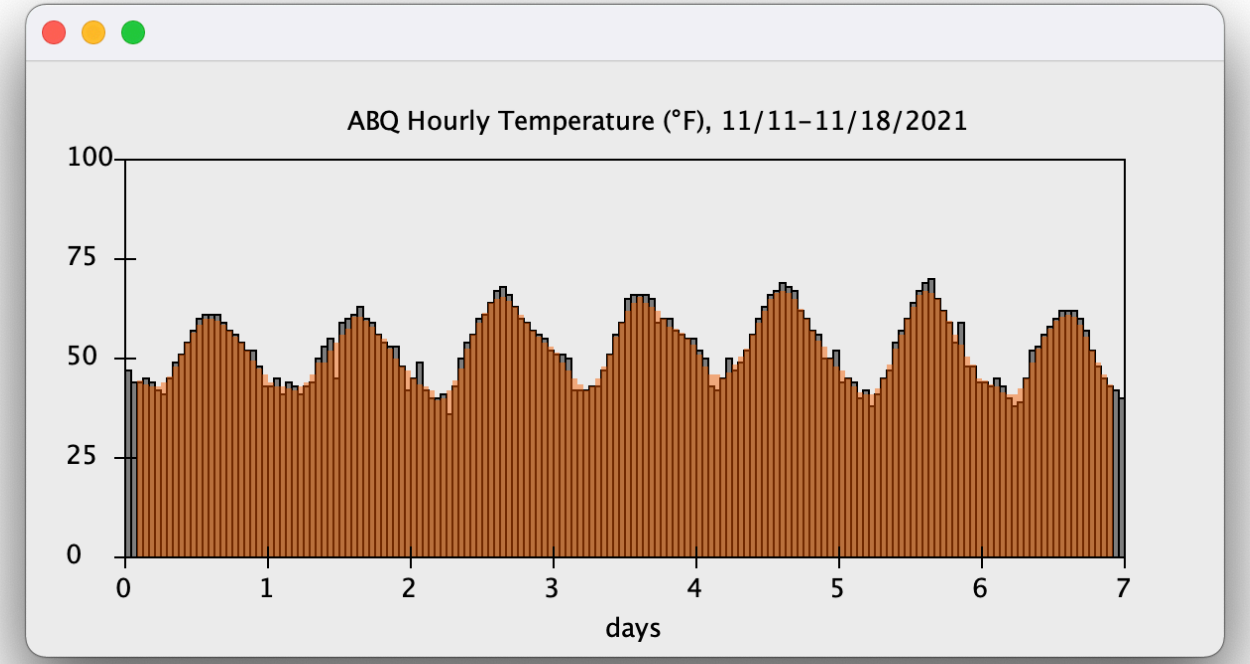
4th color parameter = “alpha”

0 = clear

255 = solid

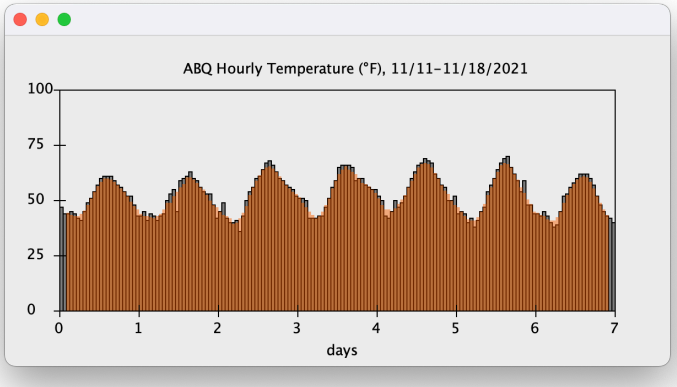
BOTH GRAPHS WITH TRANSPARENCY

window = 5

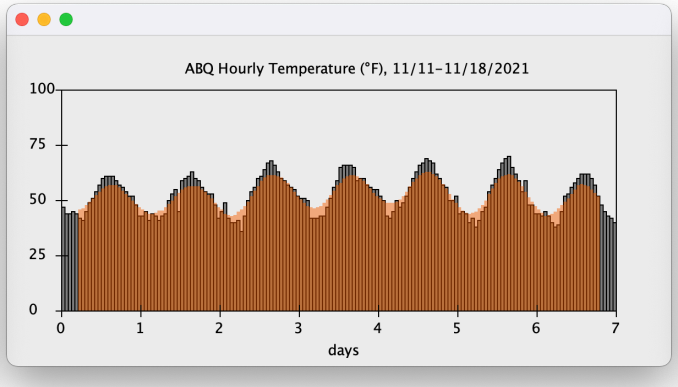


PLAY WITH WINDOW SIZE

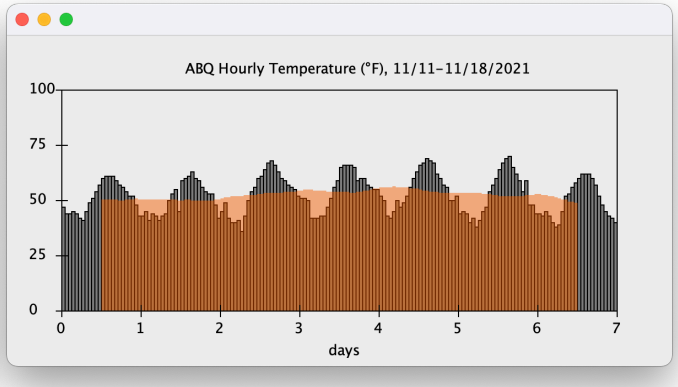
DIFFERENT SMOOTHING WINDOWS



window = 5



window = 11



window = 25

MAKE IT INTERACTIVE

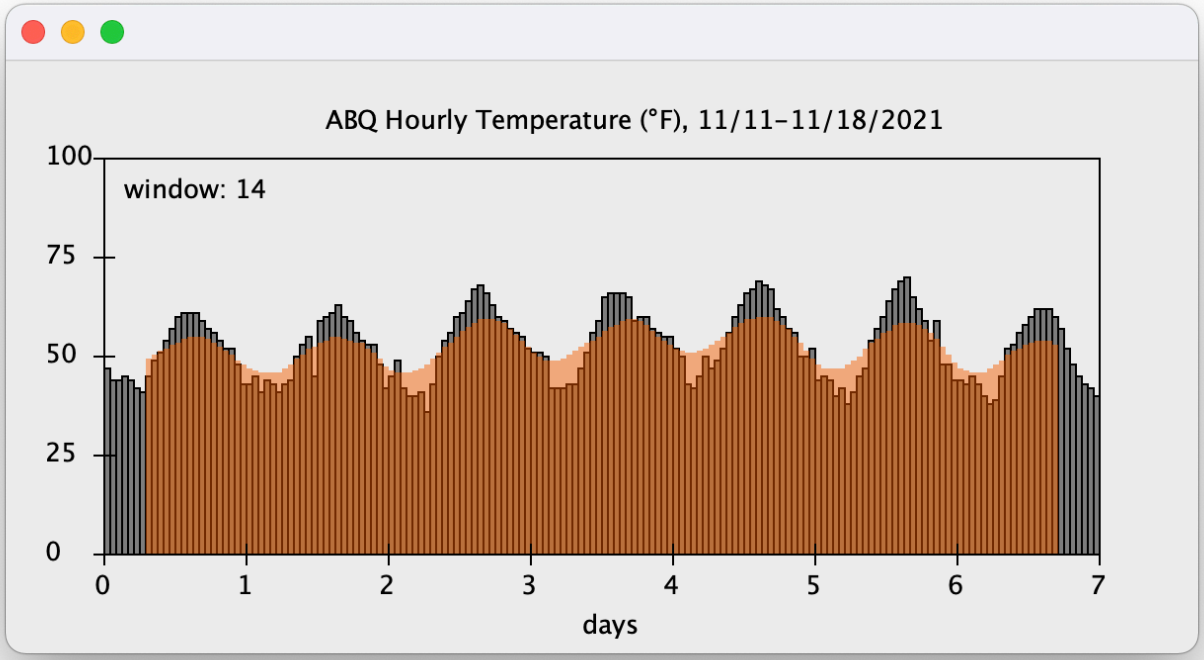
SET WINDOW SIZE WITH MOUSE Y POSITION

```
@Override
protected void paintComponent(Graphics g) {
    barGraph(g);
    barMovingAverage(g, mouseY/10);
    graphWindow(g);
}
```

ANIMATE THE WINDOW TO CAPTURE CHANGES

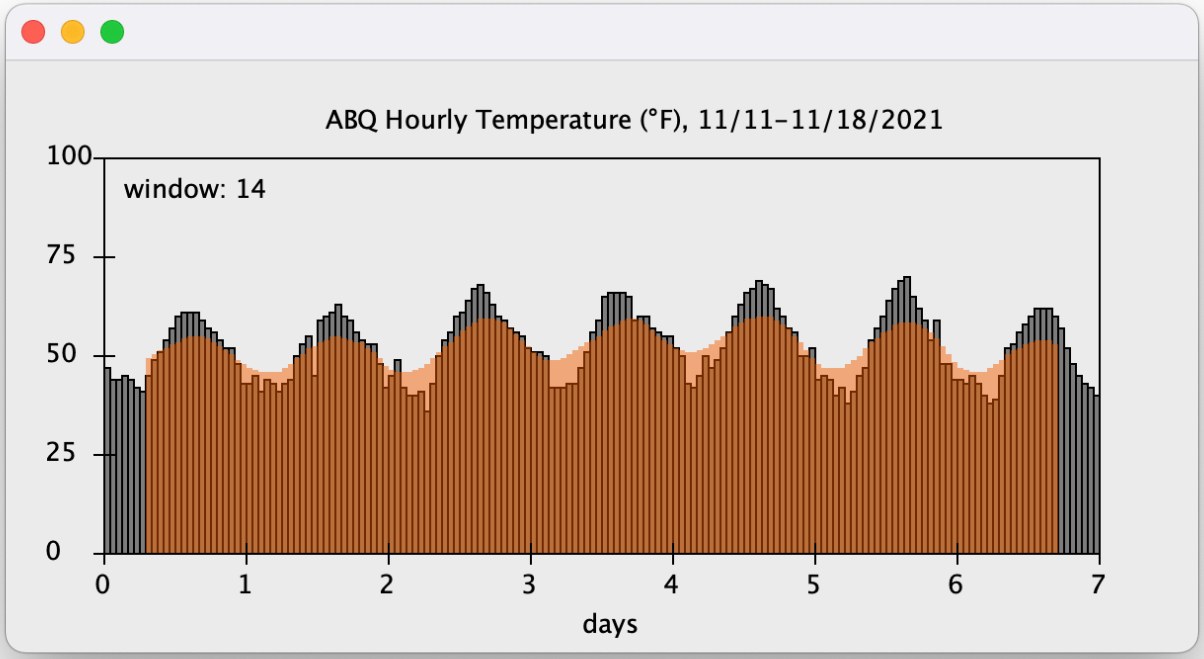
```
public static void main(String[] args) throws FileNotFoundException {
    DataVisualizationTest d = new DataVisualizationTest();
    MyFrame frame = new MyFrame(d);
    d.animate(20);
}
```

INTERACTIVE SMOOTHING



questions?

DIFFERENT SMOOTHING WINDOWS



what can we learn from different windows?

DATA SMOOTHING

- Capture or clarify patterns in data
- Remove/minimize noise
- Emphasize large scale trends over short term fluctuations
- Better big picture
- Can over-smooth, accidentally hide or eliminate important patterns
- Appropriate level of smoothing depends on analysis goal

WINDOW = 5

- Remove/minimize noise
- Emphasize daily pattern of fluctuation

WINDOW = 24

- Calculating & plotting daily average
- If plotted over a longer time period would reveal long term patterns clearly (weekly or monthly changes in temperature)

WINDOW = 24 * 7

- Calculating & plotting weekly average
- If plotted over a longer time period would reveal long term patterns clearly (monthly or yearly changes in temperature)

questions?

Thank you!

CS 152
Professor: Leah Buechley
TAs: Melody Horn, Noah Garcia, Andrew Geyko, Juan Ormaza
Time: MWF 10:00-10:50am
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