CSE 331

2D Graphics

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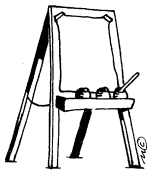
based on materials by M. Ernst, S. Reges, D. Notkin, R. Mercer, Wikipedia
http://www.cs.washington.edu/331/

Custom components

- AWT/Swing come with lots of components that you can use to implement a fully-featured GUI.

- But there are cases when you need a custom component.
  - Usually this is when you want to paint custom 2-D graphics.
  - We often call a custom painted component a *canvas*.

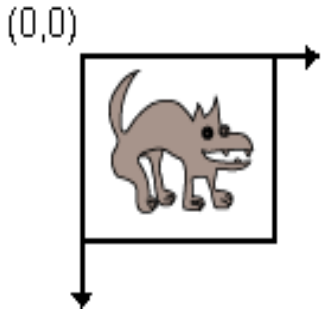


- To do so, write a class that extends `JComponent`.
  - Override method `paintComponent` to tell Java how to draw it:

```
public void paintComponent(Graphics g)
```

    - Some programmers extend `JPanel` rather than `JComponent`.

A drawing canvas



- Coordinate system: (0, 0) at top-left,
  x-axis increases rightward, y-axis ***downward.***
- Component's surface is *transparent* unless drawn on.

- `JComponent`'s `paintComponent` does important things that we don't want to lose. (e.g. paints the component's background)
  - So call the method `super.paintComponent` first thing.

```
public void paintComponent(Graphics g) {
    super.paintComponent(g);
    ...
}
```

Quick drawing example

```
public class MyCanvas extends JComponent {
    public MyCanvas() {
        this.setBackground(Color.WHITE);
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);
        g.setPaint(Color.BLUE);
        g.fillOval(10, 10, 20, 50);
    }
}
```

Graphics methods

Method name	Description
`drawImage(`**Image, x, y, [w, h], panel**`)`	an image at the given x/y position and size
`drawLine(`**x1**, **y1**, **x2**, **y2**`)`	line between points (*x1*, *y1*), (*x2*, *y2*)
`drawOval(`**x**, **y**, **width**, **height**`)`	outline largest oval that fits in a box of size *width* * *height* with top-left at (*x*, *y*)
`drawRect(`**x**, **y**, **width**, **height**`)`	outline of rectangle of size *width* * *height* with top-left at (*x*, *y*)
`drawString(`**text**, **x**, **y**`)`	text with bottom-left at *(x, y)*
`fillOval(`**x**, **y**, **width**, **height**`)`	fill largest oval that fits in a box of size *width* * *height* with top-left at (*x*, *y*)
`fillRect(`**x**, **y**, **width**, **height**`)`	fill rectangle of size *width* * *height* with top-left at (*x*, *y*)
`setColor(`**color**`)`	paint any following shapes in the given color
`setFont(`**font**`)`	draw any following text with the given font

Graphics2D

- The `Graphics` object `g` passed to `paintComponent` is a "graphical context" object to draw on the component.
  - The actual object passed in is a `Graphics2D` (can cast).

```
Graphics2D g2 = (Graphics2D) g;
```

- `Graphics2D` is a subclass of `Graphics` that adds new features, new shapes, matrix transformations, color gradients, etc.
  - Added to Java in v1.2 to improve on the features of `Graphics`.
  - Why didn't they just add the new methods and features to `Graphics` directly? Why did they bother to make it a separate class?
    - *Answer:* Open-Closed Principle. Graphics already worked just fine. Why risk breaking it by adding new features to the same file?

Graphics2D methods

method name	description
`draw(`**Shape**`)`	draws the outline of a given shape object *(replaces drawRect, etc.)*
`fill(`**Shape**`)`	draws the outline and interior of a given shape object
`getPaint(), setPaint(`**Paint**`)`	returns or sets the current paint used for drawing (`Color` is one kind of `Paint`, but there are others)
`getStroke(), setStroke(`**Stroke**`)`	returns or sets the current line stroke style used for drawing (can be thin/thick, solid/dashed/dotted, etc.)
`rotate(`**angle**`)`	rotates any future drawn shapes by the given angle (radians)
`scale(`**sx, sy**`)`	resizes any future drawn shapes by the given x/y factors
`translate(`**dx, dy**`)`	moves any future drawn shapes by the given x/y amounts
`setRenderingHint( `**key, value**`)`	sets "rendering hints" such as anti-aliasing and smoothing
`shear(`**shx, shy**`)`	gives a slanted perspective to future drawn shapes
`transform(`**t**`)`	adds a transformation that will be applied to all shapes

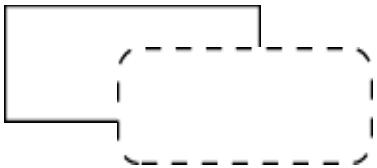
Shapes (java.awt.geom)

- `Arc2D.Double(`**x, y, w, h, start, extent, type**`)`
  An arc, which is a portion of an ellipse.

- `Ellipse2D.Double(`**x, y, w, h**`)`

- `Line2D.Double(`**x1, y1, x2, y2**`)`
  `Line2D.Double(`**p1, p2**`)`
  A line between two points.

- `Rectangle2D.Double(`**x, y, w, h**`)`
- `RoundRectangle2D.Double(`**x, y, w, h, arcx, arcy**`)`



- `GeneralPath()`
  A customizable polygon.

Methods of all shapes

method name	description

`contains(`**`x, y`**`)`
`contains(`**`point`**`)`
`contains(`**`rectangle`**`)`
	whether the given point is inside the bounds of this shape

`getBounds()`	a rectangle representing the bounding box around this shape

`getCenterX/Y()`
`getMinX/Y()`
`getMaxX/Y()`
	various corner or center coordinates within the shape

`intersects(`**`x, y, w, h`**`)` `intersects(`**`rectangle`**`)`	whether this shape touches the given rectangular region

Drawing with objects

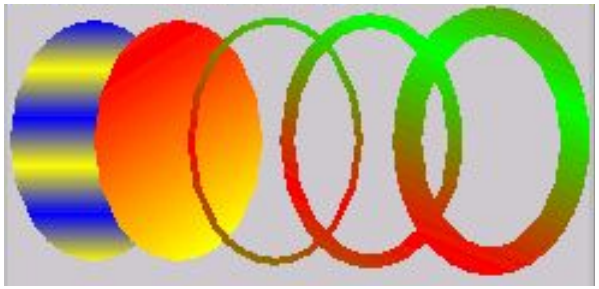
```
public class MyCanvas extends JComponent {
    public MyCanvas() {
        this.setBackground(Color.WHITE);
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);
        Graphics2D g2 = (Graphics2D) g;
        Shape shape = new Ellipse2D.Double(10, 10, 20, 50);
        g2.setPaint(Color.BLUE);
        g2.fill(shape);
    }
}
```

Colors and paints

- **`Color`** (a simple single-colored paint)
  - `Color.RED`
  - `public Color(int r, int g, int b)`
  - `public Color(int r, int g, int b, int alpha)`
    - a partially-transparent color (range 0-255, 0=transparent)

- **`GradientPaint`** (a smooth transition between 2 colors)
  - `public GradientPaint(float x1, float y1, Color color1, float x2, float y2, Color color2)`

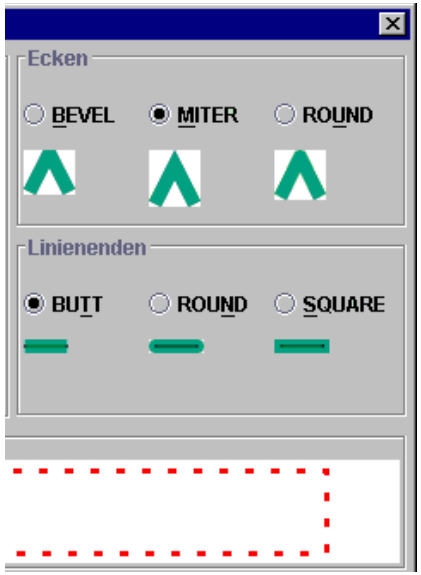
- `java.awt.TexturePaint`
  (use an image as a "paint" background)



Strokes (pen styles)

`Graphics2D`

- `public void` **`setStroke`**`(Stroke s)`
  Sets type of drawing pen (color, width, style) that will be used by this `Graphics2D`.



- **`BasicStroke`**

  A pen stroke for drawing outlines.

  - `public BasicStroke(float width)`
  - `public BasicStroke(float width, int cap, int join)`
  - `public BasicStroke(float width, int cap,`
    `int join, float miterlimit,`
    `float[] dash, float dash_phase)`
    - `cap` can be: `CAP_BUTT, CAP_ROUND, CAP_SQUARE`
    - `join` can be: `JOIN_BEVEL, JOIN_MITER, JOIN_ROUND`

Repainting

- Most canvases are drawing the state of fields, a model, etc.
  - When the state updates, you must tell the canvas to re-draw itself.
  - But you can't call its `paintComponent` method, because you don't have the `Graphics g` to pass.

  - The proper way is to call `repaint` on the canvas instead:

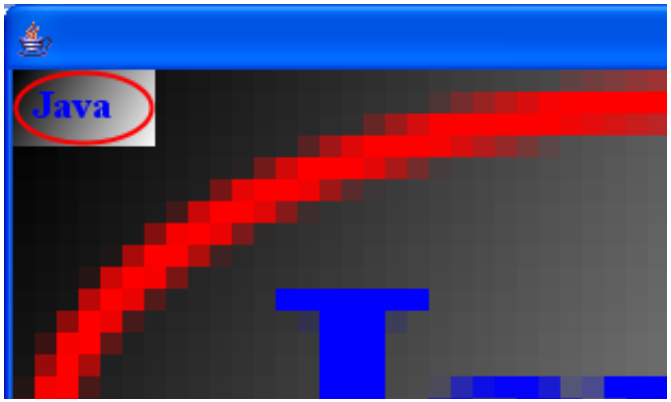
```
public void repaint()
```

```
…
public void update(Observable o, Object arg) {
    myView.repaint();  // perhaps this.repaint();
}
```

Anti-aliasing

- Onscreen text and shapes can have jagged edges, or *aliases*. These can be removed by smoothing, or *anti-aliasing*, the component.
  - `public void setRenderingHint(key, value)`
  - Example:

```
g2.setRenderingHint(
        RenderingHints.KEY_ANTIALIASING,
        RenderingHints.VALUE_ANTIALIAS_ON);
```



Creating images

```
// import java.awt.image.*;
```

`BufferedImage`

A blank graphic image buffer surface onto which you can draw

- `public BufferedImage(int w, int h, int type)`
  - where `type` is a constant such as `BufferedImage.TYPE_INT_ARGB`
- `public Graphics getGraphics()`
  - returns a graphical pen for "drawing on" this image

- you can draw a `BufferedImage` onto the screen from within the `paintComponent` method of your canvas:
  - `g.drawImage(`**`BufferedImage, x, y,`** `this);`

Upload Images

- ImageIO : class that makes it convenient to upload images.

Public static BufferedImage read (File input) throws IOException

Public static BufferedImage read(URL input) throws IOException

Example

- FunImageDisplayer.java
- Graph Application