Chapter 12
A display model

Bjarne Stroustrup

www.stroustrup.com/Programming
Overview

- Why graphics?
- A graphics model
- Examples
Why bother with graphics and GUI?

- It’s very common
  - If you write conventional PC applications, you’ll have to do it
- It’s useful
  - Instant feedback
  - Graphing functions
  - Displaying results
- It can illustrate some generally useful concepts and techniques
Why bother with graphics and GUI?

- It can only be done well using some pretty neat language features 😊
- Lots of good (small) code examples
- It can be non-trivial to “get” the key concepts
  - So it’s worth teaching
  - If we don’t show how it’s done, you might think it was “magic”
- Graphics is fun!
Why Graphics/GUI?

- **WYSIWYG**
  - What you see (in your code) is what you get (on your screen)
  - Direct correspondence between concepts, code, and output
- Objects (such as graphs) are “attached to” a window.

- The “display engine” invokes display commands (such as “draw line from x to y”) for the objects in a window.

- Objects such as Square contain vectors of lines, text, etc. for the window to draw.
Display model

- An example illustrating the display model

```cpp
int main()
{
    using namespace Graph_lib;    // use our graphics interface library

    Point tl(100,200);    // a point (obviously)

    Simple_window win(tl,600,400,"Canvas");    // make a simple window

    Polygon poly;    // make a shape (a polygon, obviously)

    poly.add(Point(300,200));    // add three points to the polygon
    poly.add(Point(350,100));
    poly.add(Point(400,200));

    poly.set_color(Color::red);    // make the polygon red (obviously)

    win.attach(poly);    // connect poly to the window

    win.wait_for_button();    // give control to the display engine
}
```
The resulting screen
Graphics/GUI libraries

- You’ll be using a few interface classes we wrote
  - Interfacing to a popular GUI toolkit
    - GUI == Graphical User Interface
    - FLTK: www.fltk.org // Fast Light Tool Kit
  - Installation, etc.
    - See piazza.com, Appendix D and ask instructor/friend
      - FLTK
      - Our GUI and graphics classes
      - Project settings

- This model is far simpler than common toolkit interfaces
  - The FLTK (very terse) documentation is 370 pages
  - Our interface library is <20 classes and <500 lines of code
  - You can write a lot of code with these classes
    - And you can build more classes on them
Graphics/GUI libraries (cont.)

- The code is portable
  - Windows, Unix, Mac, etc.

- This model extends to most common graphics and GUI uses

- The general ideas can be used with any popular GUI toolkit
  - Once you understand the graphics classes you can easily learn any GUI/graphics library
    - Well, relatively easily – these libraries are huge
Graphics/GUI libraries

- Often called “a layered architecture”
Oddly, y-coordinates “grow downwards” // right, down
Coordinates identify pixels in the window on the screen
You can resize a window (changing x_max() and y_max())
- An arrow means “is a kind of”
- Color, Line_style, and Point are “utility classes” used by the other classes
- Window is our interface to the GUI library (which is our interface to the screen)
Interface classes

- Current
  - Color, Line_style, Font, Point,
  - Window, Simple_window
  - Shape, Text, Polygon, Line, Lines, Rectangle, …
  - Axis

- Easy to add (for some definition of “easy”)
  - Grid, Block_chart, Pie_chart, etc.

- Later, GUI
  - Button, In_box, Out_box, …
Demo code 1

// Getting access to the graphics system (don’t forget to install):
#include "Simple_window.h"  // stuff to deal with your system’s windows
#include "Graph.h"          // graphical shapes

using namespace Graph_lib;  // make names available

// in main():

Simple_window win(Point(100,100),600,400,"Canvas");
    // screen coordinate (100,100) is top left corner of window
    // window size(600 pixels wide by 400 pixels high)
    // title: Canvas

win.wait_for_button();    // Display!
A “blank canvas”
**Demo code 2**

```cpp
Axis xa(Axis::x, Point(20,300), 280, 10, "x axis");

// make an Axis
// an axis is a kind of Shape
// Axis::x means horizontal
// starting at (20,300)
// 280 pixels long
// 10 “notches” ("tick marks")
// text “x axis”

win.set_label("Canvas #2");
win.attach(xa);  // attach axis xa to the window
win.wait_for_button();
```

*Stroustrup/Programming*
Add an X-axis
win.set_label("Canvas #3");

Axis ya(Axis::y, Point(20,300), 280, 10, "y axis");
ya.set_color(Color::cyan); // choose a color for the axis
ya.label.set_color(Color::dark_red); // choose a color for the text

win.attach(ya);
win.wait_for_button();
Add a Y-axis (colored)

Yes, it’s ugly, but this is a programming course, not a graphics design course.

Stroustrup/Programming
win.set_label("Canvas #4");

**Function sine(sin,0,100,Point(20,150),1000,50,50); // sine curve**

// plot sin() in the range [0:100)
// with (0,0) at (20,150)
// using 1000 points
// scale x values *50, scale y values *50

win.attach(sine);

win.wait_for_button();
Add a sine curve
win.set_label("Canvas #5");

sine.set_color(Color::blue);    // I changed my mind about sine’s color

Polygon poly;                   // make a polygon (a kind of Shape)
poly.add(Point(300,200));       // three points make a triangle
poly.add(Point(350,100));
poly.add(Point(400,200));

poly.set_color(Color::red);     // change the color
poly.set_style(Line_style::dash); // change the line style

win.attach(poly);
win.wait_for_button();
Add a triangle (and color the curve)
Demo code 6

win.set_label("Canvas #6");

Rectangle r(Point(200,200), 100, 50);  // top left point, width, height

win.attach(r);
win.wait_for_button();
Add a rectangle
Demo code 6.1

- Add a shape that looks like a rectangle

```cpp
Closed_polyline poly_rect;
poly_rect.add(Point(100,50));
poly_rect.add(Point(200,50));
poly_rect.add(Point(200,100));
poly_rect.add(Point(100,100));

win.set_label("Canvas #6.1");
```
Add a shape that looks like a rectangle

But is it a rectangle?
We can add a point

```cpp
poly_rect.add(Point(50, 75); // now `poly_rect` has 5 points
```

```cpp
win.set_label("Canvas #6.2");
```

“looking like” is not the same as “is”
Obviously a polygon
Add fill

```
r.set_fill_color(Color::yellow);  // color the inside of the rectangle
poly.set_style(Line_style(Line_style::dash,4));  // make the triangle fat
poly_rect.set_fill_color(Color::green);
poly_rect.set_style(Line_style(Line_style::dash,2));
win.set_label("Canvas #7");
```
Add fill
Demo Code 8

Text t(Point(100,100),"Hello, graphical world!");  // add text
   // point is lower left corner on the baseline

win.set_label("Canvas #8");
Add text

Hello, graphical world!
Demo Code 9

- Modify text font and size

  t.set_font(Font::times_bold);
  t.set_font_size(20);  // height in pixels
Text font and size
Add an image

Image ii(Point(100,50),"image.jpg"); // open an image file
win.attach(ii);
win.set_label("Canvas #10");
Add an image
Oops!

- The image obscures the other shapes
  - Move it a bit out of the way

```cpp
ii.move(100,200);  // move 100 pixels to the right (-100 moves left)
                   // move 200 pixels down (-200 moves up)
win.set_label("Canvas #11");
win.wait_for_button();
```
Note how the parts of a shape that don’t fit in the window are “clipped” away
Circle c(Point(100,200),50);  // center, radius

Ellipse e(Point(100,200), 75,25);  // center, horizontal radius, vertical radius
e.set_color(Color::dark_red);

Mark m(Point(100,200),'x');

ostringstream oss;
oss << "screen size: " << x_max() << "*" << y_max() << "; window size: " << win.x_max() << "*" << win.y_max();

Text sizes(Point(100,20),oss.str());

Image cal(Point(225,225), "snow_cpp.gif");  // 320*240 pixel gif
cal.set_mask(Point(40,40),200,150);  // display center of image

win.set_label("Canvas #12");
win.wait_for_button();
Add shapes, more text
#include "Graph.h"     // header for graphs
#include "Simple_window.h" // header containing window interface

int main ()
try
{
    // the main part of your code
}
catch(exception& e) {
    cerr << "exception: " << e.what() << '\n';
    return 1;
}
catch (...) {
    cerr << "Some exception\n";
    return 2;
}
Primitives and algorithms

- The demo shows the use of library primitives
  - Just the primitives
  - Just the use
- Typically what we display is the result of
  - an algorithm
  - reading data

Next lectures
- 13: Graphics Classes
- 14: Graphics Class Design
- 15: Graphing Functions and Data
- 16: Graphical User Interfaces