Introduction to Computer Graphics

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Uses of Computer Graphics

- Graphical user interfaces
  - mouses, windows
- Virtual Reality
  - input: gloves, head-tracker
  - output: simulation
- Digital Media Technologies
  - digital publishing
  - multi-media

Uses of Computer Graphics (2)

- Visualization
  - medicine
  - financial data
- Simulation
  - engineering, GIS, architecture,…
- Entertainement
  - Movies (Toy Stoy, Jurassic Parc,…)
  - Games (Doom, Marathon, Descent…)

Interdisciplinary

- Theory:
  - Mathematics of curves, surfaces, matrices
  - Physics of lights, materials, colors
- Practice:
  - Hardware: display, processors
  - Software: graphics libraries, windows
- Aesthetics: how does it look?

What's in this course?

- OpenGL for the practicals
- Basic Computer Graphics:
  - what everybody must know before doing Computer Graphics.
- Advanced Computer Graphics:
  - more advanced topics, demand-driven.

When is the course?

- Video-conferencing, Thursdays at 17h30
- Drill session, 26-27 March (12 hours)
- ≈ 25 lectures (3+12+10)
- Slides and course information on the WWW:

`http://www.cs.uct.ac.za/~holzschu/Pretoria.html`

The Textbook

- Foley, van Dam, Feyner et al.
- *Two* textbooks:
  - one is a reference for CG.
  - the other is an abridged version, easier for beginners.
- Which should I buy?
  - the small one is enough, cheaper and easier
  - except if you are going to work in CG for several more years.

OpenGL for the practicals

- Graphics Library
- Multi-platform
  - runs on SGI and on all X11 machines
  - also on Windows 32
  - gets all the power of the SGI
- Easy to use
  - one or two lectures of introduction

Basic Computer Graphics

- Graphics Primitives
  - rasterization, clipping
- Transformations
- Hierarchical Modelling
- Color Spaces and transformations
- Hidden Surface Removal
- Lighting Models

Advanced Computer Graphics

- Demand-driven
- Curves and surfaces (splines, Bézier)
- Texture-mapping
- Quaternions
- Radiosity and ray-tracing

The Practicals

- Subject available on the WWW:

`http://www.cs.uct.ac.za/~holzschu/Pretoria.html`

- Collective e-mail when subject is ready
- Send your pracs by e-mail on due date
- 2 practicals, three-four weeks per prac.
- Subjects tend to be writing an application, with progressive steps
- Suggestions?

The Marks

- 2 practicals, one final exam
- Final exam is 2 hours, 5 exercises
- Pick 3 out of 5
- Open-book exam, lots of thinking
- Probably 0.35 for each practical, 0.3 for the exam

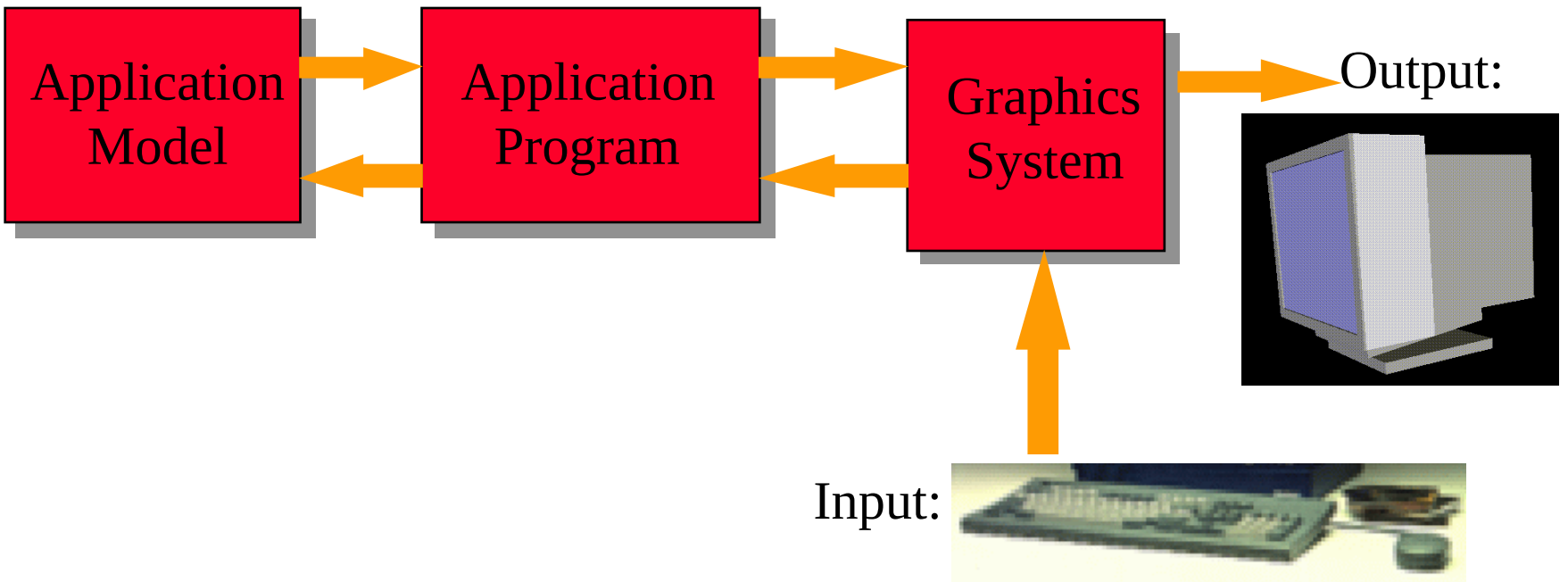
Life after the exam

- Hey, I want to do more Computer Graphics!
- Masters studies
  - in SA: UCT, Rhodes,…
  - abroad: France, US, Germany…
- Siggraph Student Volunteers Program:

  `http://www.siggraph.org`

Framework of Computer Graphics

- Graphics Pipeline:



Application Modeling

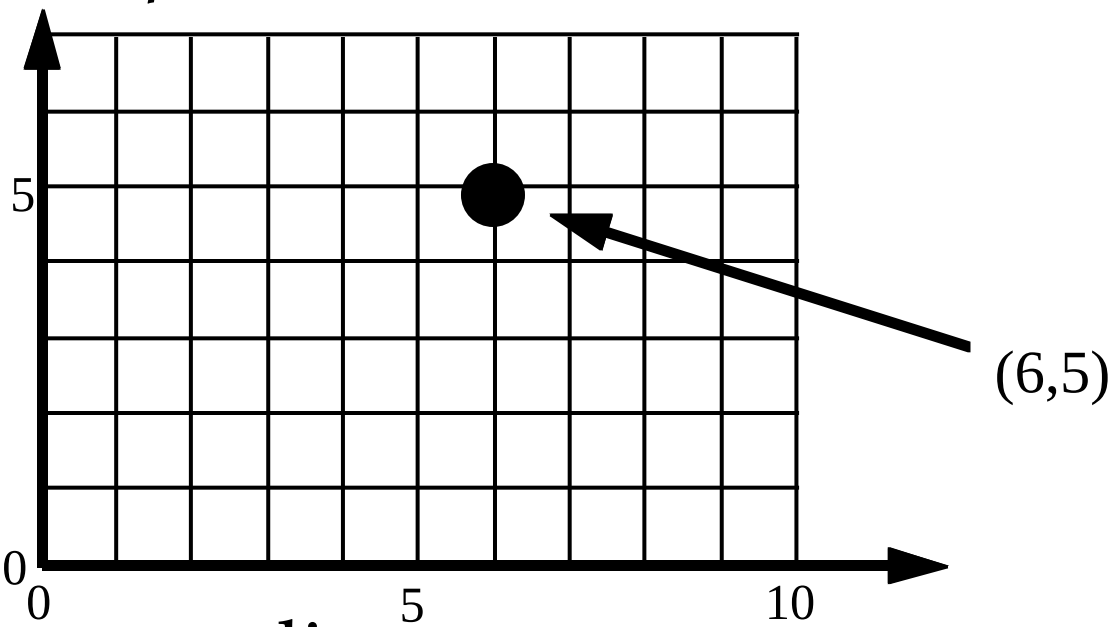
- Description of the objects
  - shape
  - attributes
  - behaviour and properties
- Stored in the application memory
- Can be modified by the application
- Sent to display

Display of the Model

- From internal representation to standard graphics primitives
  - lines, circles, polygons
  - geometric transformations
  - using the *graphic library*
- Interactions:
  - event-driven loop
  - queue of events to process

Graphics Primitives

- Pixels (=*pict*ure *el*ements)



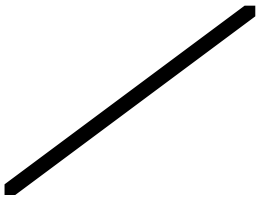
- Screen coordinates

Screen Resolution

- Number of pixels per square cm
  - Measured in dots per inch (*dpi*)
- Number of adressable colors per pixel
  - measured in bits
- Depends on the medium:

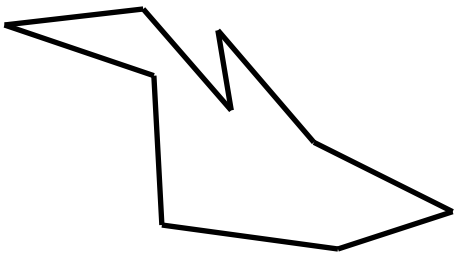
  TV Screen: 30 dpi, 8 bits color
  Computer Screen: 70-100 dpi, up to 24 bits color
  Laser Printer: 300-2400 dpi, 3 bits color (8 colors)
  Photo: ≈ 800 dpi, 36 bits color

Simple Graphics Primitives



- Lines:

```
void LineCoord(int xmin, int ymin, int xmax, int ymax);
void Line(point pt1, point pt2);
```

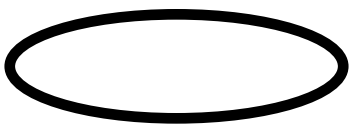


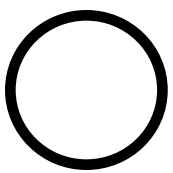
- Polygons:

```
void polyLine(int count, point* vertices);
void polygon(int count, point* vertices);
```

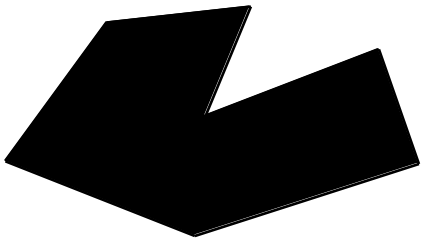
- Circles and ellipses:

```
void circle(point center, int radius);
void ellipse(point center, int radiusX, int radiusY);
void ellipseArc(point center, int radiusX, int radiusY,
                float startAngle, float endAngle);
```

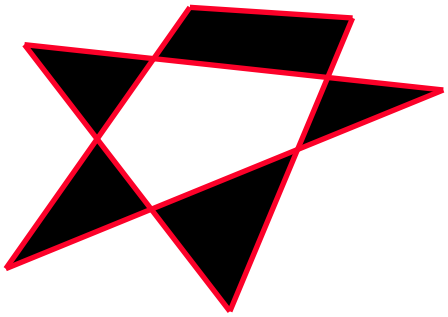




Filled Graphics Primitives



- Same primitives, but filled:
- Filling can be:
  - solid *vs* bitmap pattern
  - opaque *vs* transparent
- Where is the interior?

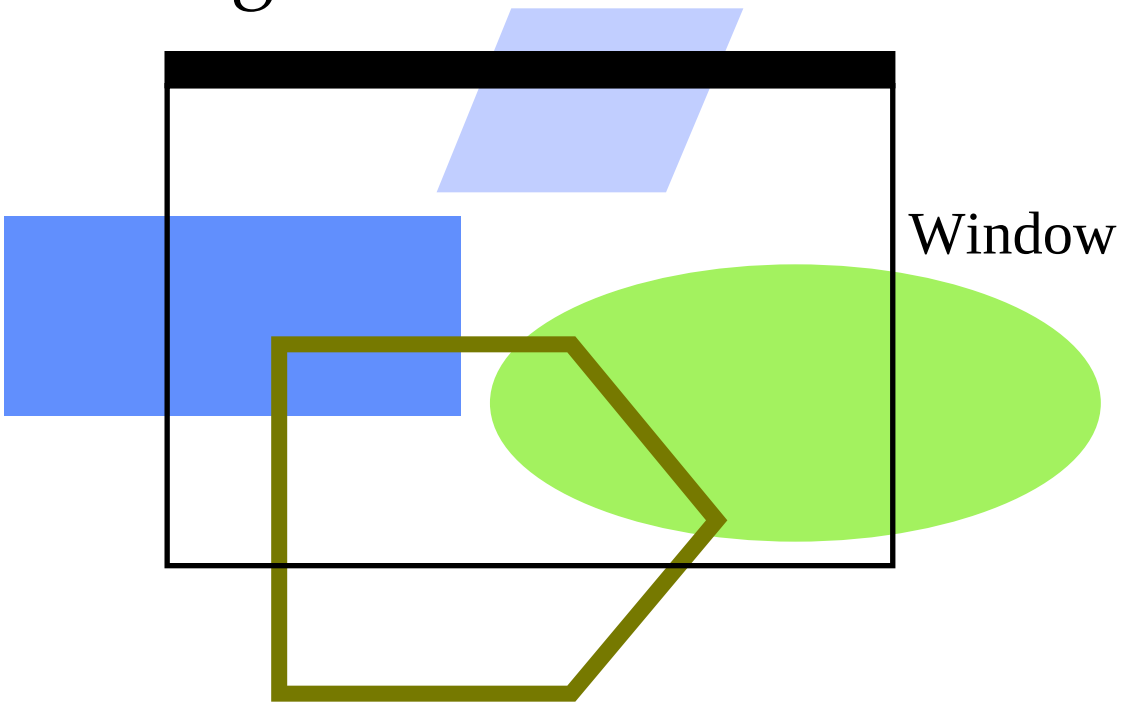


Odd-even rule

Edge orientation rule

Clipping Graphics Primitives

- Drawing outside the window:



- Graphics have to be *clipped*.

Rasterization of Primitives

- How to draw primitives?
  - Convert from geometric definition to pixels
  - *rasterization* = selecting the pixels
- Will be done frequently
  - must be fast:
    - use integer arithmetics
    - use addition instead of multiplication