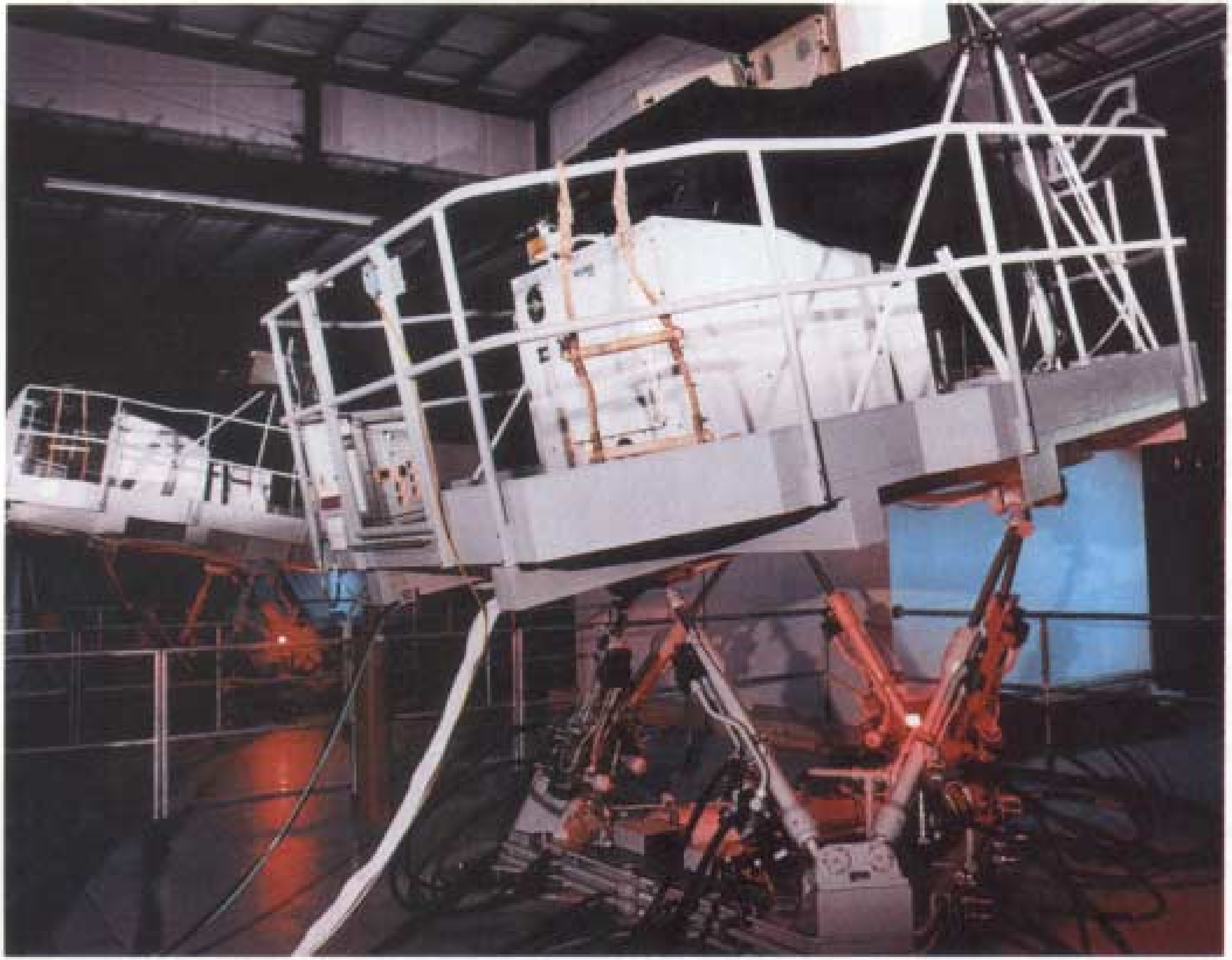
Why graphics?

- Presenting an alternative world
- Enhancing our view of the existing world
- Visual interfaces

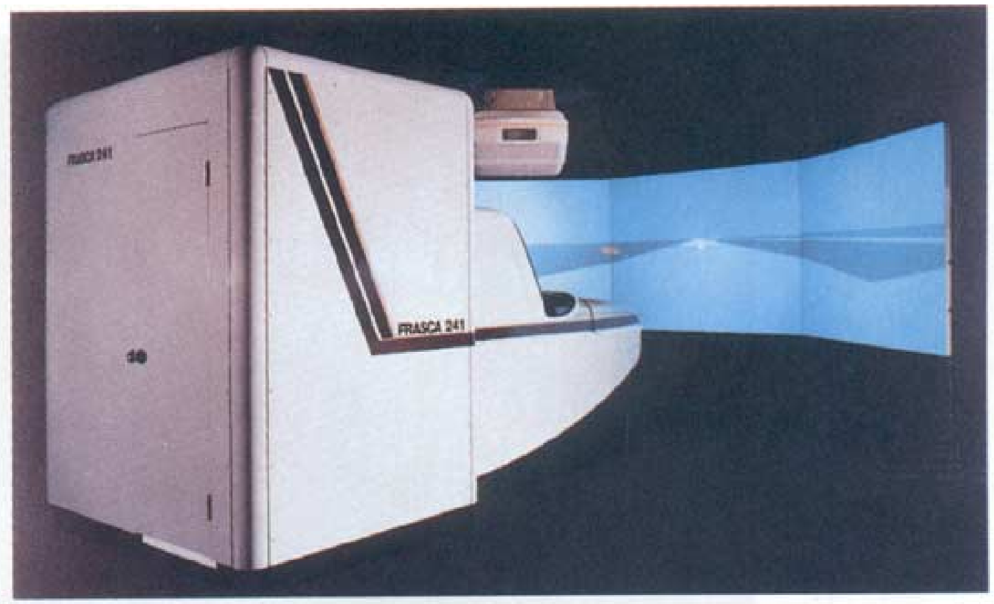
Presenting an alternative world

- For training
  - E.g. Landing expensive aircraft
- For amusement
  - Games; movies
- For aesthetic pleasure
  - Computer art
- For understanding
  - Display data sets in an accessible way (e.g. in book)

Tank simulator, from Hearn and Baker



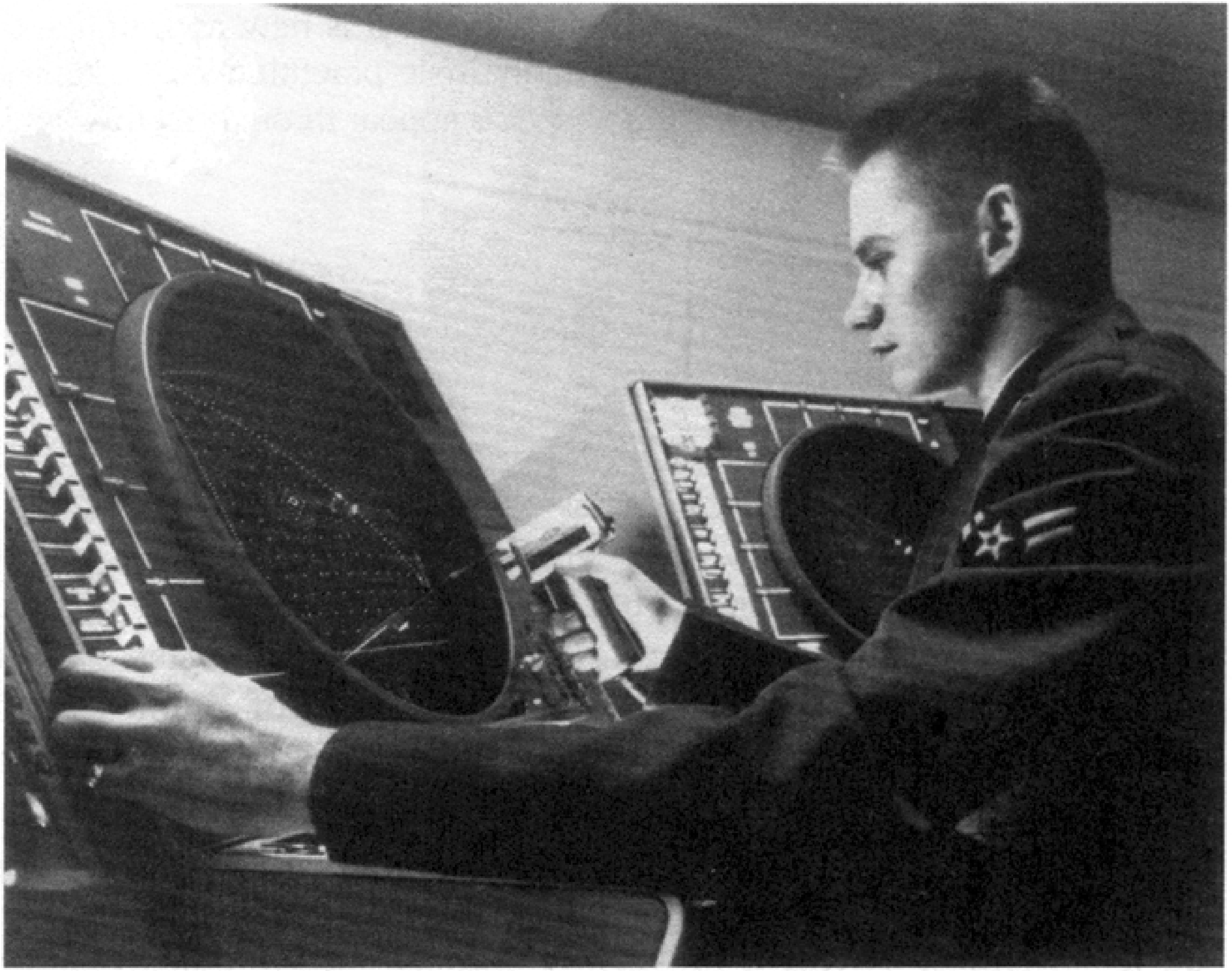
Display projectors



From Hearn and Baker

Interaction

- Key to the games industry
- Key to most current user interfaces
- Idea dates back to ‘55, at least
- Sketchpad was the first interactive graphics system where user could author displays (‘63 thesis, Ivan Sutherland)

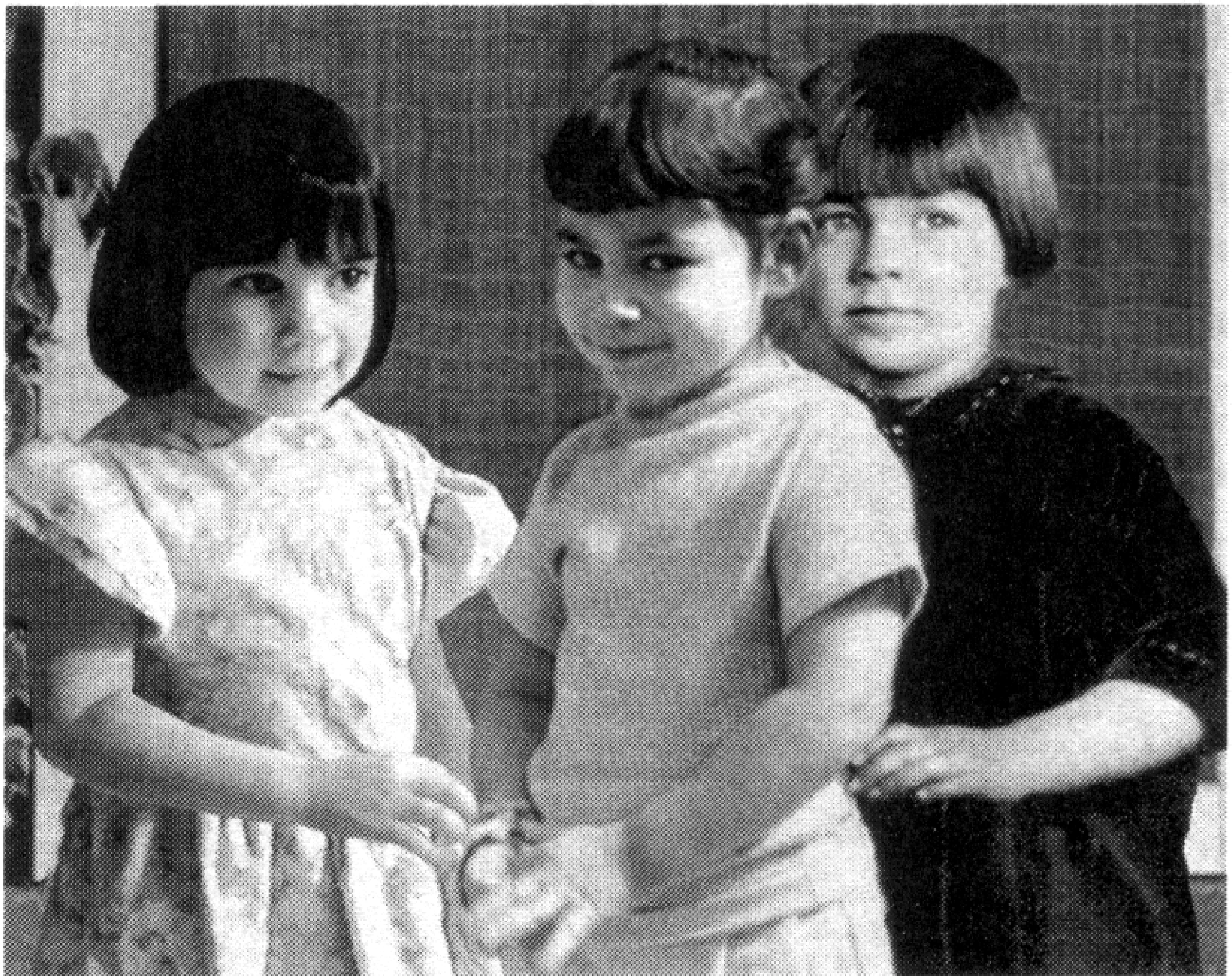


SAGE - aircraft target selection - 1958, from Spalter

Sketchpad, c 1955, from Spalter

Computer Art

- 2D graphics lends itself particularly well to sophisticated collages
  - Image editing and composition tools
  - Computer paint programs
  - User interfaces are improving - pressure sensitive tablets, etc.



Me, My Mom and My Girl at Three, 1992, Michele Turre

You Wish, from Tree Fix, 1997, Michele Turre

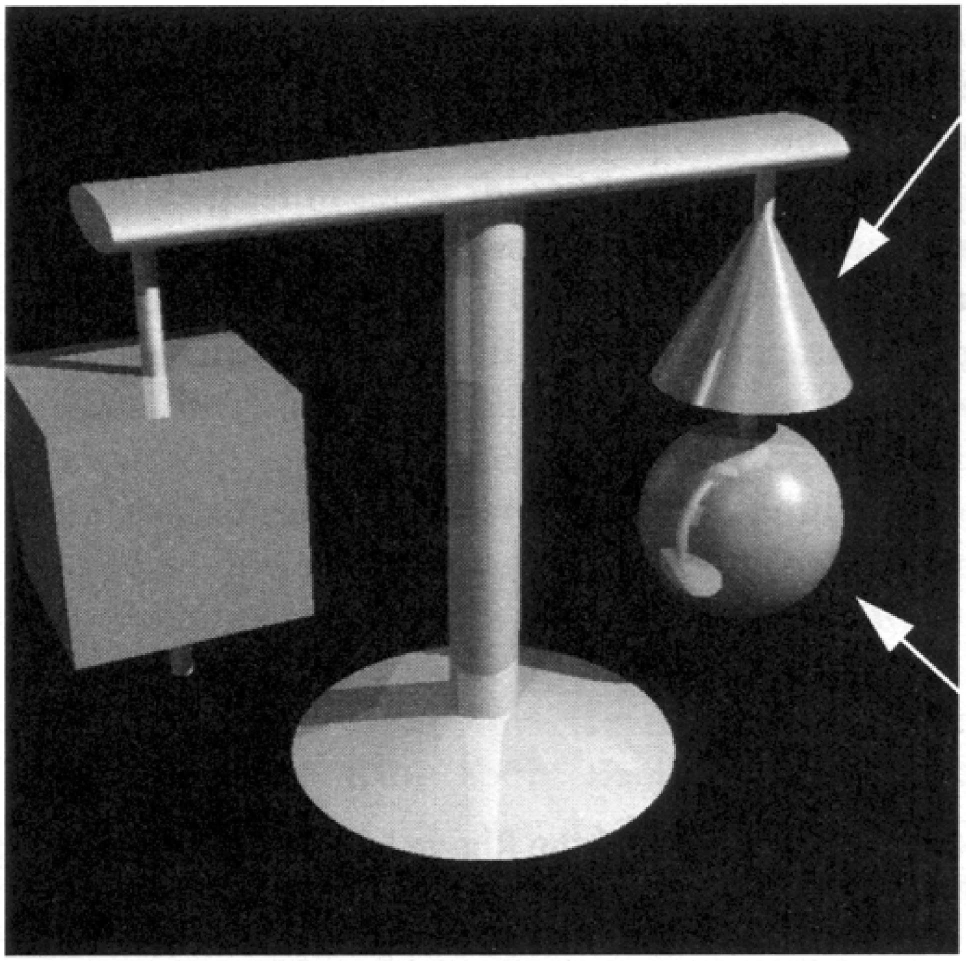
Enhancing the existing world

- Mix models with the real world
  - Movies!
- Allow operation planning
  - Neurosurgery
  - Plastic surgery
- Add information to a surgeons view to improve operation
  - Neurosurgery

From Eric Grimson’s research group at MIT

Rendering takes a model to a picture

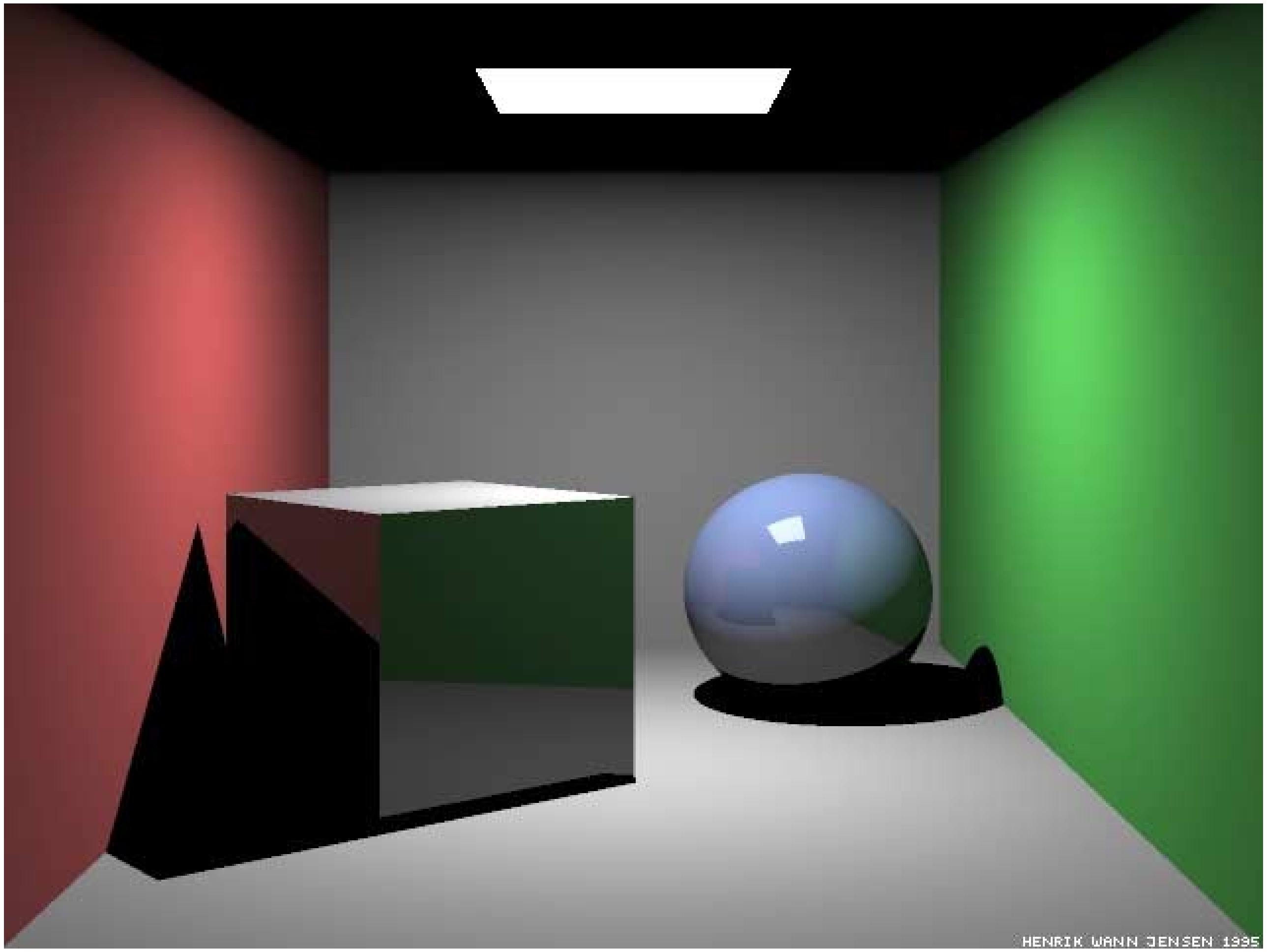
```
trans [
scale 1.03 1.03 1.03
translate -1.55 0.29 0
object cube [
diffuse 0.9 1 0.9
ambient 0.06 0.05 0.07
specular 0.9 0.9 0.9
reflect 0.38 0.38 0.38
shine 30
]
]
```



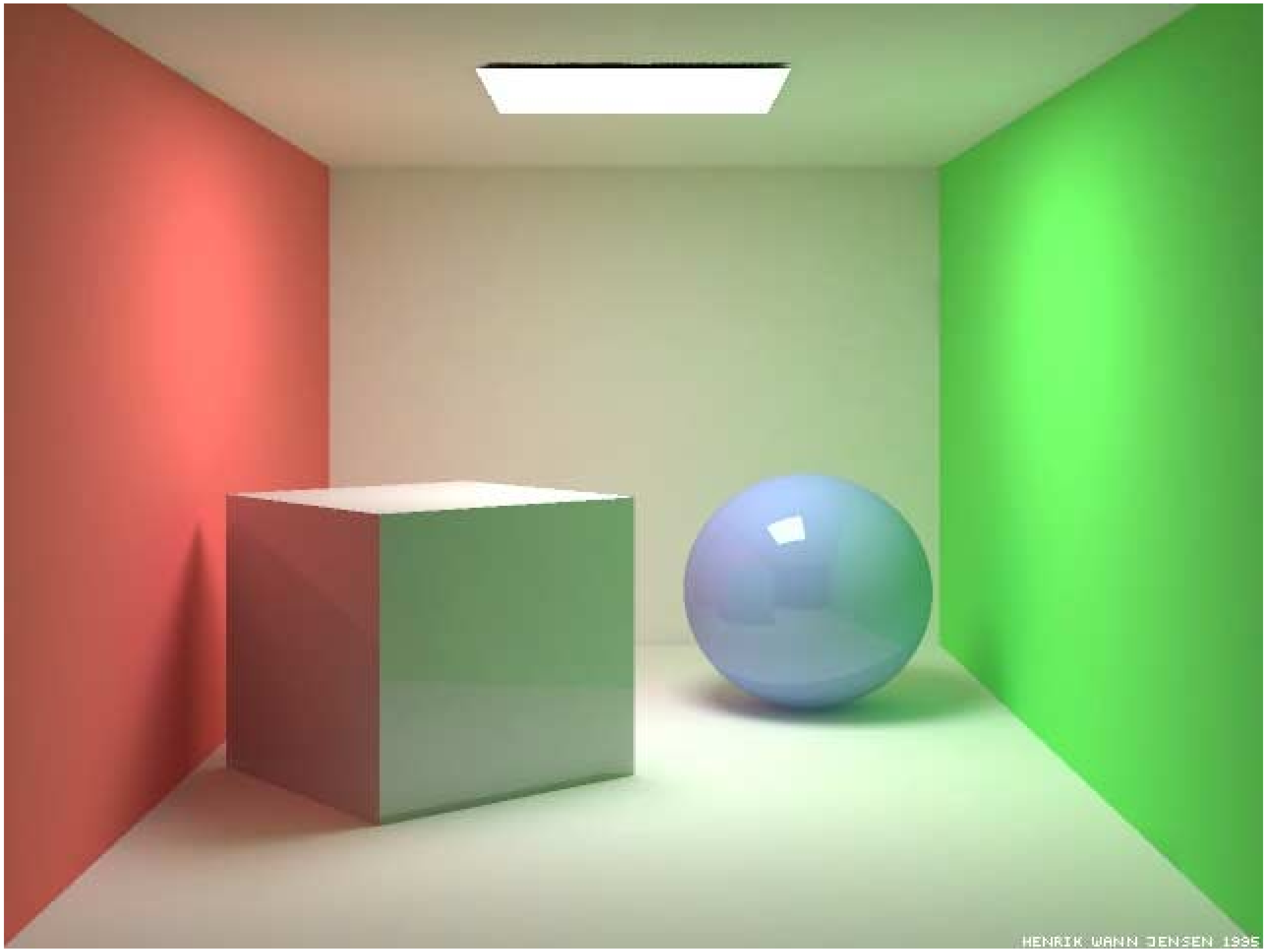
```
trans [
translate 1.55 0.74 0
scale 1.04 0.93 1.04
object cone [
diffuse 0.9 1 0.9
ambient 0.06 0.05 0.07
specular 0.9 0.9 0.9
reflect 0.47 0.47 0.47
shine 30
]
]
```

```
trans [
translate 1.55 -0.53 0
scale 1.1 1.1 1.1
object sphere [
diffuse 0.9 1 0.9
ambient 0.06 0.05 0.07
specular 0.9 0.9 0.9
reflect 0.42 0.42 0.42
shine 30
]
```

PCKTWTCH by Kevin Odhner, POVRay

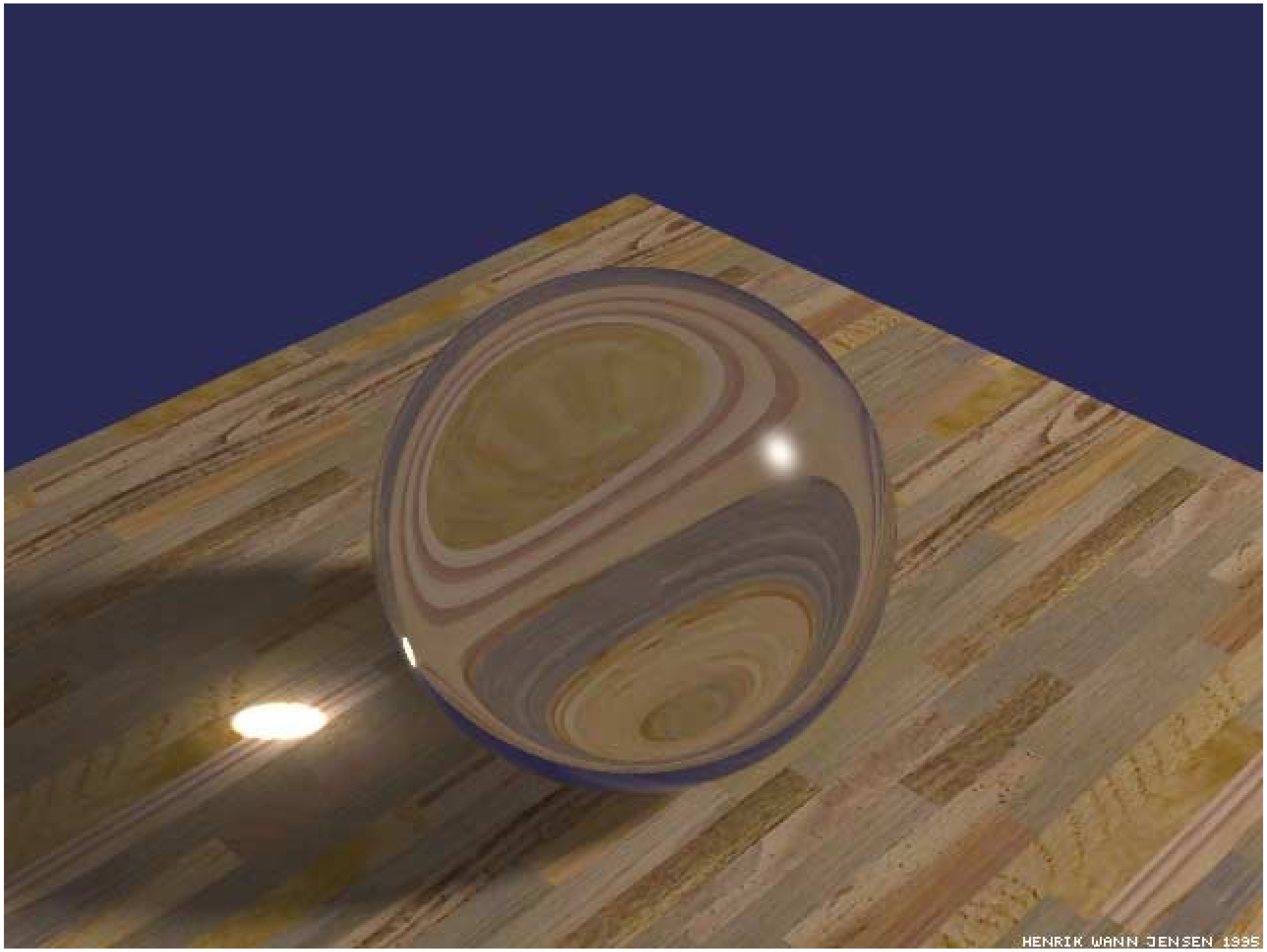


Ray-traced Cornell box, due to Henrik Jensen,
http://www.gk.dtu.dk/~hwj



Radiosity Cornell box, due to Henrik Jensen,
http://www.gk.dtu.dk/~hwj, rendered with ray tracer

Refraction caustic



Henrik Jensen, http://www.gk.dtu.dk/~hwj

Refraction caustics

Henrik Jensen, http://www.gk.dtu.dk/~hwj

Course homepage

http://www.cs.arizona.edu/classes/cs433/fall02/index.html

Note the homework on this page, which is
Due Tuesday, Sep, 17, Midnight.

Course Outline

- Intro (1 week)
- Rendering (6 weeks)
  - Proceeding from a geometrical, etc. model to an image or movie
  - Involves understanding
    - Displays
    - Geometry
    - Cameras
    - Visibility
    - Illumination
  - Technologies
    - the rendering pipeline
    - ray tracing
- Modelling (3 weeks)
  - Producing a geometrical, or other kind of model that can be rendered.
  - Involves understanding
    - Yet more geometry
    - A little calculus
- Misc (2-3 weeks)
  - colour
  - animation
  - advanced rendering
- Exam, review (1-2 weeks)

OpenGL and GLUT

- Layer between your program and lower levels (hardware, low level display issues)
- Provides primitives
  - points
  - lines
  - polygons
  - bitmaps, fonts
- Provides standard graphics facilities
  - We will learn how some of these work. Some assignments will therfore have some routines “out of bounds”
  - GLUT simplifies interactive program development with intutive callbacks and additional facilities (menus, window management).

OpenGL and GLUT

Demo and discussion of example program

http://www.cs.arizona.edu/classes/cs433/fall02/triangle.c

OpenGL and GLUT

- Initialization code from the example

```
/* initialize GLUT system */
glutInit(&argc, argv);

glutInitDisplayMode(GLUT_RGB | GLUT_DOUBLE);
glutInitWindowSize(400,500);          /* width=400pixels height=500pixels */
win = glutCreateWindow("Triangle");   /* create window */

/* From this point on the current window is win */

/* set background to black */
glClearColor((GLclampf)0.0,(GLclampf)0.0,(GLclampf)0.0,(GLclampf)0.0);
gluOrtho2D(0.0,400.0,0.0,500.0); /* how object is mapped to window */
```

OpenGL and GLUT

- Window display callback. You will likeley also call this function. Window repainting on expose and resizings is done for you

```
/* set window's display callback */
glutDisplayFunc(display_CB);
```

```
static void display_CB(void)
{
    glClear(GL_COLOR_BUFFER_BIT);         /* clear the display */

    /* set current color */
    glColor3d(triangle_red, triangle_green, triangle_blue);

    /* draw filled triangle */
    glBegin(GL_POLYGON);

    /* specify each vertex of triangle */
    glVertex2i(200 + displacement_x, 125 - displacement_y);
    glVertex2i(100 + displacement_x, 375 - displacement_y);
    glVertex2i(300 + displacement_x, 375 - displacement_y);

    glEnd();           /* OpenGL draws the filled triangle */
    glFlush();         /* Complete any pending operations */

    glutSwapBuffers(); /* Make the drawing buffer the frame buffer
                          and vice versa */
}
```

OpenGL and GLUT

- User input is through callbacks, e.g.,

```
/* set window's key callback */
glutKeyboardFunc(key_CB);

/* set window's mouse callback */
glutMouseFunc(mouse_CB);

/* set window's mouse move with button pressed callback */
glutMotionFunc(mouse_move_CB);
```

```
static void key_CB(unsigned char key, int x, int y)
{
    if( key == 'q' ) exit(0);
}

/*  /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\   */

/* Function called on mouse click */
static void mouse_CB(int button, int state, int x, int y)
{
    /*
     *  Code which responses to the button, the state (press, release),
     *  the pointer was when the mouse event occured (x, y).
     *
     *  See example on-line for sample code.
    */
}

/*  /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\ /\   */

/* Function called on mouse move while depressed. */
static void mouse_move_CB(int x, int y)
{
    /* See example on-line for sample code. */
}
```

OpenGL and GLUT

- GLUT makes pop-up menus easy. We will save development time by using (perhaps abusing) this facility.

```
/* Create a menu which is accessed by the right button. */
submenu = glutCreateMenu(select_triangle_color);
glutAddMenuEntry("Red", KJB_RED);
glutAddMenuEntry("Green", KJB_GREEN);
glutAddMenuEntry("Blue", KJB_BLUE);
glutAddMenuEntry("White", KJB_WHITE);
glutCreateMenu(add_object_CB);
glutAddMenuEntry("Triangle", KJB_TRIANGLE);
glutAddMenuEntry("Square", KJB_SQUARE);
glutAddSubMenu("Color", submenu);
glutAttachMenu(GLUT_RIGHT_BUTTON);
```

OpenGL and GLUT

- Ready for the user!

```
/* start processing events... */
glutMainLoop();
```

- For the rest of the code see
  http://www.cs.arizona.edu/classes/cs433/fall02/triangle.c