Lecture 7:
Input and Interaction

http://www.gameinformer.com
Today's lecture

- Interaction with OpenGL
  - Code examples
- Input Devices
- Haptics
- Examples from our research group
GLUT – Useful for interaction

- GLUT (OpenGL Utility Toolkit)
  - Simplifies window handling
  - User interface functions
  - Available from opengl.org
  - Methods begin with glut, e.g.
    ```
    glutInitWindowSize( 700, 700 );
    ```
Input and interaction

- Event driven: CPU waits on the device before it does anything
- Examples:
  - keyboard
  - Mouse
  - Joystick
Callback functions

- Used for input and interaction
- The user submits a pointer to a function that should be called when the corresponding event occurs
- GLUT provides an easy-to-use interface
Callback functions

```c
glutKeyboardFunc(function);       // keyboard
glutSpecialFunc(function);        // arrows, pgup
glutMouseFunc(function);          // click mouse
glutMotionFunc(function);         // move mouse
glutPassiveMotionFunc(function);  // no button
glutJoystickFunc(function);       // joystick
glutReshapeFunc(function);        // window resize
glutIdleFunc(function);           // animation
glutDisplayFunc(function);        // draw primitives
```
int main(int argc, char **argv) {
    initGLUT(argc, argv);
    initGL();

    //Set the display callback
    glutDisplayFunc(draw);

    //Set the keyboard callback
    glutKeyboardFunc(keyboard);

    //Start the GLUT main event loop.
    glutMainLoop();
    return 0;
}
Keyboard interaction

//keyboard callback
void keyboard(unsigned char key, int x, int y) {
    printf("User pressed the %c key\n", key);
    glutPostRedisplay();
}

//keyboard callback

void keyboard(unsigned char key, int x, int y)
{
    switch(key)
    {
    case 'r':
        globals.color = glm::vec3(1.0, 0.0, 0.0);
        break;
    case 'g':
        globals.color = glm::vec3(0.0, 1.0, 0.0);
        break;
    case 'b':
        globals.color = glm::vec3(0.0, 0.0, 1.0);
        break;
    }
}
Keyboard interaction

'\textcolor{red}{r}' \quad \textbf{Coding time!} \quad '\textcolor{green}{g}''
int main(int argc, char **argv) {
    ...

    // Set the keyboard callback
    glutKeyboardFunc(keyboard);

    glutMouseFunc(mouse);
    glutPassiveMotionFunc(passiveMotion);
    glutMotionFunc(motion);

    ...
}

Mouse interaction
Mouse interaction

// mouse callback
void mouse(int button, int state, int x, int y) {
    if (button == GLUT_LEFT_BUTTON && state == GLUT_DOWN) {
        printf("Left mouse button pressed");
    }
}
Mouse interaction

// mouse motion callback
void motion(int x, int y) {
    globals.position.x = double(x) / globals.width;
    globals.position.y = 1.0 - double(y) / globals.height;
    glutPostRedisplay();
}

Mouse Coordinate System

- Integers
- Closest pixel
- Origin: upper left corner

[0,0]

[width, height]
Mouse interaction

Coding time!
```c
int main(int argc, char **argv) {
    ...

    glutKeyboardFunc(keyboard);
    glutMouseFunc(mouse);
    glutPassiveMotionFunc(motion);

    glutIdleFunc(idle);

    ...
}
```
Idle Function

// idle callback
void idle() {
    double elapsed_time = double(glutGet(GLUT_ELAPSED_TIME));
    printf("Elapsed time: %f\n", elapsed_time);
    glutPostRedisplay();
}

Can be used to create animations! (Lab1)
OpenGL in GUI applications

• Basic keyboard and mouse interaction sufficient for small applications.
• Often, we need more (menus, buttons, sliders,... )
GLUI
(http://www.cs.unc.edu/~rademach/glui/)

• Minimal library for GUI:s, really easy to use
• All rendering done with OpenGL
• Good for simple applications
• Limited functionality
• Multi-platform (Windows, OS X, Linux)
• Open Source
• Large feature set
• OpenGL supported through wxGLCanvas class.
Qt (http://qt-project.org/)

- Multi-platform (Windows, OS X, Linux)
- Open Source (since 2008)
- Large feature set
- OpenGL support.
Questions so far…?
Input Devices
Input Device Characteristics

Based on the properties they measure:

- e.g. Degrees of Freedom (DoF)
  Number of independent spatial properties of an object
  Modality: spatial vs. non-spatial

How properties are reported:

- Discrete or continuous (value and time)

Based on users intervention:

- Active vs. passive (passive are rather monitoring devices)

Intended use

- spatial vs. non-spatial properties (location vs. value)
- absolute vs. relative input
# Desktop Input Devices

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| **Keyboards**                    | - Discrete (value and time)  
- Active  
- Symbolic, non-spatial          |
| **2D Mice and Trackballs**       | - Spatial 2D, necessitated by WIMP  
- Active, continuous locator  
- **Relative** position control  
- Predominant for desktop 2D GUI  
- Trackball is conceptually a mouse |
| **Pen-based Tablets**            | - Spatial 2D, necessitated by WIMP  
- Active, continuous locator  
- **Absolute** position control  
- Handheld device GUI  
- Facilitate handwriting          |
| **Joysticks**                    | - Active  
- A) **isotonic** rate control, location relative, constant force  
- B) **isometric**, location absolute, proportional to applied force |
| **6-DOF Devices for the Desktop**| - Spatial 3D input, 6 DOF  
- Active, continuous locator  
- Relative location, rate control  
- Used for 3D object manipulation (CAD/CAM)  
- Rate control hampers fine positioning |
# Desktop Input Devices

## Direct (absolute) 2D position input

<table>
<thead>
<tr>
<th>Mode of interaction</th>
<th>Stylus (indirect)</th>
<th>Direct-Touch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-located</td>
<td>Virtual Mummy on Compaq TabletPC</td>
<td>e.g. Microsoft PixelSense</td>
</tr>
<tr>
<td>Not Co-located</td>
<td>Anoto Optical Pen (Intelligent Paper)</td>
<td>Integrated Touch Pad Multiple Points of Interaction</td>
</tr>
<tr>
<td>Visual feedback</td>
<td>Digitizing Tablet</td>
<td>Stand-alone Touch Pad</td>
</tr>
</tbody>
</table>

**Visual feedback**:
- Direct
  - Touch
- Co-located
- Not Co-located

**Mode of interaction**:
- Direct
- Stylus (indirect)
Eye Tracking

More specifically:
- Eye tracking (registering movement of the eye)
- Gaze tracking (registering point of gaze)
- Gaze tracking requires head-tracking and eye tracking!

Two established techniques:
- Optical tracking (corneal reflection method)
- Electrical potential (EOG - electro oculogram)

Use:
- Analysis of human computer user interfaces
- Analysis of visual scan patterns/preferences
- Of limited value for precise and controlled interaction
Motion Tracking

Awesome Dog Motion Capture Studio
1MD020 Advanced Visual Interfaces

Advanced visual interfaces go beyond the limits of flat 2D computer displays and conventional 2D interaction metaphors.

Some examples for advanced visual interfaces are stereoscopic 3D environments, spatial projection displays, or augmented reality based on hand-held or head-mounted displays.

5 Credits
Teacher: Stefan Seipel
Haptics refers to the sense of touch (from Greek ἅπτω [haːptɔː] = "I fasten onto, I touch").

**Haptic perception**, the process of recognizing objects through touch.

**Haptic technology**, technology that interfaces with the user through the sense of touch.

A highly cross-disciplinary field: HCI, mechanical engineering, computer science, control theory, robotics, psychology, physiology, etc.
Haptic Perception

Tactile Perception
Surface textures, vibrations

Proprioception
The sense of the relative position of neighbouring body parts.

Images: Ion Design (top left), Therapeutic Play (bottom left), Maria Ly (right)
Bi-directionality

Our haptic sense and motor (muscle) control are closely tied.

The designer can feel the clay and affect its shape at the same time.
Haptic Devices/Displays

- Can generate the perception of touching and/or manipulating virtual objects.
- Many haptic devices are bi-directional.
- Upon contact with a virtual object, the handle stops, giving the impression that we are in contact with a real object!
Novint

Novint Falcon

- 3 DOF positional sensing, 3 DOF actuated output
- Workspace: 102 W x 102 H x 102 D mm
- Maximum exertable force: Approximately 8.9 N
- Cheap model primarily for gaming/hobbyist use ($250 USD)
Phantom Premium 1.5

- 6 DOF positional sensing, 3/6 DOF actuated output
- Workspace: 381 W x 267 H x 191 D mm
- Friction (xyz): 0.04 N (0.2 N high force model)
- Maximum force: 8.5 N, (37.5 N high force model)
Haption

VIRTUOSE 6D35-45

6DOF positional/rotational sensing, 6 DOF actuated output
Workspace: Very large, depends on positions of motors
Rotations: ±40º around all three axes.
Maximum force: 40N, torque: 5 Nm
Cyberglove

Cybergrasp Glove, 5 Actuated DOF, 12 N max/finger, 22 angular sensors in glove.
Games

Joystick with Force Feedback

Vibrotactile feedback in gaming console

Tactile Gaming Vest (TGV). Solenoids generate punches when the user is “shot” in the game. In addition, the TGV displays the sensation of blood flow using heating elements...!
Design

Geomagic Claytools

Image: http://www.geomagic.com
Task Training (Surgery)

Laparoscopic surgery training with haptics\(^1\)

\(^1\) Courtecuisse et al. GPU-based real-time soft tissue deformation with cutting and haptic feedback
Rehabilitation

Haptic devices clinically used in post-stroke rehabilitation, and in research on various diseases such as Cerebral Palsy, Multiple Sclerosis and Spinal Cord Injury.

InMotion 2.0 Shoulder/Arm Robot
Planar 900x600mm workspace, 30N maximum continuous force output
Typical Visual/Haptic System

- **Graphics Engine** (~ 60 Hz)

- **Dynamic Simulation** (~ 1 kHz)

  - Virtual object position/rotation

  - Display

  - Haptic Device

  - User

- **Position, Rotation**

- **Force**

- **Graphics**
Visual/Haptic System

Combined stereo-graphics and haptic display at Vi2.
CMF Surgery Planning with Stereo Graphics and Haptics

Ingrid Carlbom, Jan-Michaël Hirsch
Fredrik Nysjö, Johan Nysjö
Pontus Olsson
Feb 18, 2014
CMF Surgery Planning with Haptics

Our goal is a planning system for the restoration of skeletal anatomy after facial trauma that will:

- Improve the precision and reduce morbidity of the craniofacial reconstruction
- Reduce the time in the operating room (reduced cost)
Plan for the repositioning of the maxilla.
2D Interaction with 3D Data

- Only visual feedback
- No sense of touch (haptic feedback)
Our CMF Surgery Planning System

Stereo display and 3D haptic interaction
Step 1: Segment and Label Bone Fragments in CT Data, Assemble to 3D volume.
Step 2: Load Segmented 3D-Data into the Planning System
Video Demonstration
Visuo-Haptic Display System

- PHANToM Premium haptic device from Geomagic
- Active stereo graphics
- Head-tracking for “look-around”
- Co-location of graphical and haptic workspaces
Semi-Automatic Bone Segmentation
Haptic Glove

One Degree of Freedom
Force ~ 4 Newton
Haptic Glove at Uppsala University

The glove is powered by a small, integrated piezoelectric motor.
Spline Grip

Eight degrees of freedom virtual modelling tool with haptics.
Questions, thoughts, ideas?

Cybergrasp