## CSE 165: 3D User Interaction <br> Lecłure \#3: Stereo

Instructor: Jurgen Schulze, Ph.D.

## Announcements

- Homework Assignment \#1
- Due this Friday, January 16 ${ }^{\text {th }}$ at 1:00pm
- To be presented in CSE lab 220
- Anyone need a team partner?
- Paper presentations
- Title/date due by entering into wiki table on Ted by Sunday, January $18^{\text {th }}$
- Tips for paper download:
- Campus network for free digital library access
- Google Scholar


## Quaternions

## Rotation Calculations

- Intuitive approach: Euler Angles:
- Simplest way to calculate rotations
- Defines rotation by 3 sequential rotations about coordinate axes
- Example Z-Y-X:

$1^{k}$, the body frame yaws right an angle $y$ about the $z$-axis

$2^{\text {20 }}$, the body frame pitches up an angle $\theta$ about the $y^{\prime}$-axis

$3^{\text {nd }}$, the body frame rolls CW an angle $\phi$ about the $x^{\prime \prime}$-axis


## Problems With Euler Angles

- Problems with Euler angles:
- No standard for order of rotations
- Gimbal Lock, occurs in certain object orientations
- Video (0:20-1:12)
- http://www.youtube.com/watch? v=zc8b2Jo7mno
- Better: rotation about arbitrary axis (no Gimbal lock)
- Can be done with $4 \times 4$ matrix
- But: smoothly interpolating between two orientations is difficult
$\rightarrow$ Quaternions


## Quaternion Definition

- Given angle and axis of rotation:
- a: rotation angle
- \{nx,ny,nz\}: normalized rotation axis
- Calculation of quaternion coefficients w, x, y, z:
o $w=\cos (a / 2)$
- $x=\sin (a / 2)$ * $n x$
o $y=\sin (a / 2)$ * ny
o $z=\sin (a / 2)^{*} n z$


## Useful Quaternions

| w | x | y | z | Description |
| :---: | :---: | :---: | :---: | :---: |
| 1 | 0 | 0 | 0 | Identity quaternion, no rotation |
| 0 | 1 | 0 | 0 | $180^{\circ}$ turn around X axis |
| 0 | 0 | 1 | 0 | $180^{\circ}$ turn around $Y$ axis |
| 0 | 0 | 0 | 1 | $180^{\circ}$ turn around $Z$ axis |
| sqrt(0.5) | sqrt(0.5) | 0 | 0 | $90^{\circ}$ rotation around X axis |
| sqrt(0.5) | 0 | sqrt(0.5) | 0 | $90^{\circ}$ rotation around $Y$ axis |
| sqrt(0.5) | 0 | 0 | sqrt(0.5) | $90^{\circ}$ rotation around $Z$ axis |
| sqrt(0.5) | -sqrt(0.5) | 0 | 0 | $-90^{\circ}$ rotation around X axis |
| sqrt(0.5) | 0 | -sqrt(0.5) | 0 | $-90^{\circ}$ rotation around $Y$ axis |
| sqrt(0.5) | 0 | 0 | -sart(0.5) | $-90^{\circ}$ rotation around $Z$ axis |

## Quaternions in Bullet

- Quaternions can be specified by rotation angle and axis:
o btQuaternion(const btVector3 \&_axis, const btScalar \&_angle)
- Or by an $x, y, z, w$ tuple:

O btQuaternion(const btScalar \&_x, const btScalar \&_y, const btScalar \&_z, const btScalar \&_w)

- Bullet defines mathematical and other operators:

```
O +, -, *, /, inverse, getAngle, getAxis,
    slerp, etc.
```


## Quaternions: Further Reading

- Gamasutra: Rotating Objects Using Quaternions
- http://www.gamasutra.com/view/feature/1316 86/rotating objects using quaternions.php
- Quaternions in Ogre3D:
- http://www.ogre3d.org/tikiwiki/Quaternion+and +Rotation+Primer
- Quaternions in OSG:
- http://www.openscenegraph.org/projects/osg/ wiki/Support/Maths/QuaternionMaths


## 3D Displays

## Introduction To Displays

- Display: device which presents perceptual information
- Often term "display" is used for "visual display"
- Goal: display devices which accurately represent visual perception in a simulated world


## Lecture Outline

- Visual System
- Depth Cues
- Visual Display Characteristics
- Visual Display Examples
- monitors
- surround screen displays
- workbenches
- head mounted displays
- arm-mounted displays
- virtual retinal displays
- autostereoscopic displays


## Depth Cues How Do We See 3D?

- Monocular/static cues
- Occulomotor cues (Accommodation/Convergence)
- Motion Parallax
- Binocular Disparity and Stereopsis


## Monocular/Static Cues

- Relative Size



## Monocular/Static Cues

- Height relative to horizon



## Monocular/Static Cues

- Occlusion


Depth perception based on overlapping. The object with more continuous border line is felt to lie closer. In figure (a) it is the larger rectangle and in figure (d) it is the smaller. In figures (b) and (c) no depth information can be obtained.
http://www.hitl.washington.edu/projects/knowledge_base/virtua l-worlds/EVE/III.A.1.c.DepthCues.htm/

## Monocular/Static Cues

- Linear Perspective



## Monocular/Static Cues

- Shading, Lighting, and Texture



## Oculomotor Cues

- Accommodation - physical stretching and relaxing of eye lens
- Convergence - rotation of viewer's eyes so images can be fused together at varying distances



## Motion Parallax

- Stationary viewer vs. moving viewer



## Binocular Disparity and Stereopsis

- Each eye gets a slightly different image
- Only effective within a few feet of viewer
- Many implementation schemes



## AccommodationConvergence Mismatch

- Standard stereo displays confuse the brain based on oculomotor cues

- Only "true 3D" displays can provide these correctly

Displays

## Visual Display Characteristics

- Field of View (FOV) and Field of Regard (FOR)
- FOR - amount of physical space surrounding viewer in which visual images appear
- FOV - maximum visual angle seen instantaneously
- Spatial Resolution
- number of pixels and screen size
- Screen Geometry
- rectangular, hemispherical, etc...
- Light Transfer Mechanism
- front projection, rear projection, laser light, etc...
- Refresh Rate
- not the same as frame rate
- Ergonomics

