CSE 165: 3D User Interaction

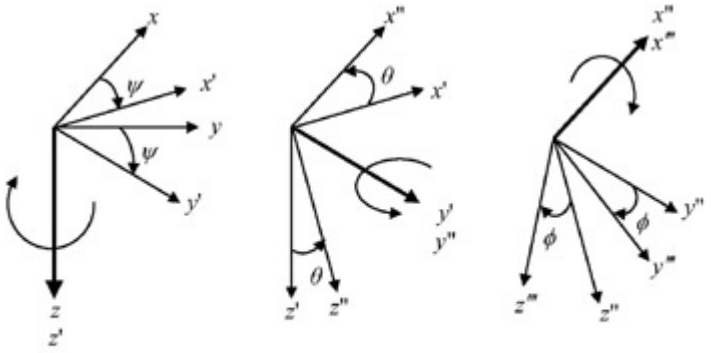
Lecture #5: Quaternions

Announcements

- Homework project 1 is due Friday

Rotation Calculations

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



1st, the body frame yaws right an angle ψ about the z-axis

2nd, the body frame pitches up an angle θ about the y'-axis

3rd, the body frame rolls CW an angle ϕ about the x''-axis

http://www.globalspec.com/reference/49379/203279/3-3-euler-angles

Problems With Euler Angles

- Problems with Euler angles:
  - No standard for order of rotations
  - Gimbal Lock, occurs in certain object orientations
    - Video
      - https://www.youtube.com/watch?v=rrUCBOlJdt4
- Better: rotation about arbitrary axis (no Gimbal lock)
  - Can be done with 4x4 matrix
  - But: smoothly interpolating between two orientations is difficult

➔ 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:
  - w = cos(a/2)
  - x = sin(a/2) * nx
  - y = sin(a/2) * ny
  - z = sin(a/2) * nz

Useful Quaternions

w	x	y	z	Description
1	0	0	0	Identity quaternion, no rotation
0	1	0	0	180° turn around X axis
0	0	1	0	180° turn around Y axis
0	0	0	1	180° turn around Z axis
sqrt(0.5)	sqrt(0.5)	0	0	90° rotation around X axis
sqrt(0.5)	0	sqrt(0.5)	0	90° rotation around Y axis
sqrt(0.5)	0	0	sqrt(0.5)	90° rotation around Z axis
sqrt(0.5)	-sqrt(0.5)	0	0	-90° rotation around X axis
sqrt(0.5)	0	-sqrt(0.5)	0	-90° rotation around Y axis
sqrt(0.5)	0	0	-sqrt(0.5)	-90° rotation around Z axis

Quaternions: Further Reading

- Rotating Objects Using Quaternions
  - http://www.gamasutra.com/view/feature/131686/rotating_objects_using_quaternions.php
- Quaternions in Unity 3D:
  - https://docs.unity3d.com/ScriptReference/Quaternion.html
- Quaternions in OpenSceneGraph:
  - http://www.openscenegraph.org/projects/osg/wiki/Support/Maths/QuaternionMaths