

# Musculoskeletal Biomechanics BIOEN 520 | ME 527

### Session 4A

Kinematics and Kinetics

#### Review: Session 3B

- Motion capture systems
  - Retro-reflective vs. active vs. electromagnetic
- Force plates
  - Strain gage vs. piezoelectric
- Pressure plates
  - Capacitive vs. force sensing resistors
- Cadaveric gait simulation

#### Session 4 Overview...

- Review/complete session 3B
  - Markerless motion analysis
  - Cadaveric Gait Simulation
    - Kinematics and kinetics of the RGS
- Kinematic highlights
- Kinematics and kinetics of gait analysis
- Homework 1
- Mini-Lab 2: Grant writing
- Final project

#### **Motion Capture**

- Markerless
  - Organic Motion
    - Developer of world's only professional markerless motion capture software and systems.
    - Biostage 14 to 24 cameras



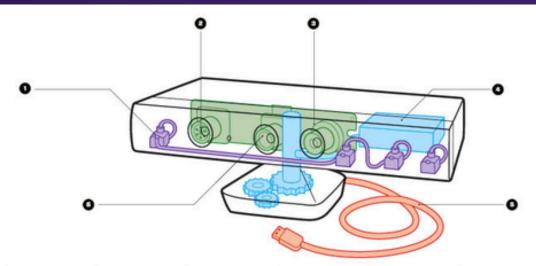


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#### **Motion Capture**

- Markerless
  - Kinect
    - Microphone array
    - IR emitter
    - Depth camera
    - Color camera





Microphone array Four mics pinpoint where voices or sounds are coming from while filtering out background noise.

IR emitter
Projects a
pattern of
infrared light into
a room. As the
light hits a
surface, the
pattern becomes
distorted, and
the distortion is
read by the
depth camera.

Depth camera
Analyzes IR
patterns to build
a 3-D map of the
room and all
objects and
people within it.

Tilt motor
Automatically adjusts based on the object in front of it. If you're tall, it tilts the box up. If you're short, it knows to angle down.

USB cable
Transmits data to the Xbox via an unencrypted feed, which makes it relatively easy to use the Kinect with other devices.

Color camera
Like a webcam, this captures a video image. The Kinect uses that information to get details about objects and people in the room.

https://www.quora.com/How-does-Microsofts-Kinect-work-from-a-technology-standpoint

http://www.businessinsider.com/why-microsoft-xbox-kinect-didnt-take-off-2015-9



#### **Motion Capture**

- Markerless
  - Strengths
    - Easier to collect no special suits, markers or equipment are required – just cameras
    - Less expensive systems
    - Real time
  - Weaknesses
    - Less accurate (1-2 cm??)

#### Cadaveric Gait Simulation

- Development of the robotic gait simulator (RGS)
- Kinematics and kinetics of the RGS
- Summary slide deck
  - Methods for quantifying foot kinematics
  - How the RGS works

#### Kinematic highlights

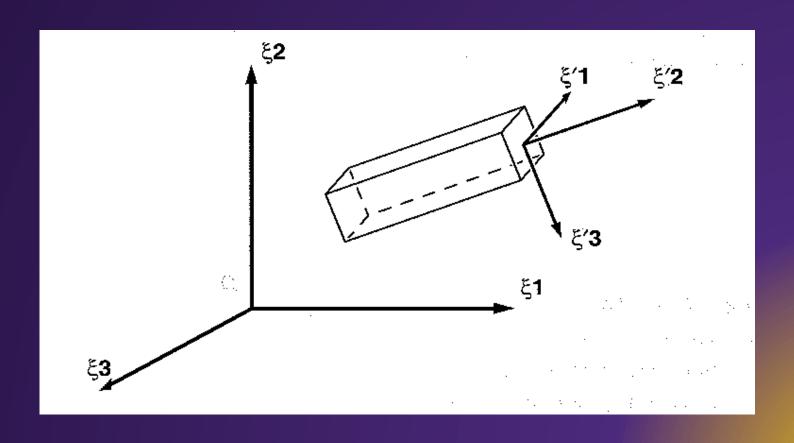
- Position vectors and rotation matrices
  - Craig chapter (on your own)
- Marker-based coordinate systems
  - Nigg and Herzog chapter p2
- Anatomic v. technical coordinate systems
  - Nigg and Herzog chapter p2
- Descriptions of rigid body kinematics
  - Nigg and Herzog chapter p5-6, 8-10

#### Kinematic highlights

- Position vectors and rotation matrices
  - Craig chapter (on your own)
    - Spatial Descriptions and Transformations
  - Position = vector
  - Rotation = matrix
  - Transformations between coordinate systems
  - Appendix on how to determine angles from transformation matrices

### Marker-based coordinate systems

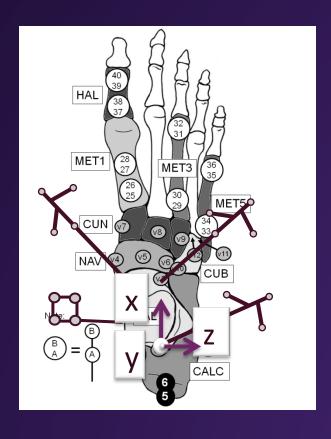
Nigg and Herzog p2



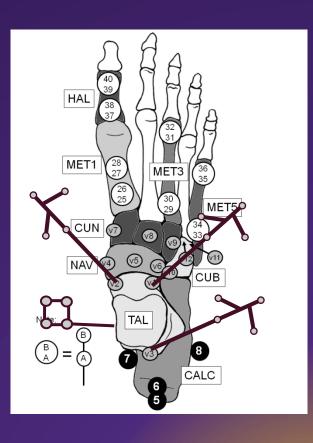
#### Anatomic v. technical coordinates

- Difference?
- Anatomical if possible
- Technical
  - Neutral position calibration
    - Medial malleolus marker
  - Digitization
    - Cadaver foot model
  - Nigg and Herzog chapter
    - Joint coordinate systems p2

#### Anatomic v. technical coordinates







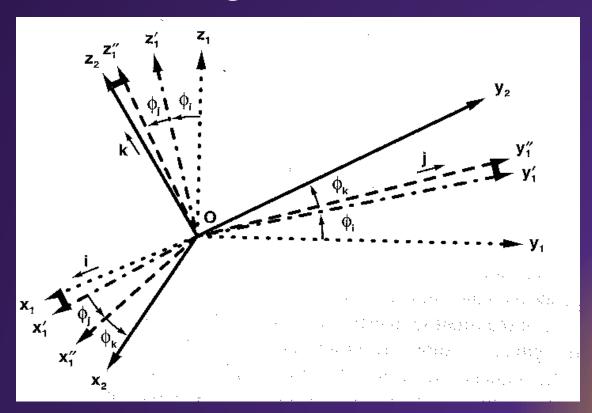
+Z axis: Lateral for right, Medial for left (sagittal plane)

+X axis: Anterior (coronal)

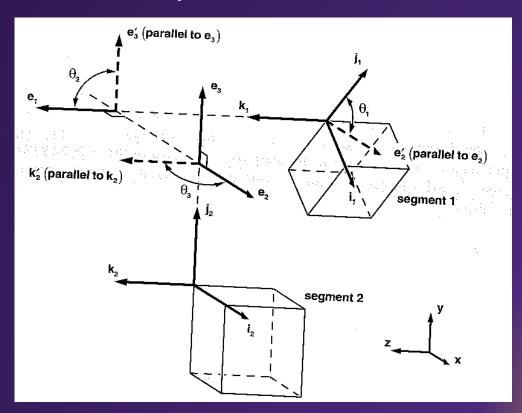
+Y axis: Superior (transverse)



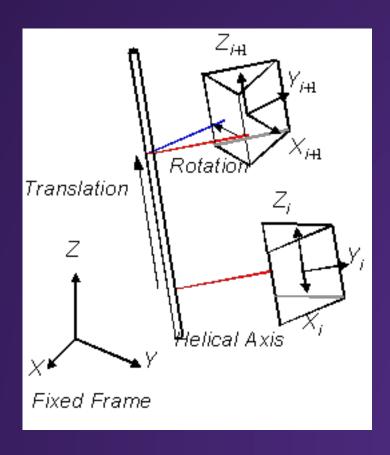
- Cardan/Euler angles
  - 3 independent rotations, sequence dependent
  - Similar to fixed angles



- Joint Coordinate System
  - Axes: flexion/extension; longitudinal; third
  - Grood and Suntay at the knee



- Finite helical axis:
  - axis orientation, translation, rotation



Helical angles (or axis-angle)

