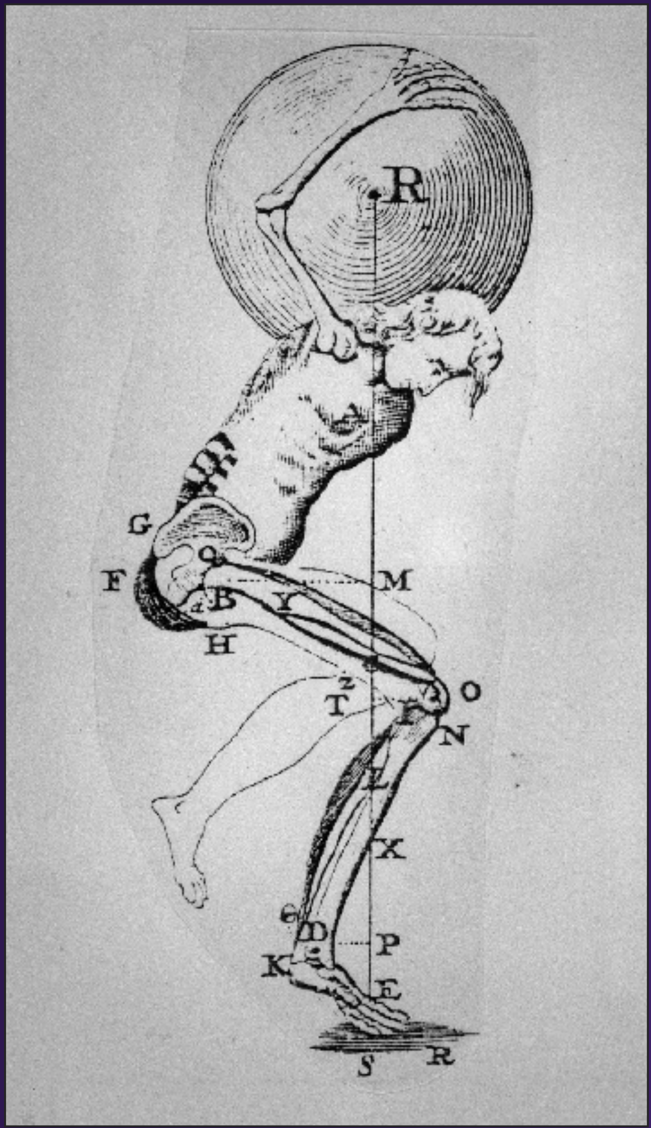


Musculoskeletal Biomechanics

BIOEN 520 | ME 527

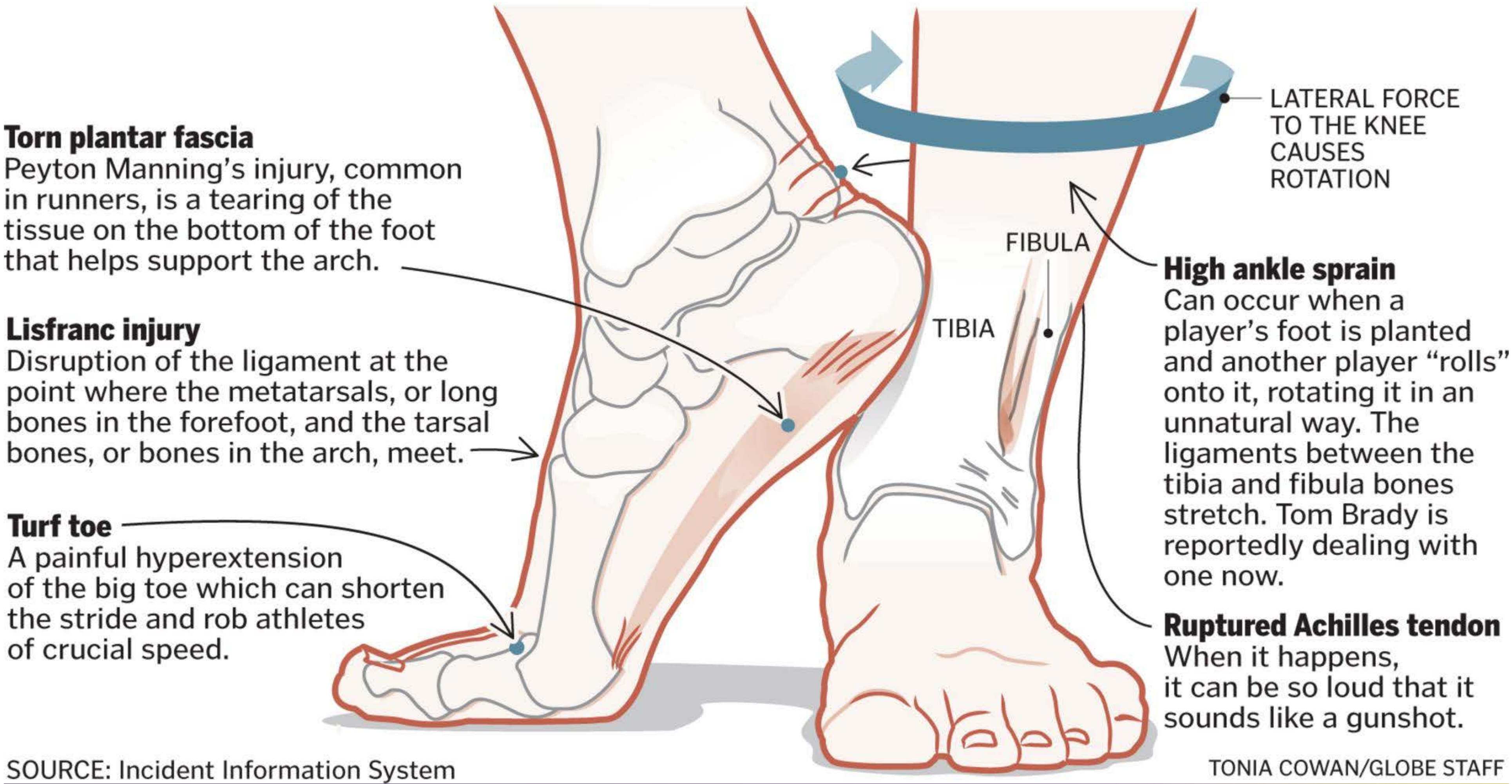
Session 3B

Tools of the Trade 2: (Mocap/Force Plates/ Pressure Plates/ Cadaveric Gait Simulation)

Foot injuries in the news

- Headline: Foot fetish: A brief -- and scientific -- review of foot injuries on the eve of the NFL playoffs - The Boston Globe
- Date: Jan 7, 2016
- Several key players, including Tom Brady, have contended with feet and ankle injuries this NFL season.
- http://tinyurl.com/zq92vpm

Foot injuries in the news



Review of Session 2A

- Define some basic terms: elasticity, plasticity, viscosity, and viscoelasticity
- Review simple, linear viscoelastic models
- Describe the important properties of viscoelastic materials
- Discuss concepts using in house data, as well as text books

Session 3B Overview…

- Motion capture
- Force plates
- Pressure measurement
- Cadaveric gait simulation

Motion Capture

- Retro-reflective markers
- Active markers
- Electromagnetic
- Markerless
- Other

Motion Capture

- Retro-reflective markers
  - How do this work?
  - Instrument subject with retro-reflective markers
  - High resolution cameras distributed around FOV
  - Strobe (near) infra-red light from cameras
  - Reflects of markers and onto sensors in cameras
  - Specialized software converts multiple 2D images into 3D description
    - Marker drop out, filtering
  - Why so many cameras?
    - Cover FOV, redundancy

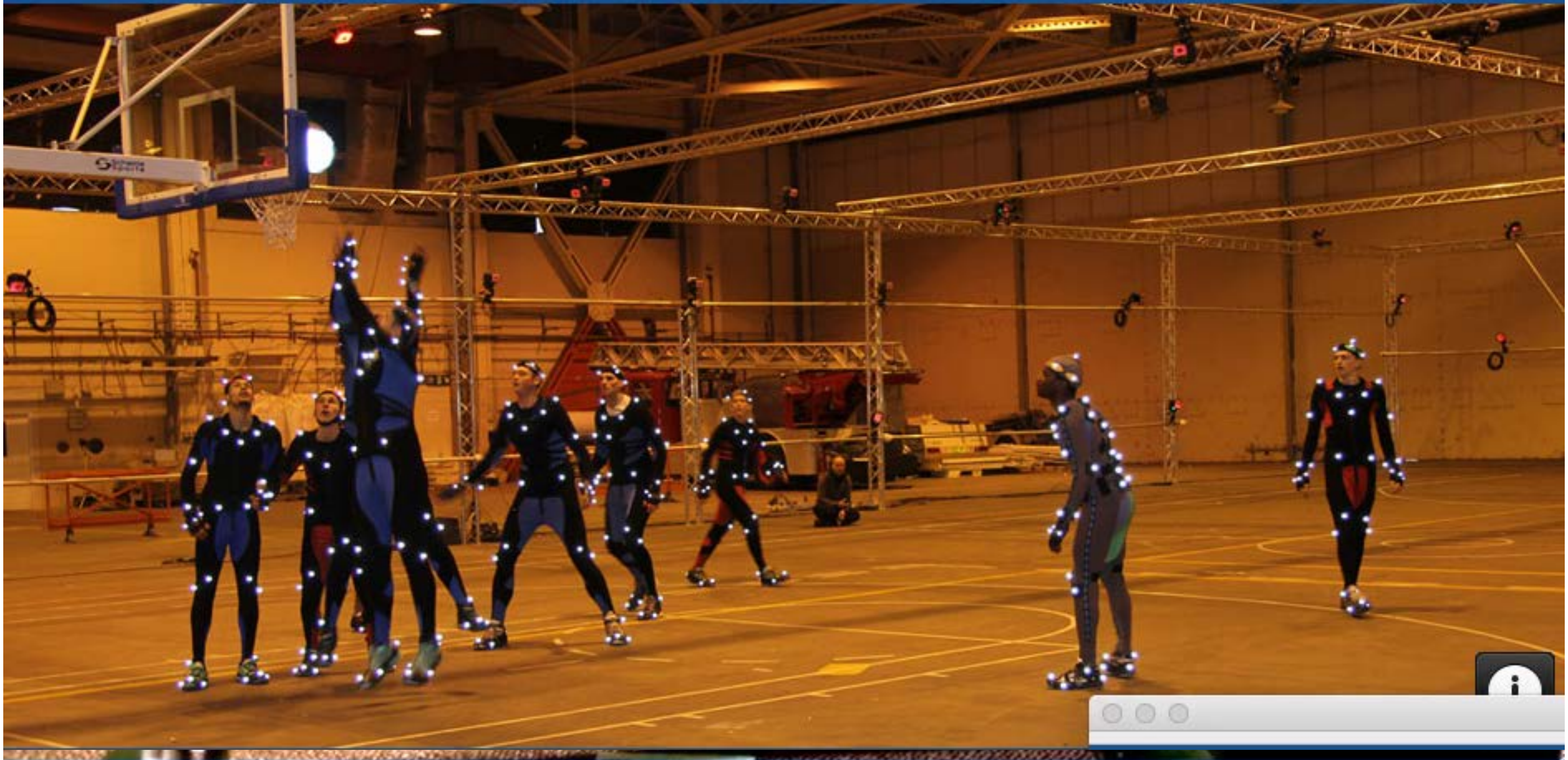
Motion Capture

- Retro-reflective markers
  - Vicon
    - Vantage – higher end
    - Bonita – affordable
    - Cara – facial motion capture

www.vicon.com

http://www.tft.ucla.edu/mediascape/Winter2011_Avatar.html

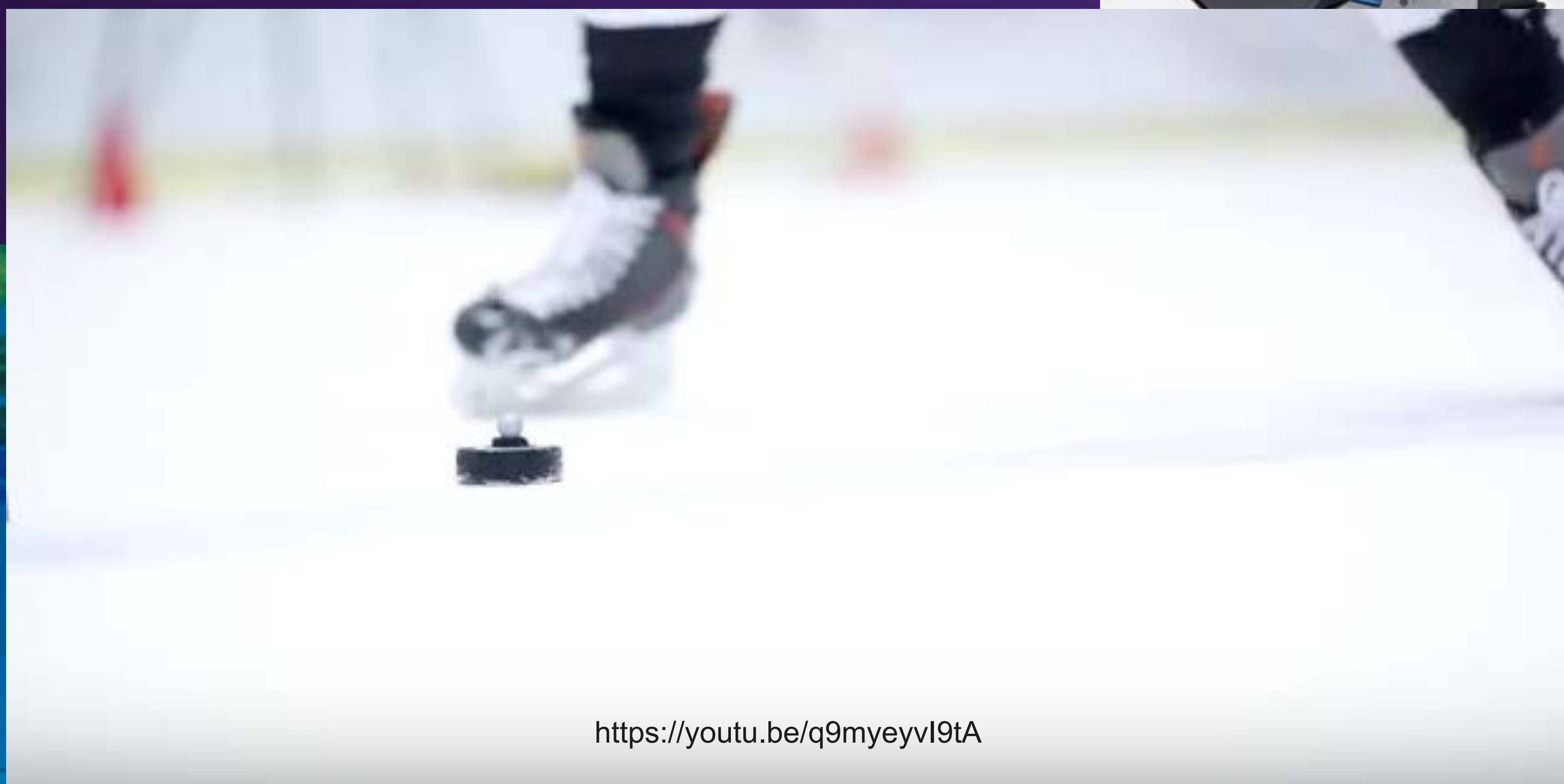
Motion Capture



www.motionanalysis.com

Motion Capture

- Retro-reflective markers
  - Qualysis



https://youtu.be/q9myeyvI9tA

www.qualysis.com

Motion Capture

- Retro-reflective markers
  - Strengths
    - Mature technology, most popular
    - Flexible
    - Relatively accurate (1-2mm)
  - Weaknesses
    - Can be labor intensive
    - Skin motion artifact
    - Expensive systems

Motion Capture

- Active markers
  - How does this work?
  - Similar to retro-reflective, but light emitted not reflected from markers
  - Synchronized to fire in a known pattern

Motion Capture

- Active markers
  - OptiTrack, Qualysis

www.optitrack.com

www.qualysis.com

Motion Capture

- Active markers
  - Strengths
    - Mature technology
    - Increased flexibility (active and passive)
    - Easier to process (no confusion about marker ID)
  - Weaknesses
    - Tethered (battery pack)
    - Skin motion artifact
    - Expensive systems (more than passive)

Motion Capture

- Electromagnetic
  - How does this work?
  - Transmitter creates orthogonal magnetic fields
  - Receivers move through fields, sense location

Motion Capture

- Electromagnetic
  - Polhemus, Ascension

www.polhemus.com

www.ascension-tech.com

Motion Capture

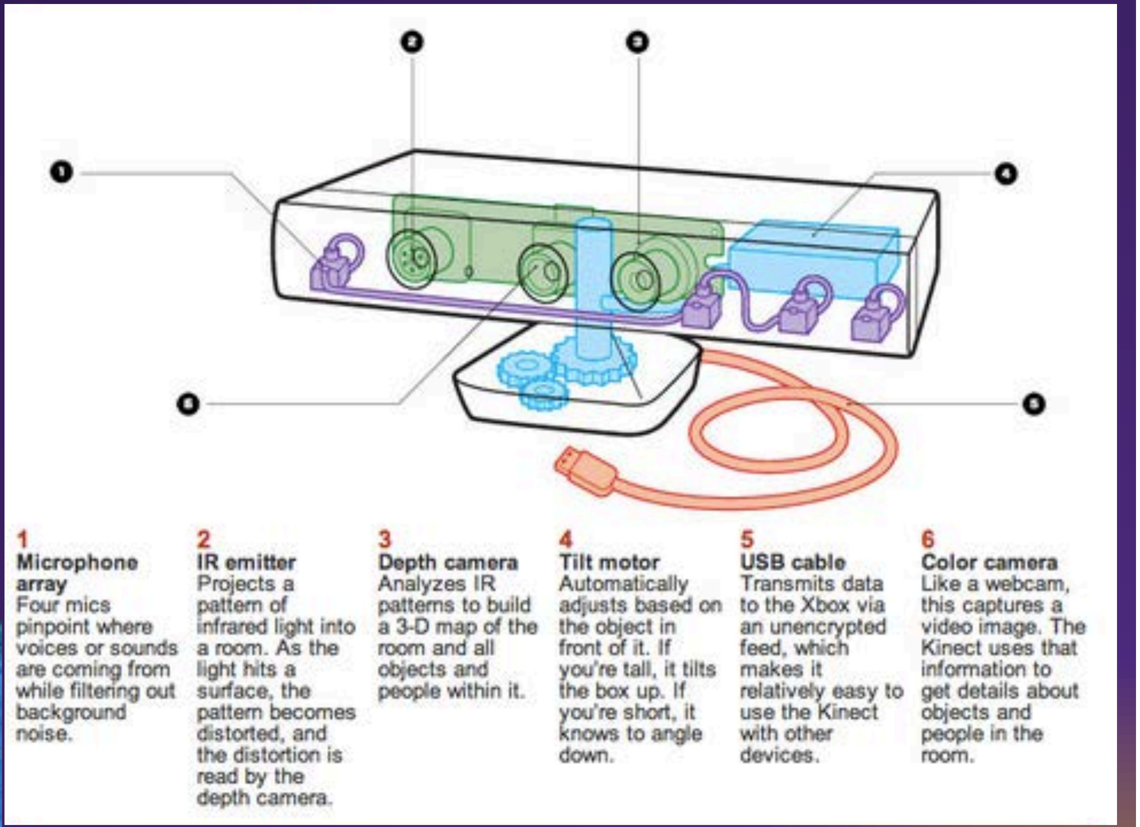
- Electromagnetic
  - Strengths
    - Less expensive
    - Flexible – line of sight not needed
    - Increased accuracy (.1 to .2 mm)
  - Weaknesses
    - Tethered
    - Skin motion artifact
    - Sensitive to metal (rebar)

Motion Capture

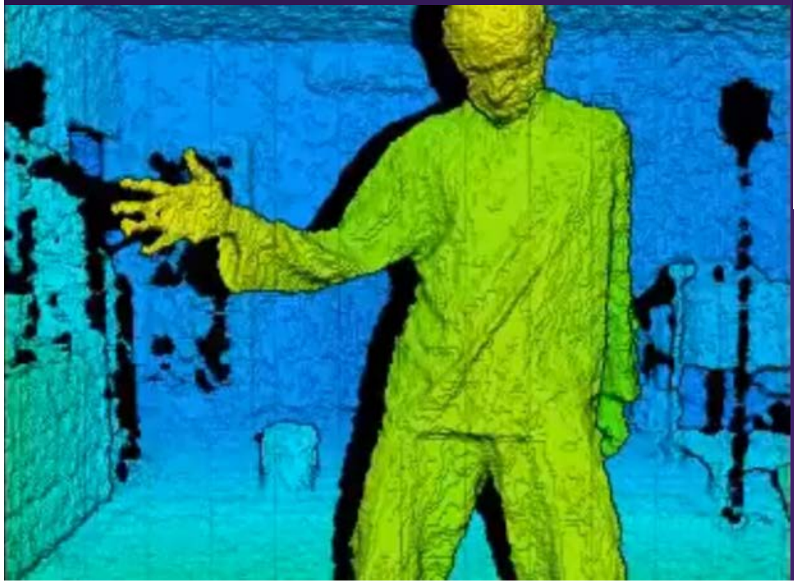
- Markerless
  - Organic Motion
    - Developer of world's only professional markerless motion capture software and systems.
    - Biostage – 14 to 24 cameras

Motion Capture

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



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??)

Motion Capture

- Other
  - Inertial measurement units (IMUs)
  - High speed video
  - X-ray stereophotogrammetry
  - CT/MRI
  - Bone pins
  - Fluoroscopy (single, biplane)

Mocap in the news

Obama Outfitted With 238 Motion Capture Sensors For 3-D Record Of Presidency

NEWS
March 3, 2009

VOL 45 ISSUE 10

Politics · Elections · Electronics · Barack Obama

The specially designed bodysuit will record every historic movement President Obama makes in 360 degrees of rotation.

WASHINGTON—In what is being hailed as a breakthrough in the field of historical record-keeping, the National Archives announced Monday that it would immediately begin outfitting Barack Obama's chest, limbs, and face with an array of motion capture sensors for use in preserving a 3-D account of his time as president.

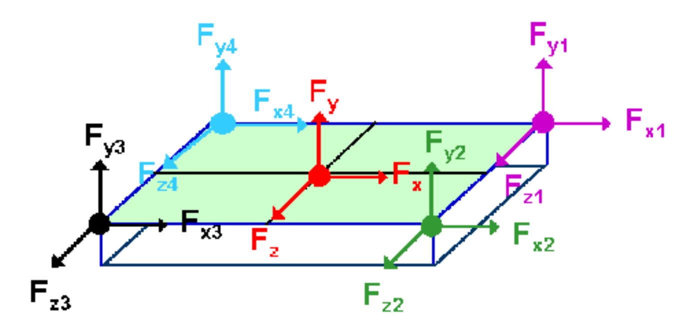
http://tinyurl.com/hcr4vbv

Force plates

- Kistler
  - piezoelectric
- AMTI
  - strain gage
- Bertec
  - strain gage

Force plates

- How do they work?
- Sensors in all four corners
- Calculate vertical and shear, center of pressure and free moment



Four-Corner Type Force Plate

http://www.pt.ntu.edu.tw/hmchai/Biomechanics/BMmeasure/KineticAnalysis.htm

Force plates

- piezoelectric
  - + small, very fast response (dynamic)
  - - drift, non-linear

- strain gage
  - + higher linearity and stability in long-term measurements (static)
  - - hysteresis, creep, temperature

Pressure measurement

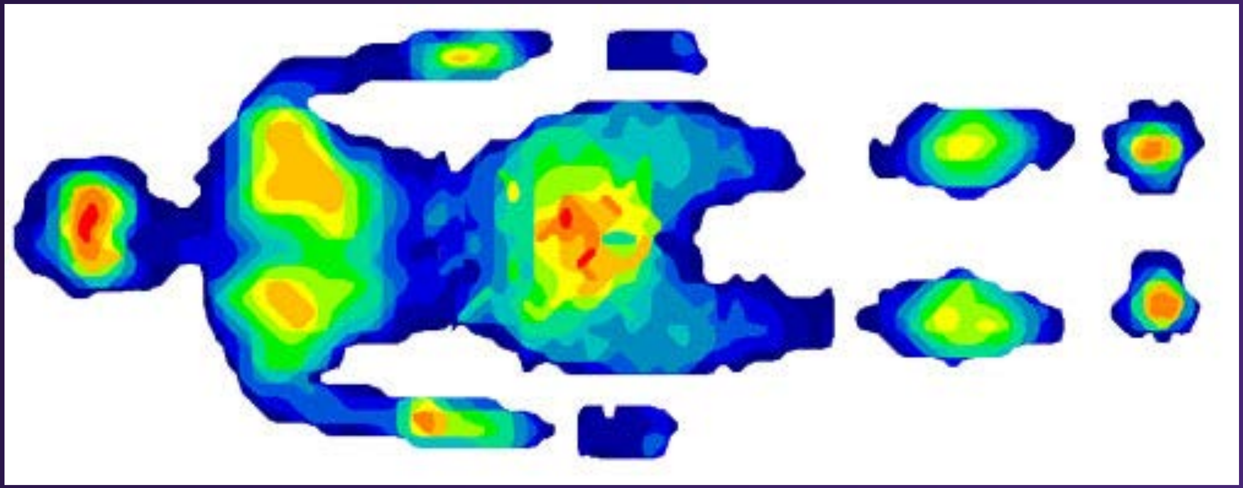
- novel

  capacitive

Pressure measurement

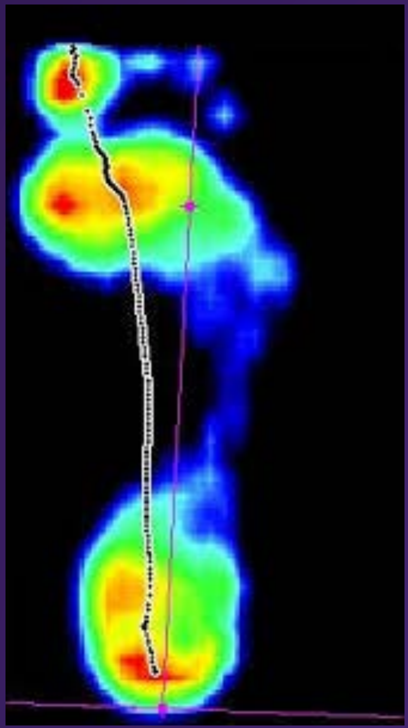
- Tekscan

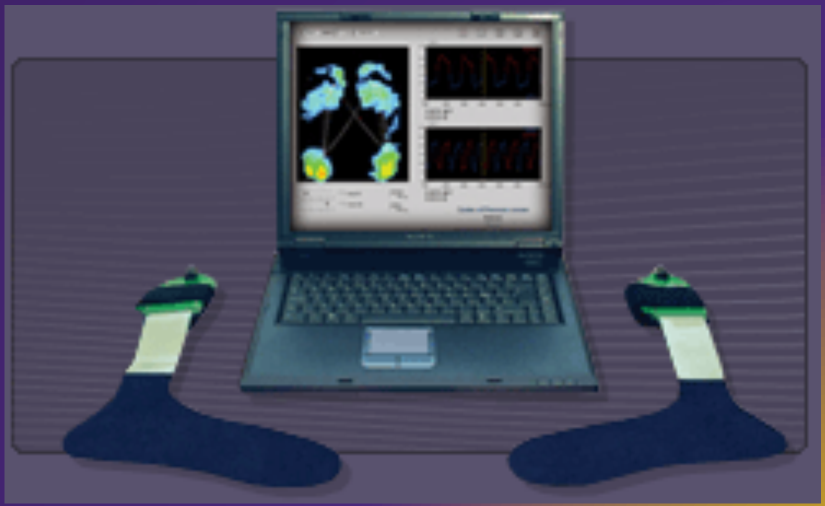
  force sensing resistor



Pressure measurement

- RSscan
  - resistive

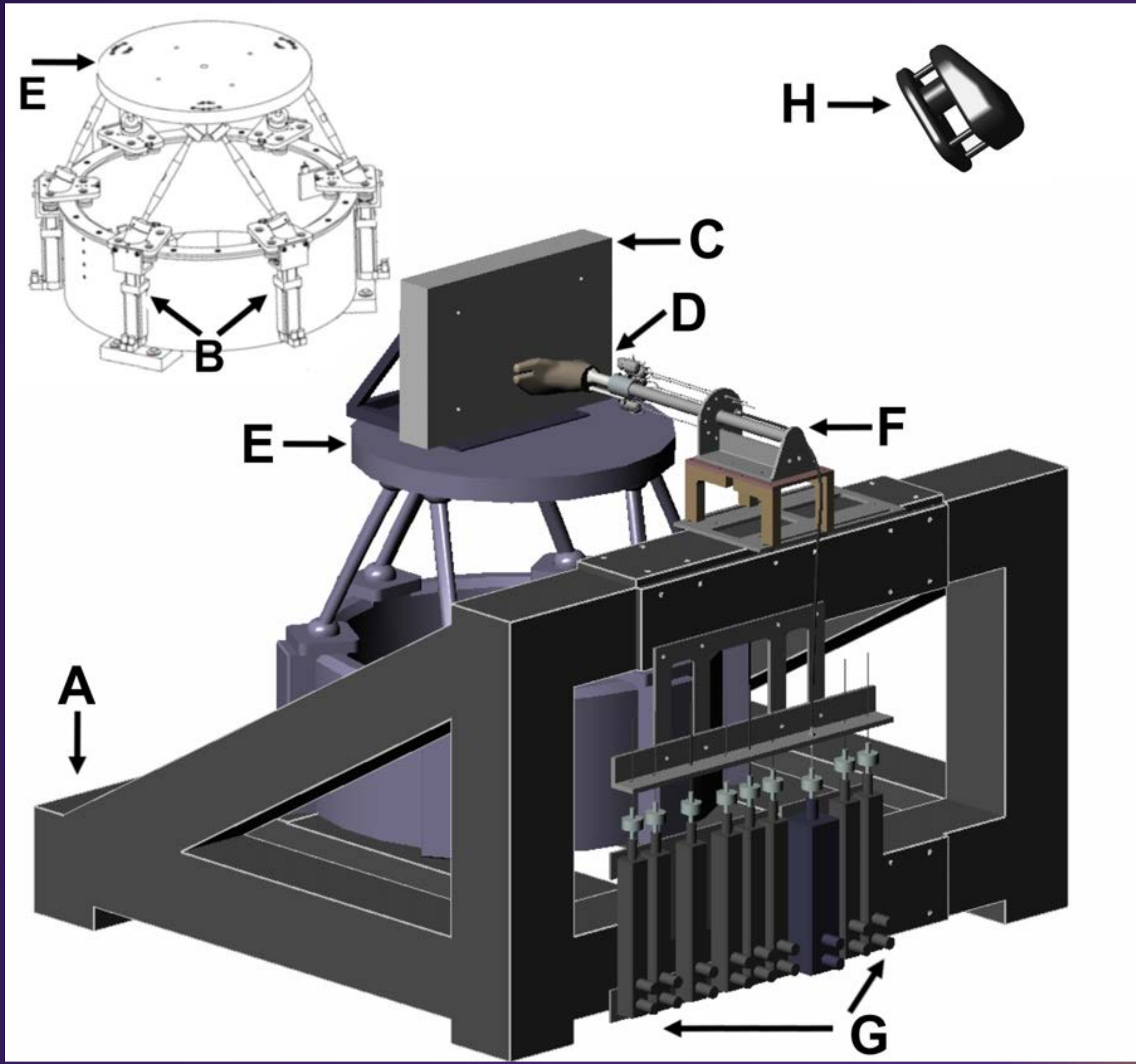




Pressure plates

- Force sensing resistors
  - + thin
  - - drift, unstable
- Capacitive-based
  - + stable
  - - thicker

Cadaveric gait simulation

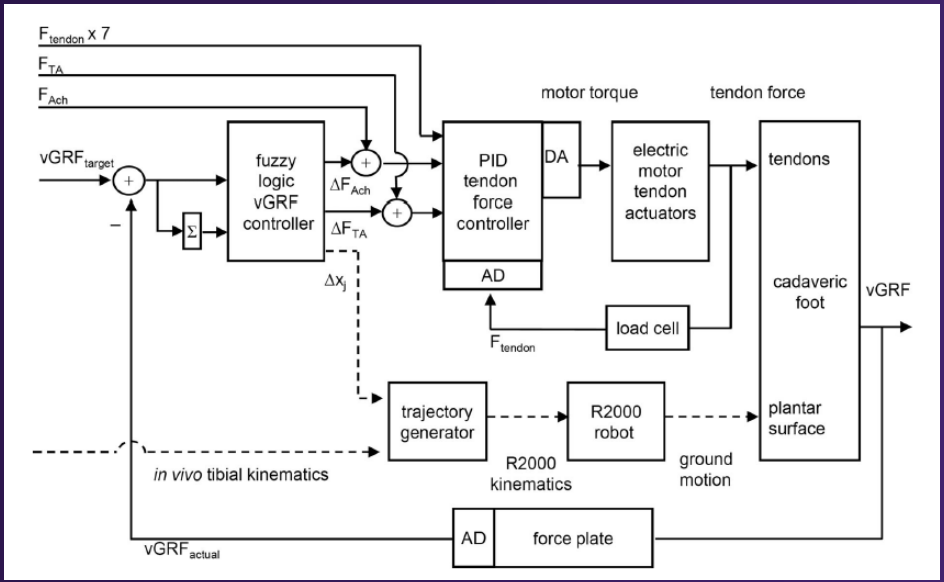


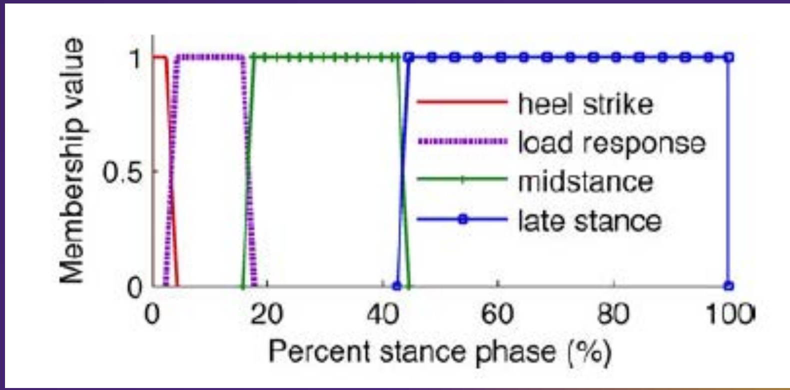
Cadaveric gait simulation

246 IEEE TRANSACTIONS ON ROBOTICS, VOL. 28, NO. 1, FEBRUARY 2012

A Robotic Cadaveric Gait Simulator With Fuzzy Logic Vertical Ground Reaction Force Control

Patrick M. Aubin, *Member, IEEE*, Eric Whittaker, and William R. Ledoux





Cadaveric gait simulation

Gait & Posture 33 (2011) 645–650

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Foot bone kinematics as measured in a cadaveric robotic gait simulator

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Cadaveric gait simulation

Comparison of Transfer Sites for Flexor Digitorum Longus in a Cadaveric Adult Acquired Flatfoot Model

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