

1

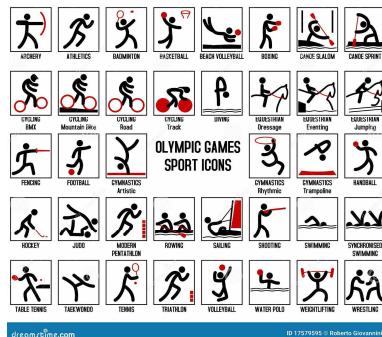
Content

- October 4th Measurement devices
- October 8th Kinetics and kinematics, knee osteoarthritis
- October 30th Shoulder
- November 22nd Ankle



2

Complexity of human movement



There should be a specific need!



3

Measures of human movement



Spatio-temporal parameters

- Ground contact
- Stride length
- ...

Kinematics

- Joint angle
- Segment angular velocity
- ...

Kinetics

- Joint moment
- Trajectory of the center of mass
- ...

Electromyography

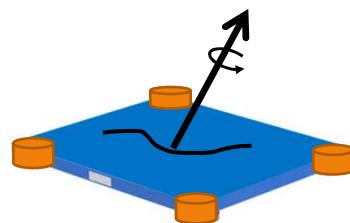
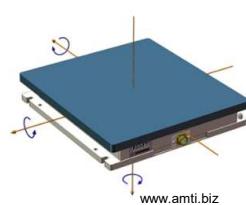
- Contraction amplitude
- Activation period
- ...



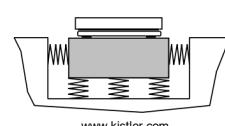
4

Measurement devices

Force plate



- Measure: 3D force, 3D moment, center of pressure
- High sampling frequency
- Mounting could be an issue



Force plate

- Embedded in the ground or portable



www.kistler.com



www.amti.biz



7

Force plate

- Embedded in the ground or portable or in built-in treadmill



www.hpscocosmos.com



www.bertec.com



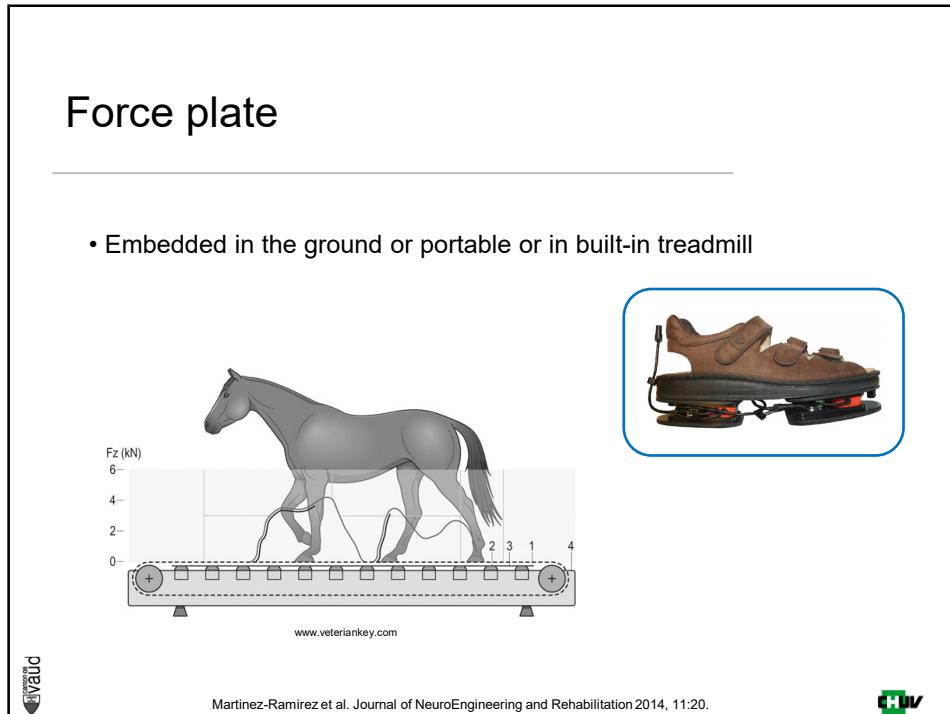
www.amti.biz



8

Force plate

- Embedded in the ground or portable or in built-in treadmill



9

Plantar pressure mat



- Measure: pressure distribution
- Resolution of ~2-5 sensels /cm²
- Sampling frequency up to several hundreds of Hz



10

Plantar pressure treadmill



- Measure: pressure distribution

Plantar pressure insole

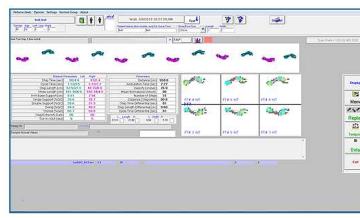


- Measure: pressure distribution
- Resolution of ~2-5 sensels /cm²
- Sampling frequency up to several hundreds of Hz

Gait analysis mat



www.gaitrite.com



www.gaitrite.com

- Measure: contact
- Resolution of ~0.5 -1 sensels /cm²
- Sampling frequency up to several hundreds of Hz



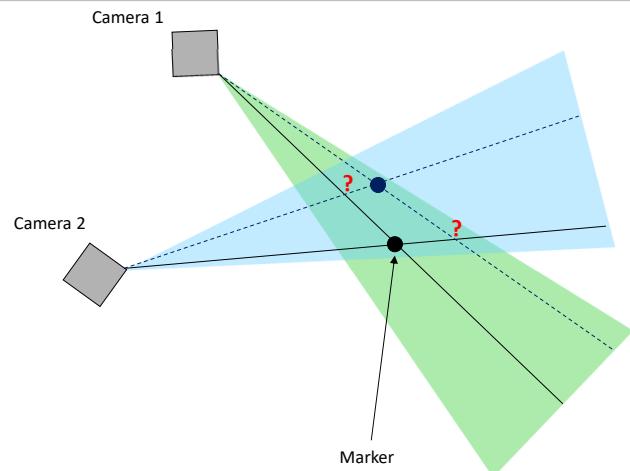
13

Passive marker-based motion capture



14

Passive marker-based motion capture



15

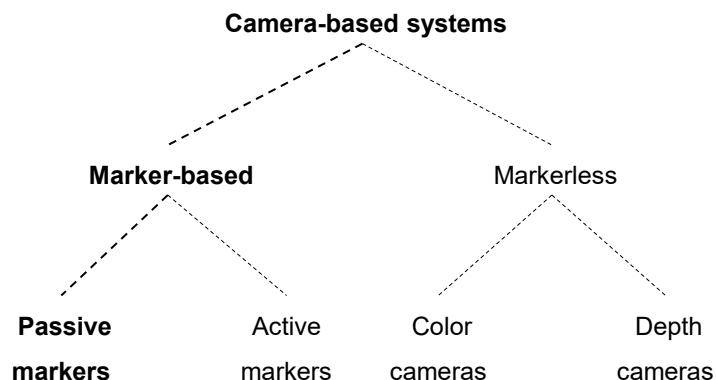
Passive marker-based motion capture

- Measure: marker positions
- Large number of markers possible
- Capture volume of up to 5 x 10 m
- Sampling frequency of 100 Hz and above
- Accuracy ~1 mm
- Drawbacks: calibration, line of sight, tracking & ambient light
- Compatible with ~active~ markers



16

Camera-based motion capture



17

Active marker-based motion capture



- Measure: marker positions
- Large number of markers possible
- Sampling frequency dependent to the number of markers (eg., 4600 Hz / n)
- Drawbacks: line of sight & powering of the markers

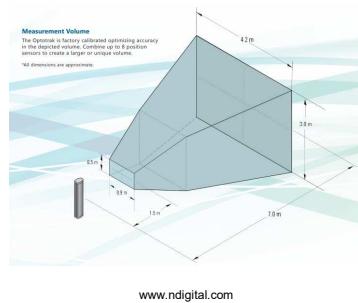


www.ndigital.com

18

Active marker-based motion capture

- Capture volume

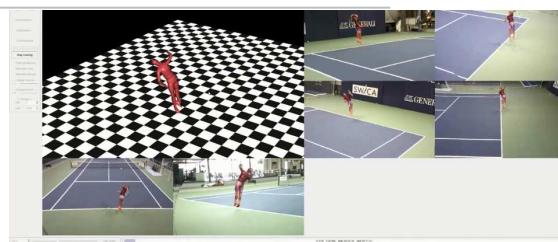
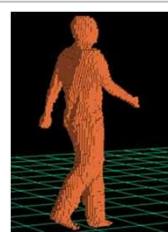


www.codamotion.com



19

Markerless motion capture (color camera)



www.sim3.com

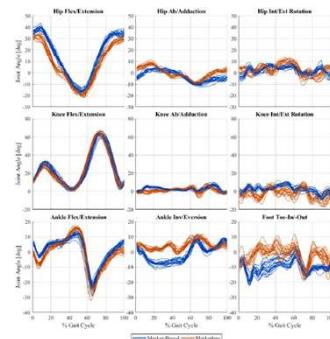
- Measure: joint position & joint angle
- Large capture volume possible
- Sampling frequency of 100 Hz and above
- Less accurate than marker-based
- Drawbacks: calibration, ambient light, background

Zang et al. IEEE Transactions on multimedia 2013, 106-119.



20

Markerless motion capture (color camera)



- Measure: joint position & joint angle
- Large capture volume possible ?
- Sampling frequency of 100 Hz and above
- Less accurate than marker-based
- Drawbacks: calibration, ambient light, background ?

Dependency on the AI algorithms

Kanko et al. Journal of Biomechanics 2021, 110665.



21

Markerless motion capture (depth camera)



www.Microsoft.com



www.graphics.Stanford.edu

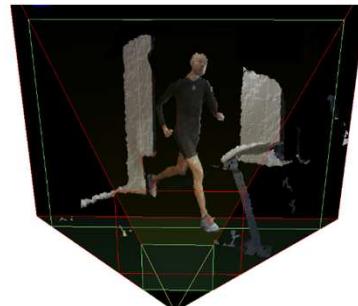


www.graphics.Stanford.edu



22

Markerless motion capture (depth camera)



- Measure: joint position & joint angle
- Limited capture volume
- Rather low sampling frequency (<100 Hz)
- Less accurate than marker-based
- Drawbacks: dependent on the built-in AI



www.motionmetrix.com



23

Magnetic-based motion capture



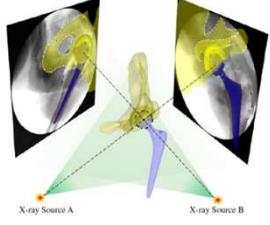
www.polhemus.com

- Measure: marker position and orientation
- Limited number of markers
- Limited capture volume
- Sampling frequency over 100 Hz
- Accuracy ~1 mm & ~1°
- Drawbacks: magnetic distortion, cable



24

Fluoroscopy

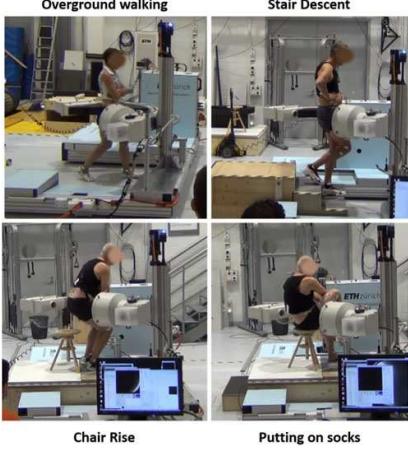


• Measure: bone or implant position & orientation
• Error < 1mm and <1°
• Invasive
• Low sampling rate & short capture duration
• Limited capture volume

Journal of Biomechanics 46:13:1300 

25

Fluoroscopy

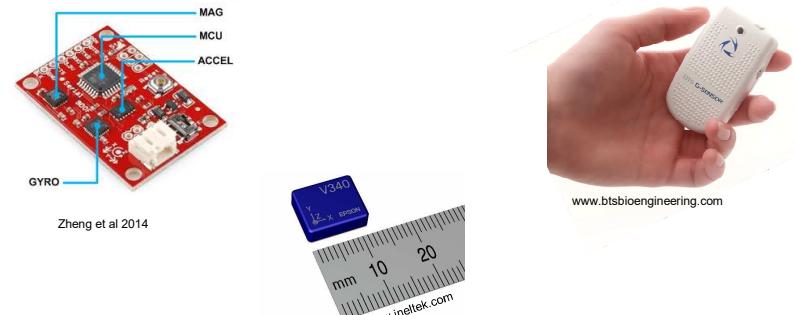


Overground walking Stair Descent
Chair Rise Putting on socks

Frontiers Bioengineering Biotechnology, 11:1095845 

26

Inertial measurement unit (IMU) -based motion capture



The image shows a red printed circuit board (IMU) with various electronic components. Labels point to the 'GYRO', 'ACCEL', 'MCU', and 'MAG' sensors. Below the board is a small white handheld device with a screen and buttons, labeled 'Gyroscopic'. A blue component labeled 'V340' is shown next to a ruler for scale. The text 'Zheng et al 2014' is at the bottom left, and 'www.btsbioengineering.com' is at the bottom right.

- Measure (3D): acceleration, angular velocity and magnetic field
- Can provide orientation

EPFL

CHUV

27

Inertial measurement unit (IMU) -based motion capture



The image shows a person wearing a white and black motion capture suit with numerous black IMU sensors attached to the torso, arms, and legs. The text 'www.utwente.nl' is at the bottom right.

- Measure (3D): acceleration, angular velocity and magnetic field
- Can provide orientation
- Unlimited number of markers and unlimited capture volume
- Sampling frequency over 100 Hz
- Different approach than stationary devices
- Application-specific algorithms, variable accuracy
- Drawbacks: attachment, anatomical calibration

EPFL

CHUV

28

Electromyography



www.myon.ch



www.mfimedical.com

- Measure: electric potential
- High sampling frequency
- Skin preparation
- Placement, crosstalk, reference value



29



Julien.favre@chuv.ch



30