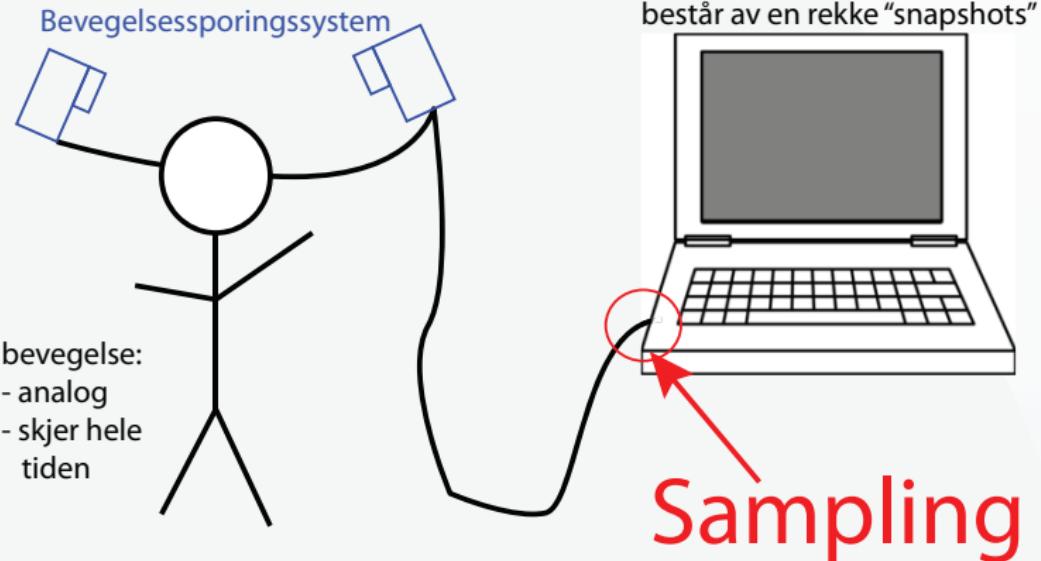


Bevegelsessporing

MUS2006 - Musikk og bevegelse

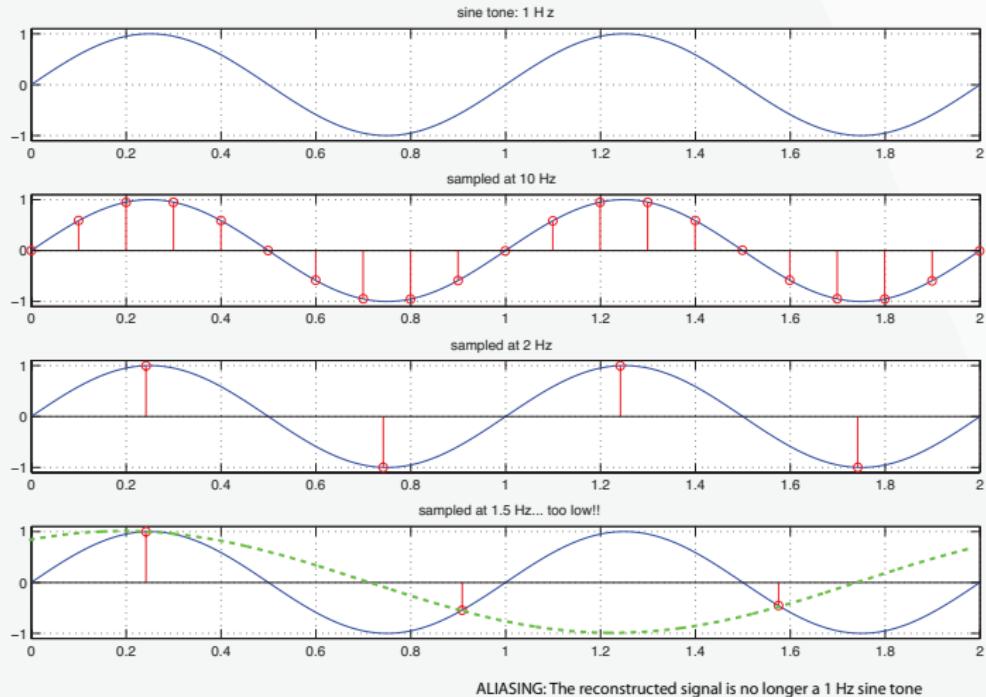
6 mars 2014

Analog → Digital: Sampling



- ▶ I virkeligheten skjer en bevegelse hele tiden
- ▶ En datamaskin kan ikke forholde seg til analoge data, og må sample den analoge bevegelsen et visst antall ganger per sekund.

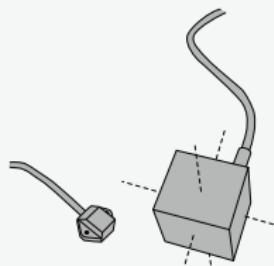
Det er viktig at samplingsraten er høy nok



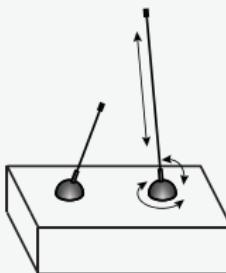
Det er viktig at oppløsningen er høy nok

- ▶ Vi kan for eksempel ikke studere hoftebevegelsene til en sambadanser med et GPS system som har en oppløsning på ca 3 meter.
 - ▶ Danseren kan bevege seg 1.5 meter til hver side uten at vi ser noe forskjell i dataene.
- ▶ Hvis du vil bruke et videokamera til å studere danseren, er det viktig at kameraet enten har god oppløsning, eller står nærmere nok til å fange bevegelsene skikkelig. (helst begge deler)

Body motion: Tracking technologies



Magnetic



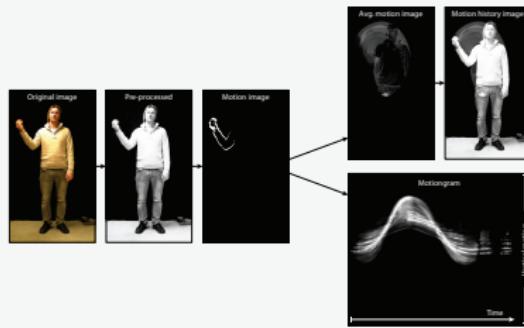
Mechanical



Inertial



acoustic



Optical markerless



Optical marker-based

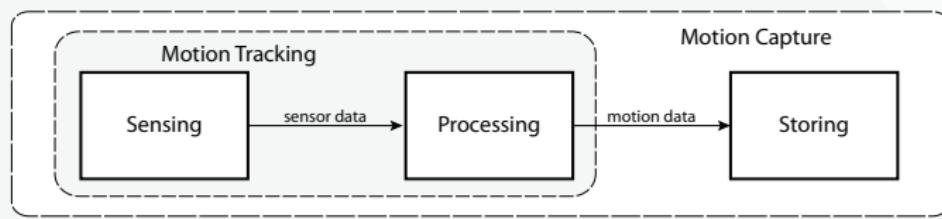
Body motion: Tracking technologies

	Inertial/ magnetic	Mechanical	Electro- magnetic	Optical (visual)	Optic (infrared)	Physiological
	- flexible - small	- flexible - small	- resolution - identification - absolute	- flexible - no cables - no markers - accessible	- speed - resolution - # markers	- indirect motion sensing
	- relative	- relative	- cable - short range	- 2D - speed - resolution - identification	- markers - calibration - identification	- indirect motion sensing

Fra Jensenius, Nymoen, Godøy (2008)

Motion Capture / Bevegelsessporing

- ▶ *Sensing* the motion
- ▶ *Processing* the sensor data
- ▶ *Storing* the data



Sensing

Body motion: Sensing technologies

- ▶ Mechanical sensing
- ▶ Force sensing
- ▶ Acoustic sensing
- ▶ Inertial sensing
- ▶ Electromagnetic sensing
- ▶ Physiological sensing
- ▶ Optical sensing

We'll go into a bit more detail on a few of these

Mechanical sensing: Potentiometers and sliders

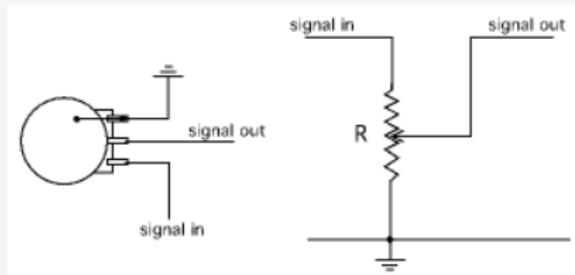


Potentiometer / potmeter



Slider

Concept: Electricity in → Scaling → Scaled electricity out



Inertial sensing: Accelerometers and Gyroscopes

Tiny chips found in every smart phone these days:

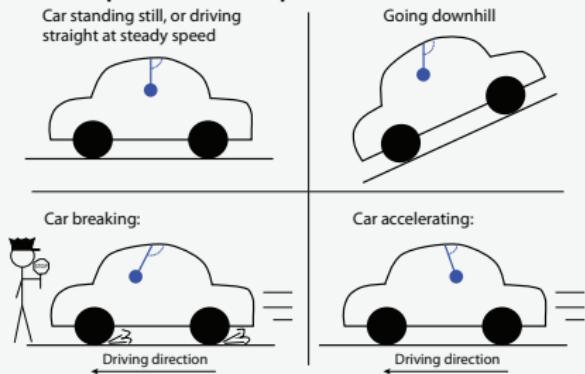


Accelerometer:

measures acceleration, including:

- ▶ Gravity
- ▶ Change in speed
- ▶ Change in direction

Conceptual example:



Gyroscope:

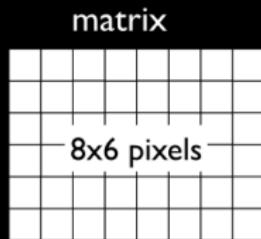
measures rotation, meaning:

- ▶ Change in direction

More difficult to illustrate, but you may know the concept from some everyday objects:



Optical sensing: Video



Video?

Illustration by Alexander Refsum Jensenius

Optical sensing: Video

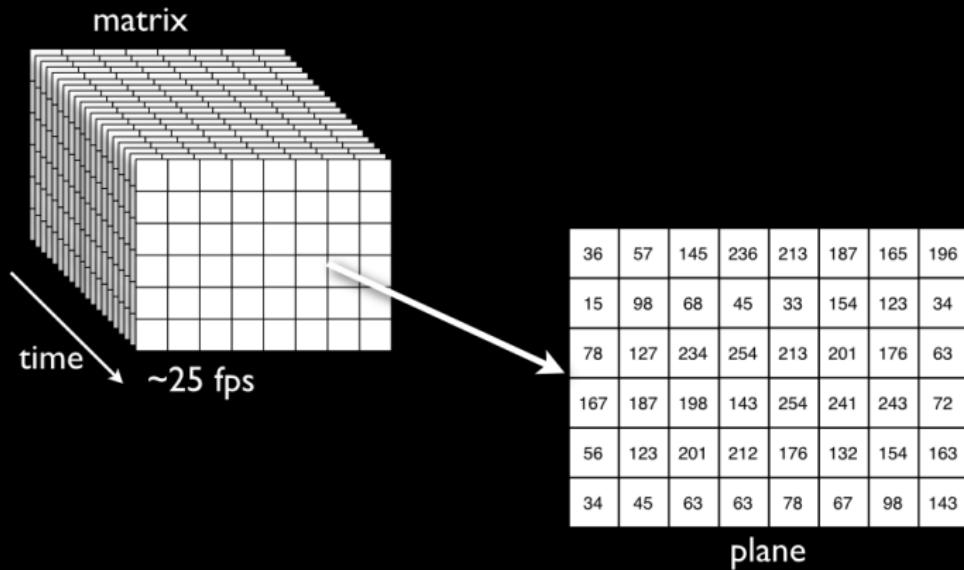


Illustration by Alexander Refsum Jensenius

Optical sensing: Video

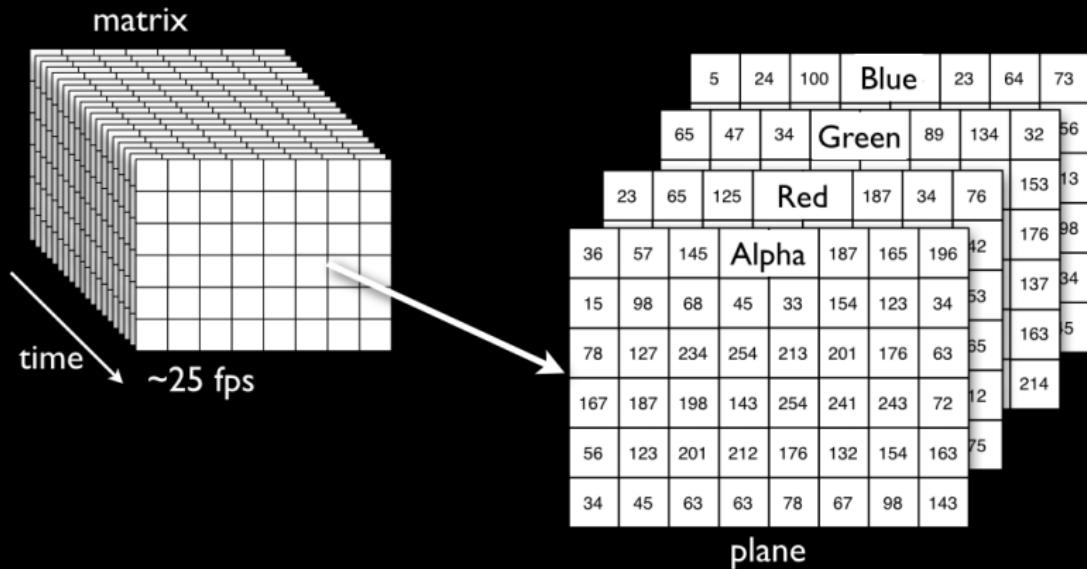


Illustration by Alexander Refsum Jensenius

Tracking

Optical tracking: Blob detection

Example task: Find the red ball:

Red plane

4	2	4	2	1	1	2	2	2	4	2	5	2	2	2
6	1	5	2	2	2	2	2	12	2	2	2	3	2	2
2	3	2	9	7	8	2	2	2	2	6	2	7	2	2
0	2	6	2	3	2	3	2	1	2	3	2	2	2	2
2	1	0	2	0	2	2	1	2	2	2	2	2	2	0
2	2	2	3	2	2	3	2	2	32	43	22	12	2	2
2	0	2	2	2	2	2	50	199	197	192	90	12	2	0
2	2	1	2	9	3	2	20	180	201	200	198	2	3	1
2	1	0	2	2	2	2	21	232	194	210	199	2	2	2
2	2	2	4	2	2	2	2	2	64	2	2	2	2	0

Optical tracking: Blob detection

Example task: Find the red ball:

Green plane

4	2	5	2	2	2	4	2	4	2	1	1	2	2	2
2	2	2	3	2	2	6	1	5	2	2	2	2	2	12
2	6	2	7	2	2	2	3	2	9	7	8	2	2	2
2	3	2	2	2	2	0	2	6	2	3	2	3	2	1
2	2	2	2	2	0	2	1	0	2	0	2	2	1	2
3	0	2	1	2	2	2	2	2	3	2	2	3	2	2
6	1	2	1	2	0	2	0	2	2	2	2	2	5	1
1	0	1	2	3	1	2	2	1	2	9	3	2	7	1
4	0	1	2	2	2	2	1	0	2	2	2	2	1	3
4	2	2	2	2	0	2	2	2	4	2	2	2	2	2

Optical tracking: Blob detection

Example task: Find the red ball:

Blue plane

1	1	2	2	2	4	2	5	2	2	2	4	2	4	2
2	2	2	2	12	2	2	2	3	2	2	6	1	5	2
7	8	2	2	2	2	6	2	7	2	2	2	3	2	9
3	2	3	2	1	2	3	2	2	2	2	0	2	6	2
0	2	2	1	2	2	2	2	2	2	0	2	1	0	2
2	2	3	2	2	3	0	2	1	2	2	2	2	2	3
2	2	2	5	1	6	1	2	1	2	0	2	0	2	2
9	3	2	7	1	1	0	1	2	3	1	2	2	1	2
2	2	2	1	3	4	0	1	2	2	2	2	1	0	2
2	2	2	2	2	4	2	2	2	2	0	2	2	2	4

Optical tracking: Blob detection

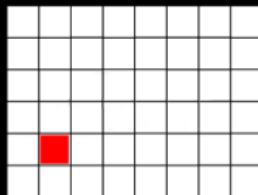
Example task: Find the red ball:

Red plane

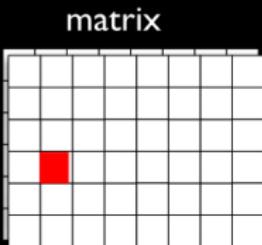
4	2	4	2	1	1	2	2	2	4	2	5	2	2	2
6	1	5	2	2	2	2	2	12	2	2	2	3	2	2
2	3	2	9	7	8	2	2	2	2	6	2	7	2	2
0	2	6	2	3	2	3	2	1	2	3	2	2	2	2
2	1	0	2	0	2	2	1	2	2	2	2	2	2	0
2	2	2	3	2	2	3	2	2	32	43	22	12	2	2
2	0	2	2	2	2	2	50	199	197	192	90	12	2	0
2	2	1	2	9	3	2	20	180	201	200	198	2	3	1
2	1	0	2	2	2	2	21	232	194	210	199	2	2	2
2	2	2	4	2	2	2	2	2	64	2	2	2	2	0

Optical tracking: From position to trajectory

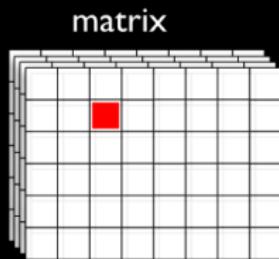
matrix



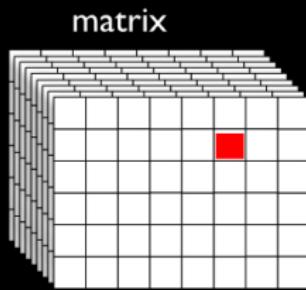
Optical tracking: From position to trajectory



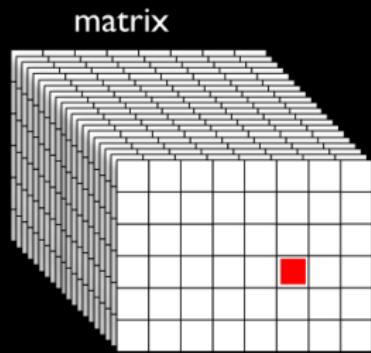
Optical tracking: From position to trajectory



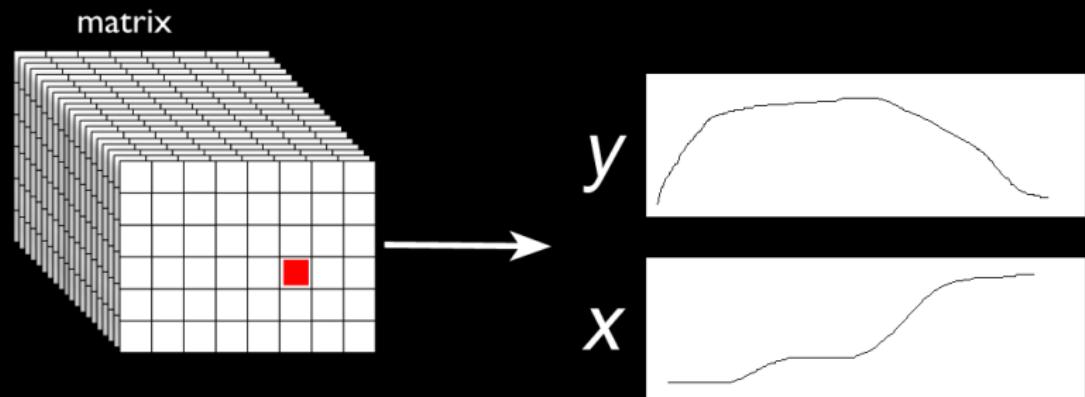
Optical tracking: From position to trajectory



Optical tracking: From position to trajectory



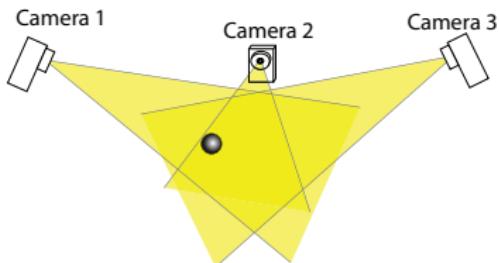
Optical tracking: From position to trajectory



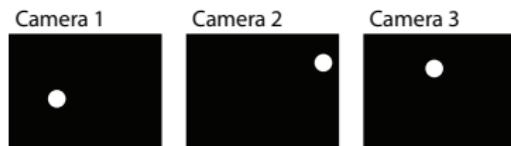
Optical Marker-Based Motion Capture

Optical Marker-Based Motion Capture

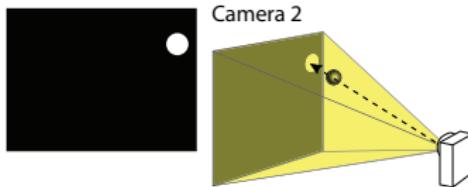
a) The cameras see a marker in their field of view



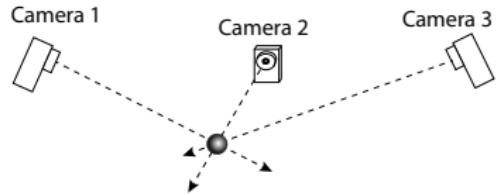
b) Each camera shows a corresponding image, where the marker position is given in two dimensions



c) Since the position and orientation of each camera is known, as well as its field of view, a 3D vector where the dot must be located can be determined.



d) The marker is found in the intersection between the 3D vectors



Optical Marker-Based Motion Capture

Systems available at UiO:

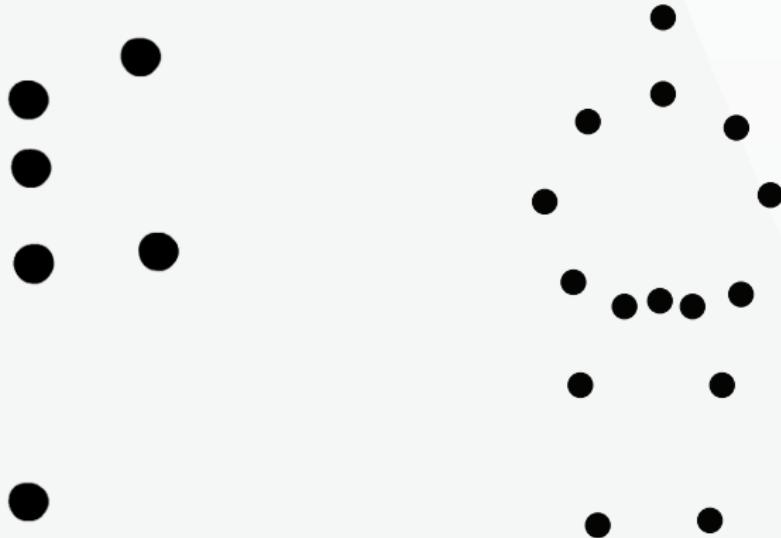


Qualisys

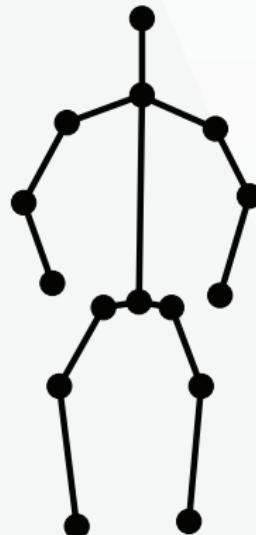


OptiTrack

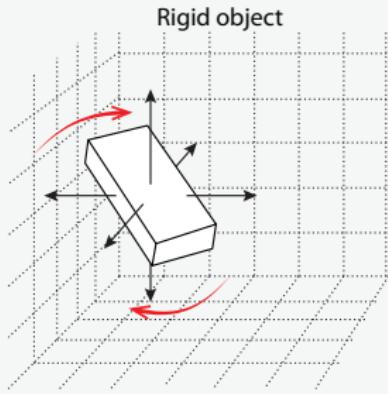
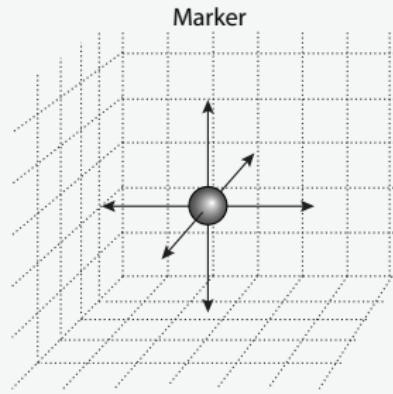
Markers — Rigid bodies — Kinematic chains



Markers — Rigid bodies — Kinematic chains

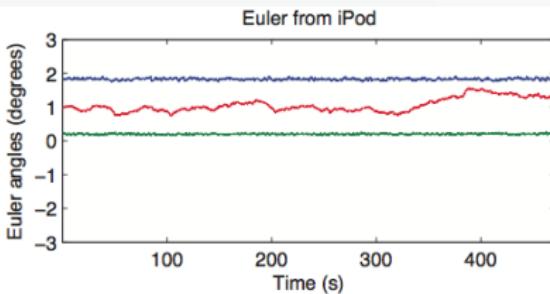
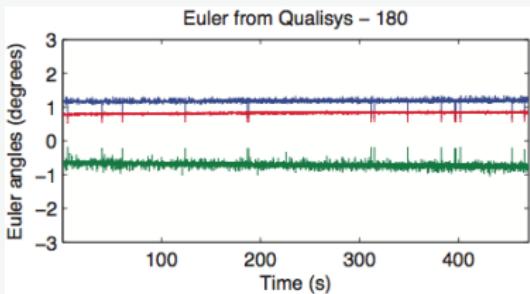
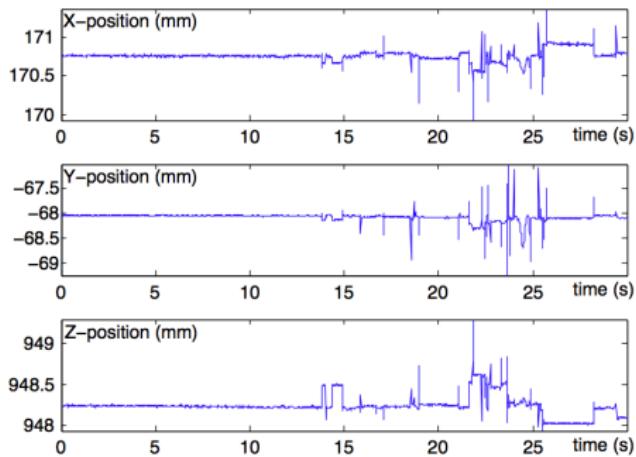
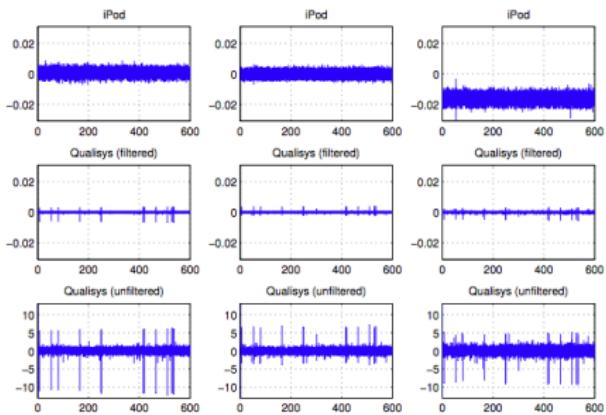


Markers — Rigid bodies — Kinematic chains



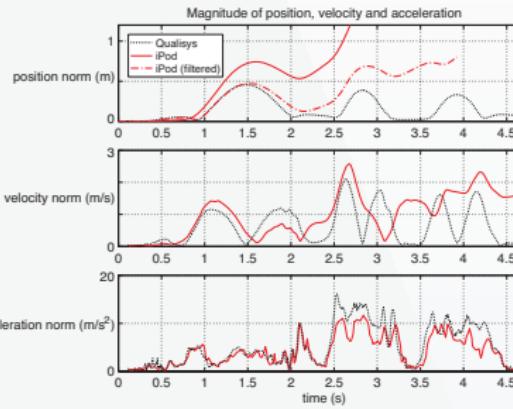
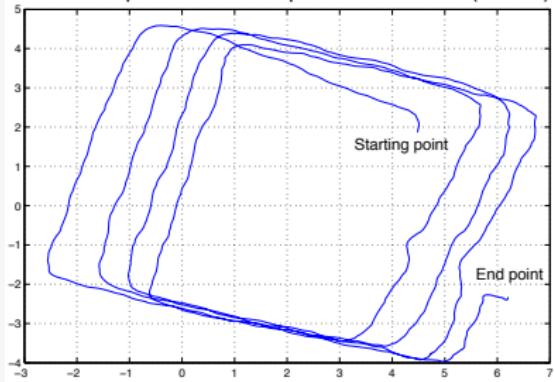
Processing motion data

All data contains noise!



Drift in inertial systems

Horizontal position of the captured Xsens data (meters)



Preprocessing: Gap-filling

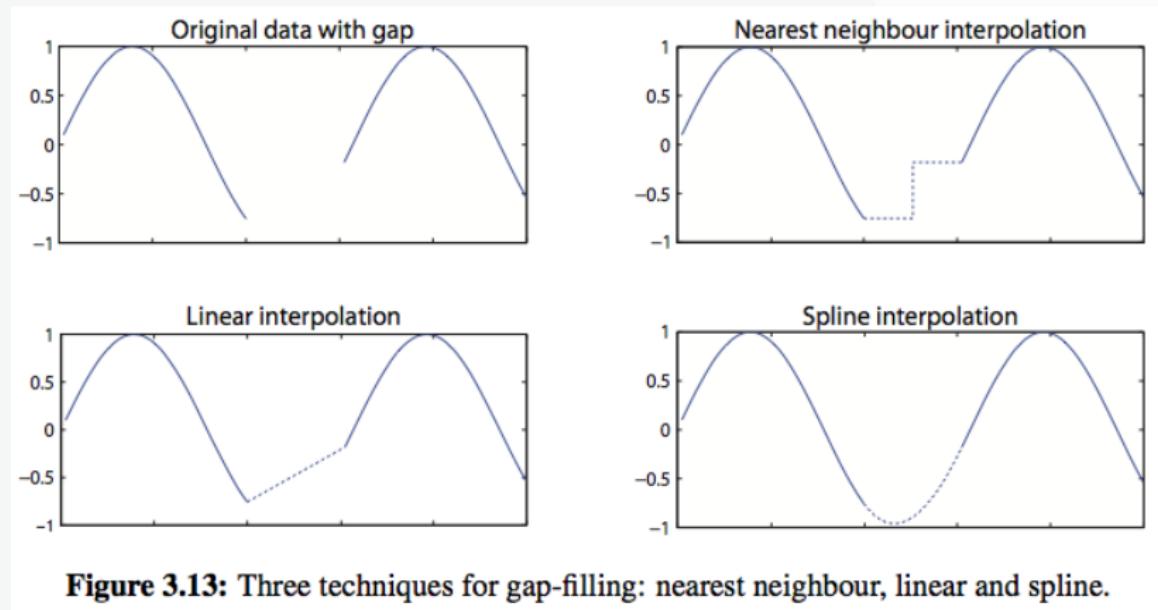
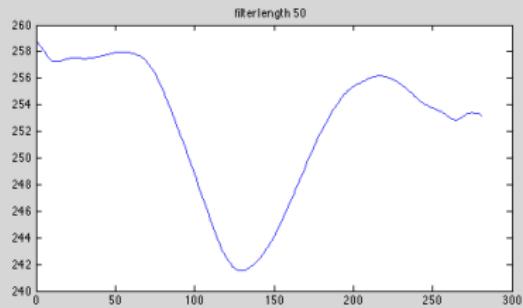
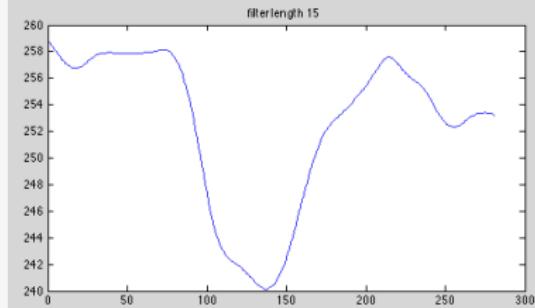
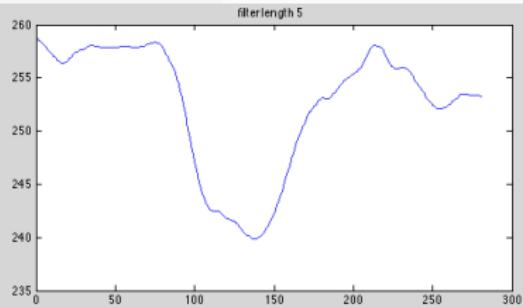
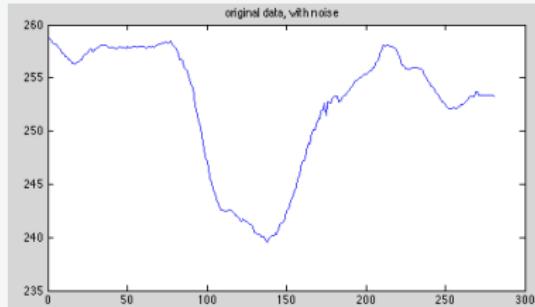


Figure 3.13: Three techniques for gap-filling: nearest neighbour, linear and spline.

Preprocessing: Smoothing



Visualization:

Typical plot of XYZ data of one marker. Not so intuitive...

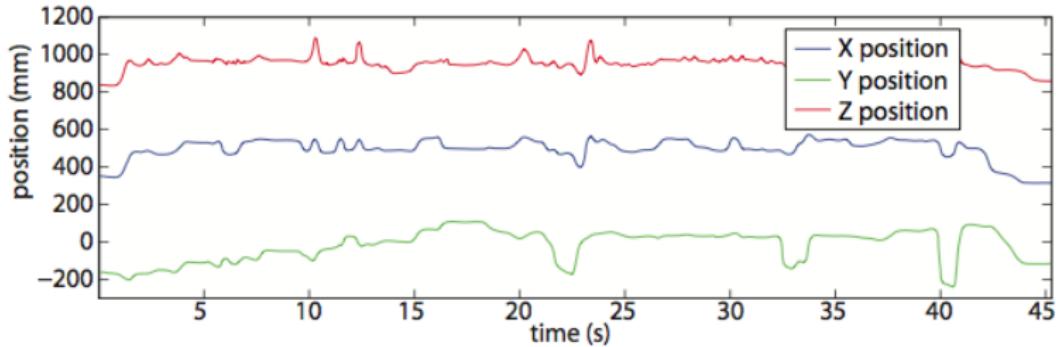
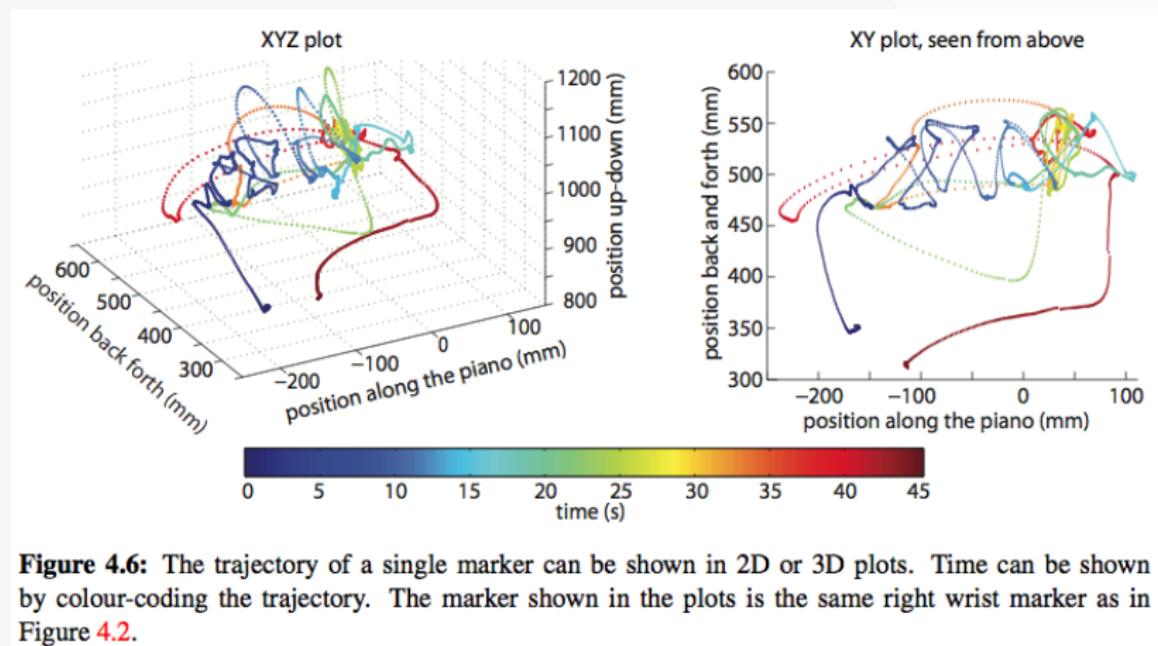


Figure 4.2: A common way of plotting three-dimensional marker data in time and space.

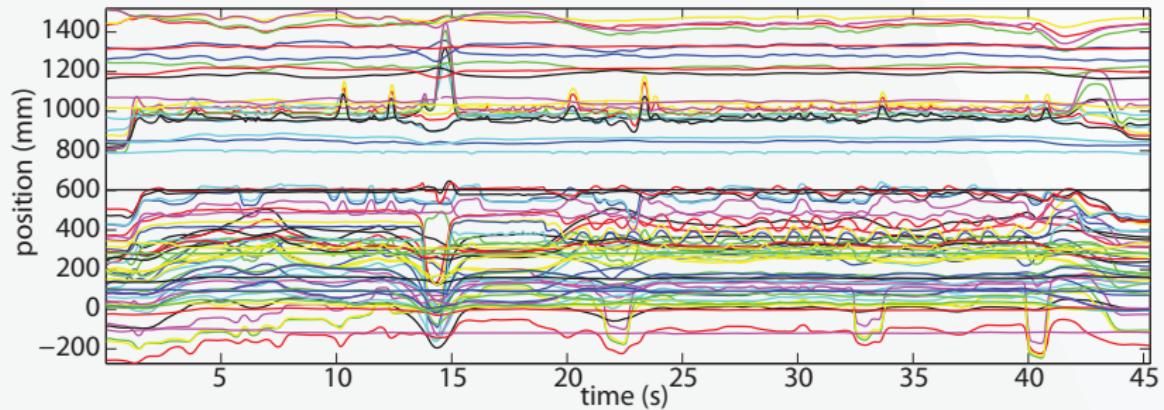
Visualization:

Another option: Putting X, Y and Z on different axes, and let colour denote time



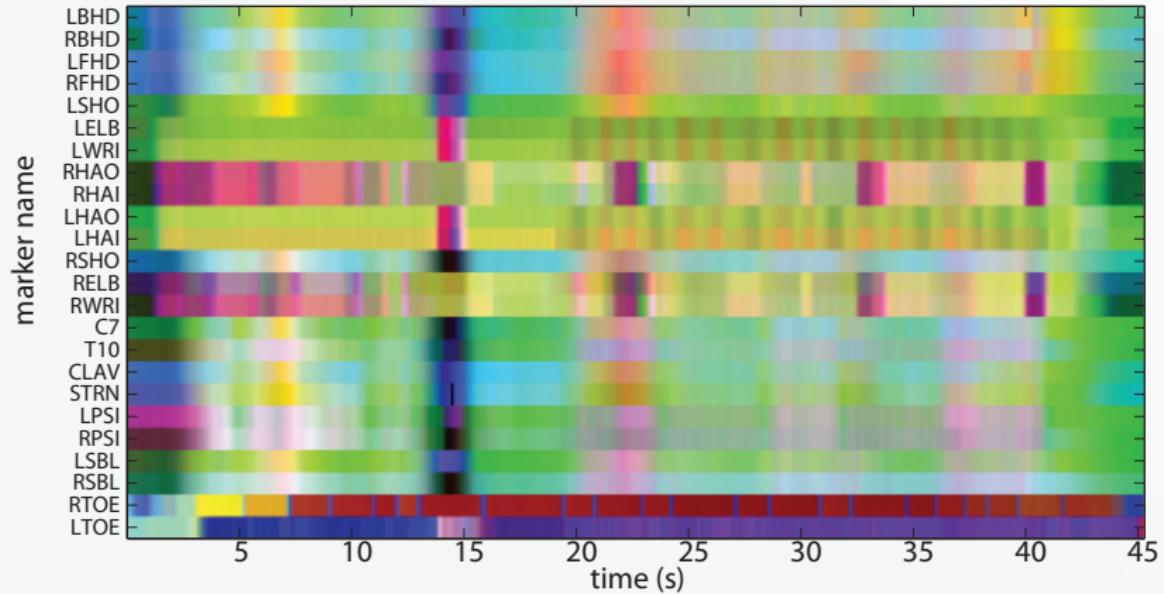
Visualization:

Plotting many (24) xyz marker positions can get really messy



Visualization:

Another option is to use colour coding: Mocapgrams



Position – Hastighet – Akselerasjon

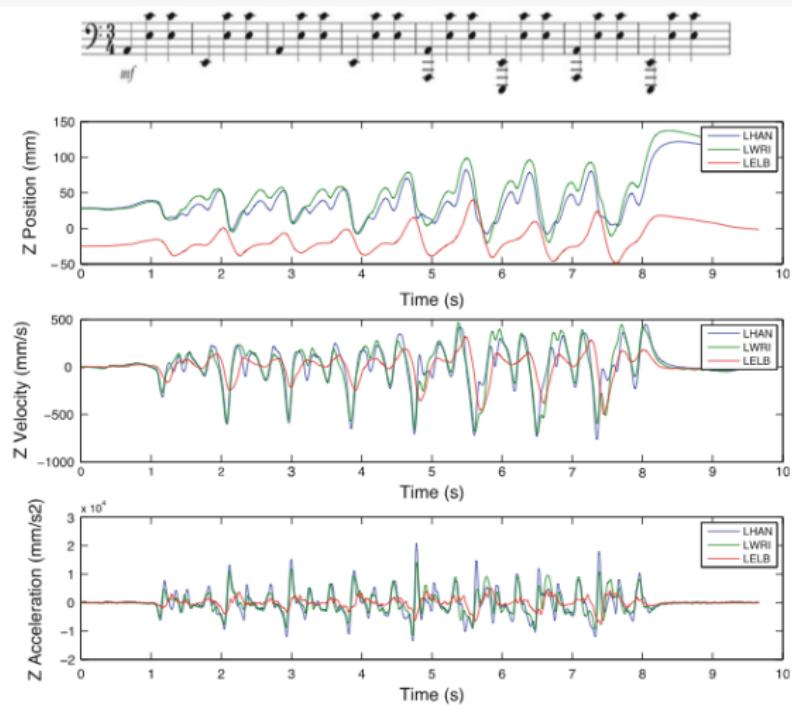


Fig. 1 A waltz-like fragment for the *piano* for *left hand solo*, with notation (top), and underneath this, motion trajectories of hand, wrist, and elbow along the *vertical plane*, and underneath this again, the velocity and acceleration plots of this motion data

Figure from:
R.I.Godøy. "Quantal Elements in Musical Experience" in
R. Bader(ed.), *Sound Perception Performance, Current Research in Systematic Musicology 1*, Springer 2013.

MoCap Toolbox Demo

Først litt annen info:

- ▶ Oppgave 2: Frist i morgen
- ▶ Oppgave 3: Frist 7 april. Legges ut snart, følg med på kurssiden
- ▶ Semesteroppgave: Finne tema
- ▶ Presentasjon av tema 10 april
- ▶ Åpen dag: 13 mars. Ikke forelesning.

Mocap toolbox til Matlab (skal være installert på midi-rommet).

- ▶ MATLAB: Mocap toolbox, from University of Jyväskylä.
<https://www.jyu.fi/hum/laitokset/musiikki/en/research/coe/materials/mocaptoolbox>