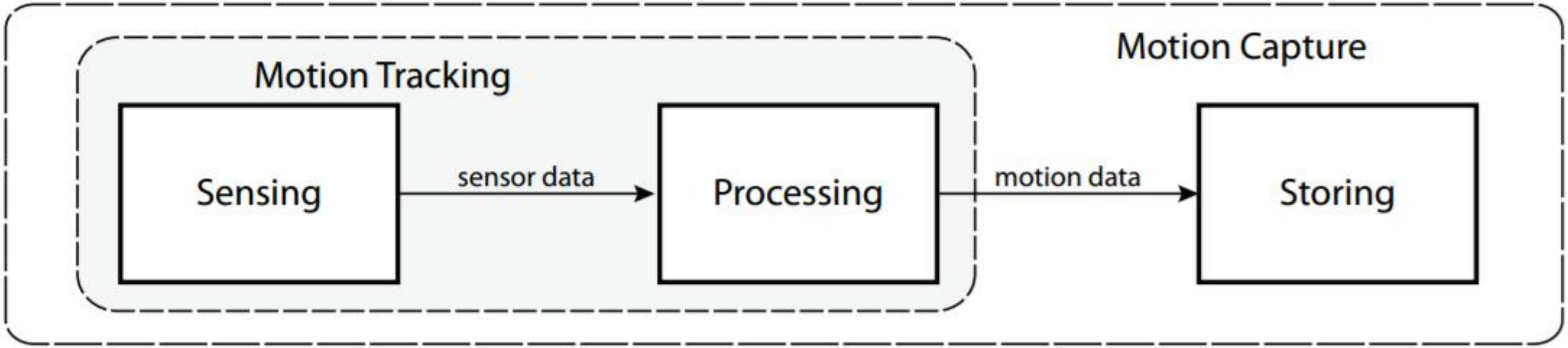
Motion Tracking

Olga Perepelkina

NEURODATA LAB

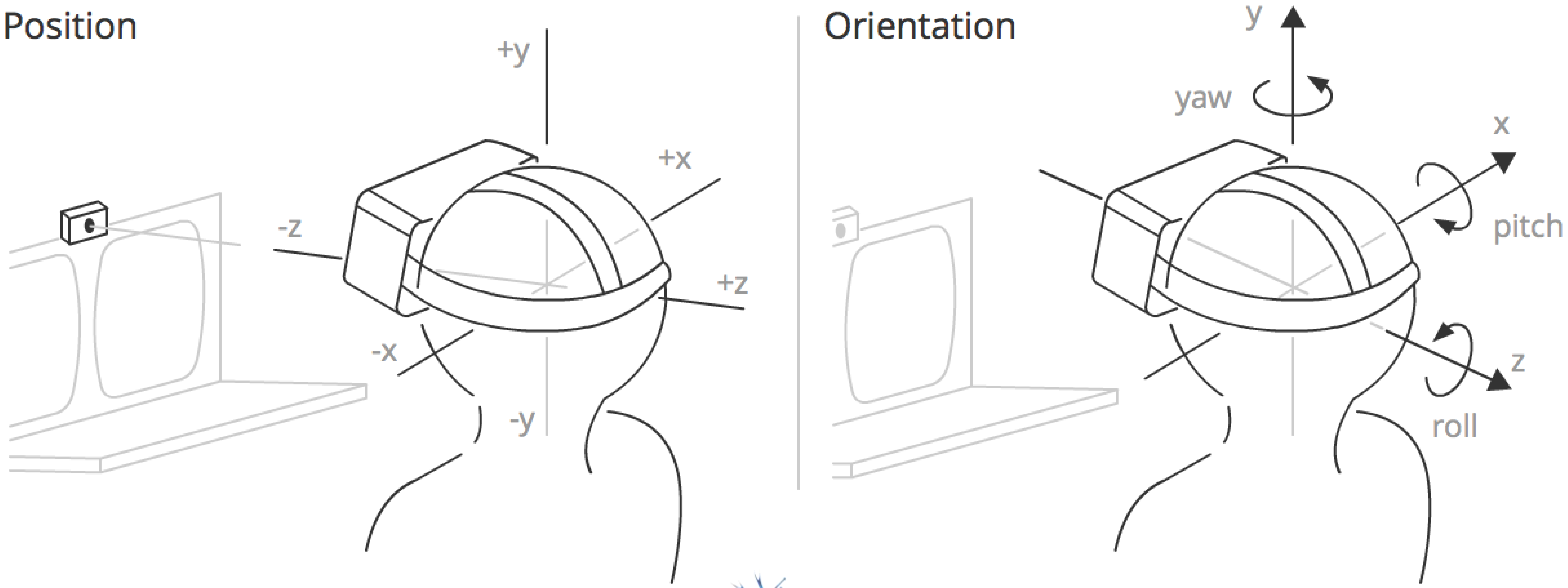
Motion capture (mocap) & Motion tracking

- Mocap involves the use of a sensing technology to track and store movement



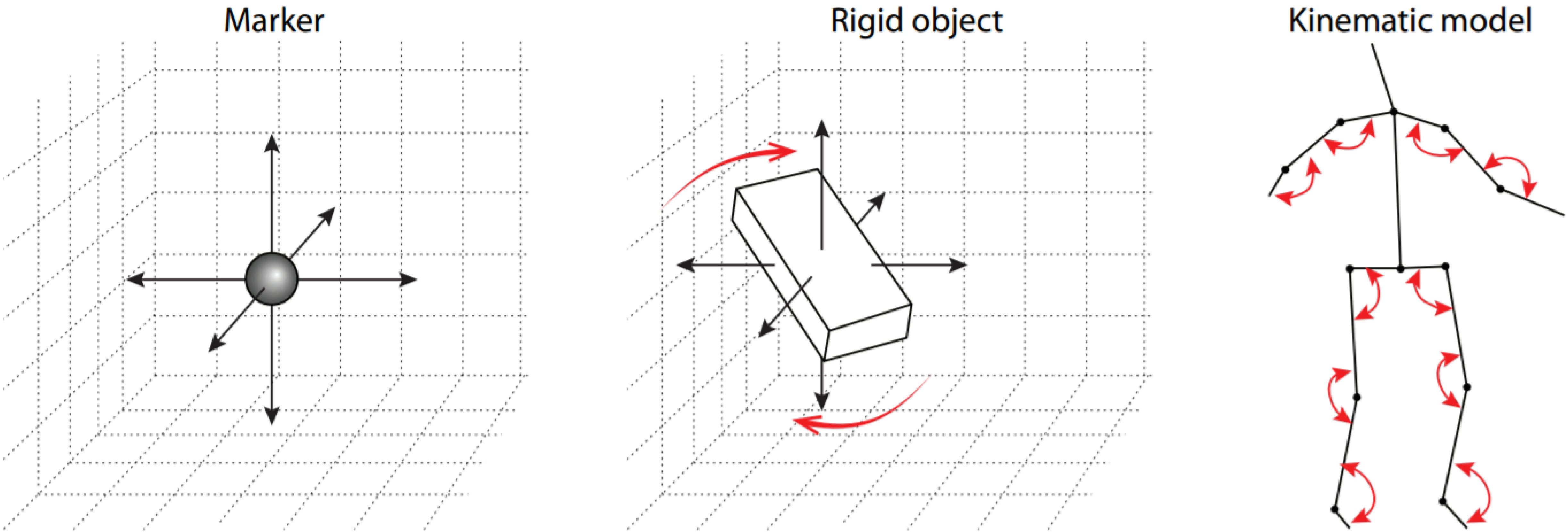
NEURODATA LAB

6-DoF Tracking



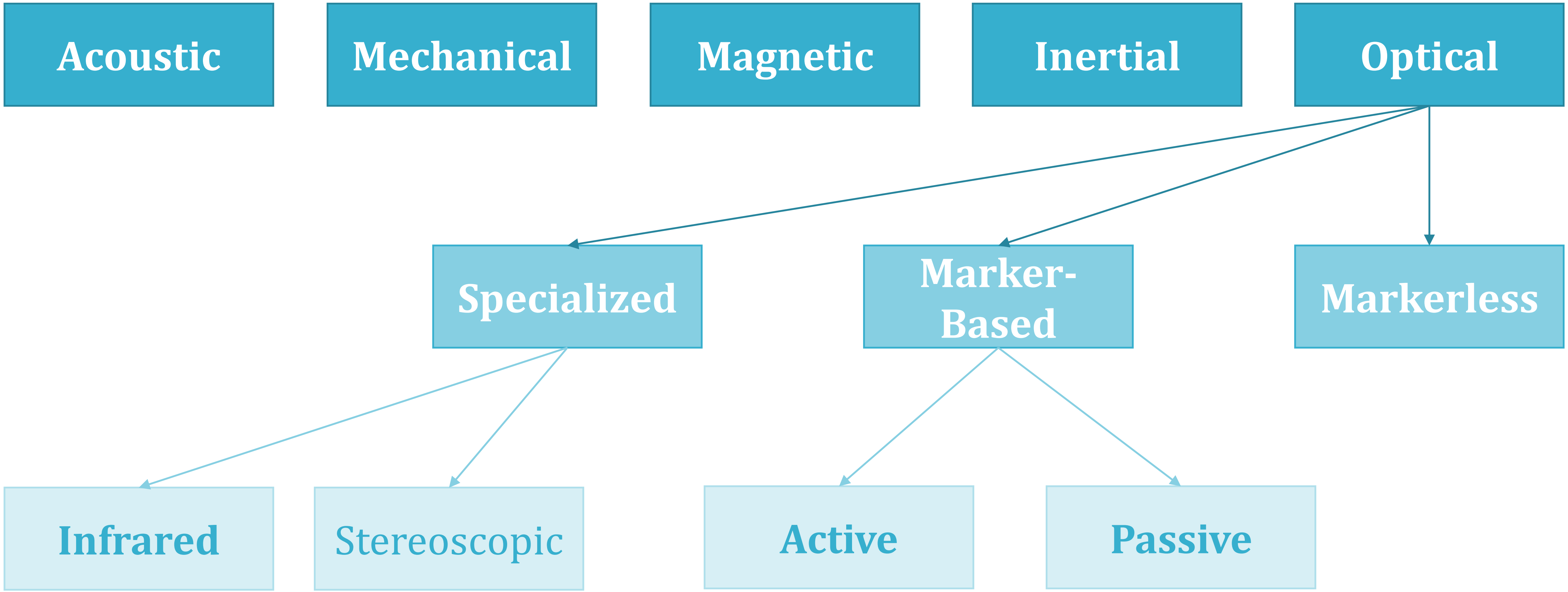
NEURODATA LAB

Tracked Objects



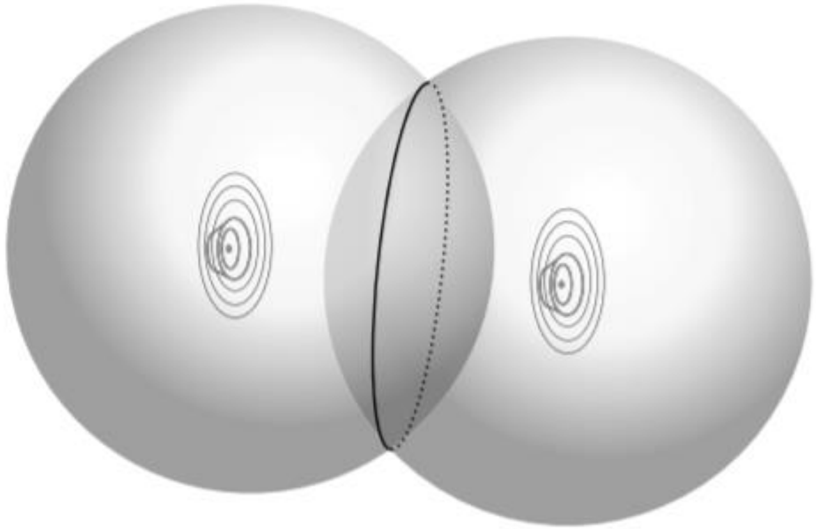
NEURODATA LAB

Tracking Types



Acoustic Tracking

- = Ultrasonic Tracking
- Acoustic tracking systems calculate position upon the wavelength of an acoustic signal and the speed of sound.
- Systems based on time of flight measure the time between the sending of a signal from a transmitter and its being picked up by a receiver.

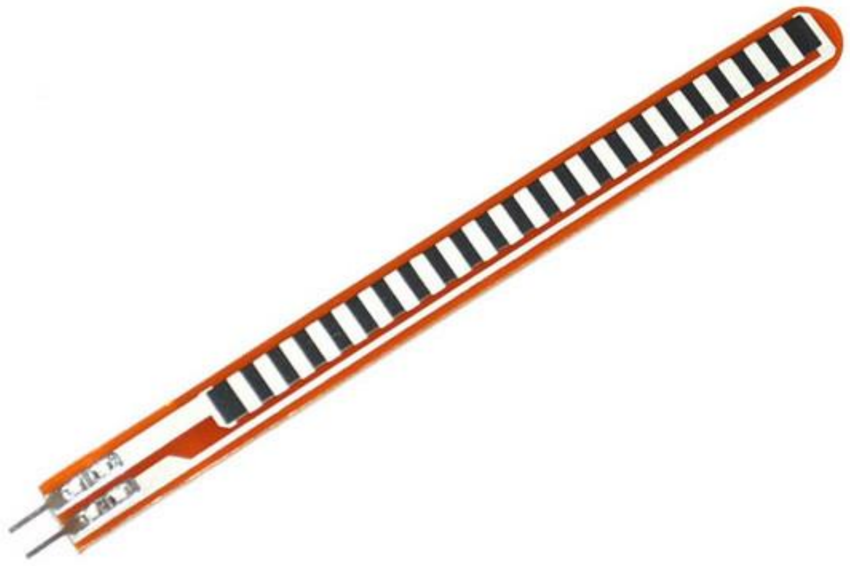


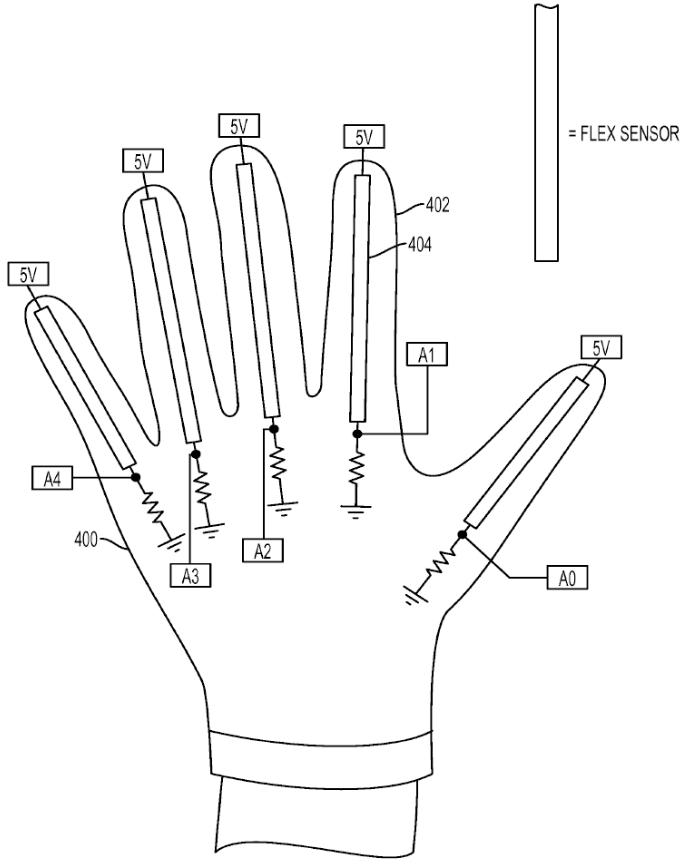
Distance measurements from two acoustic transmitters can determine the position of a receiver to be somewhere along a circle.

NEURODATA LAB

Mechanical Tracking

- Bend sensors: measure angles or lengths between the mechanical parts



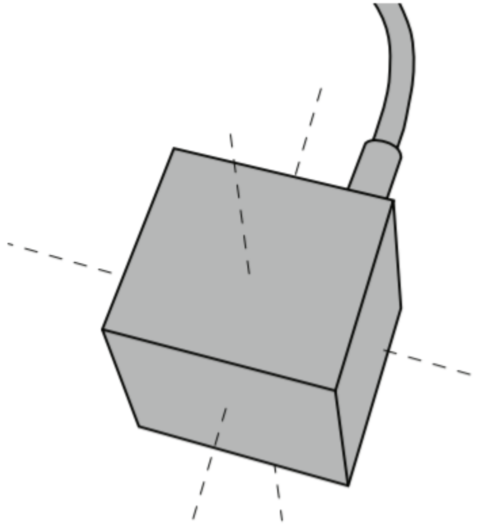


Manus VR

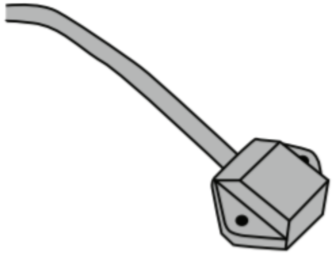
NEUR DATA LAB

Magnetic Tracking

- Is based on the principle of induction, which explains how an electric current is induced in a coil when it is moved in a magnetic field



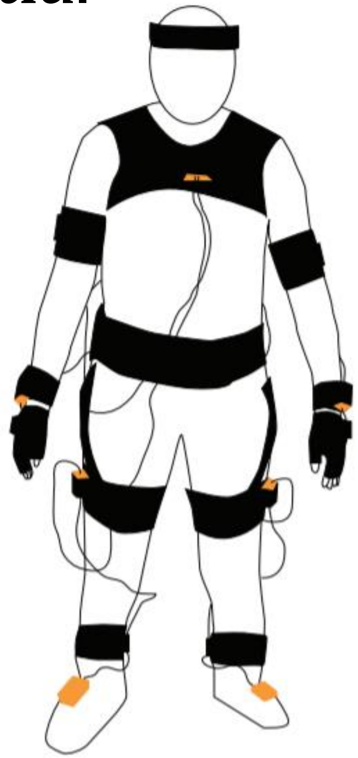
Source, sequentially setting up three perpendicular magnetic fields



Sensor, containing three perpendicular coils where voltages are induced by the magnetic fields from the source

Inertial Tracking

- Inertial tracking systems include those based on accelerometers and gyroscopes. These sensors are based on the physical principle of inertia.



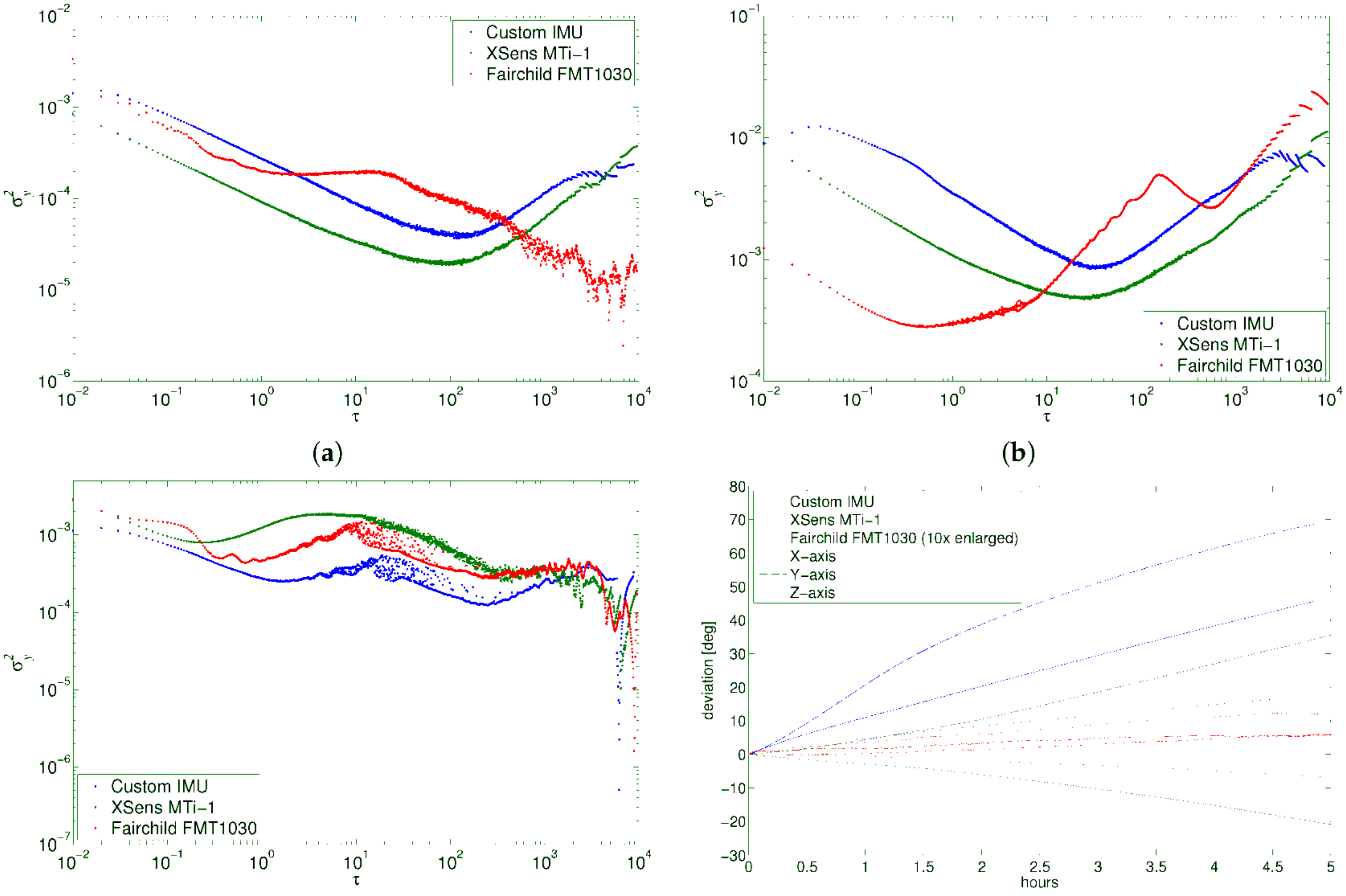
The Xsens suit consists of 17 MTx sensors combining inertial sensors and magnetometers. Full body motion capture is obtained through the use of a kinematic model.

NEURODATA LAB

Inertial Tracking: Advantages

- Self-contained: they do not rely on external sources such as acoustic ultrasound sensors or cameras which require line-of-sight.
- The sensors rely on physical laws that are not affected by external factors such as ferromagnetic objects or light conditions.
- The sensors are very small and lightweight (useful in portable devices).
- The systems have low latencies and can be sampled at very high sampling rates.

Inertial Tracking: Drift



(a) (b) (c) (d)

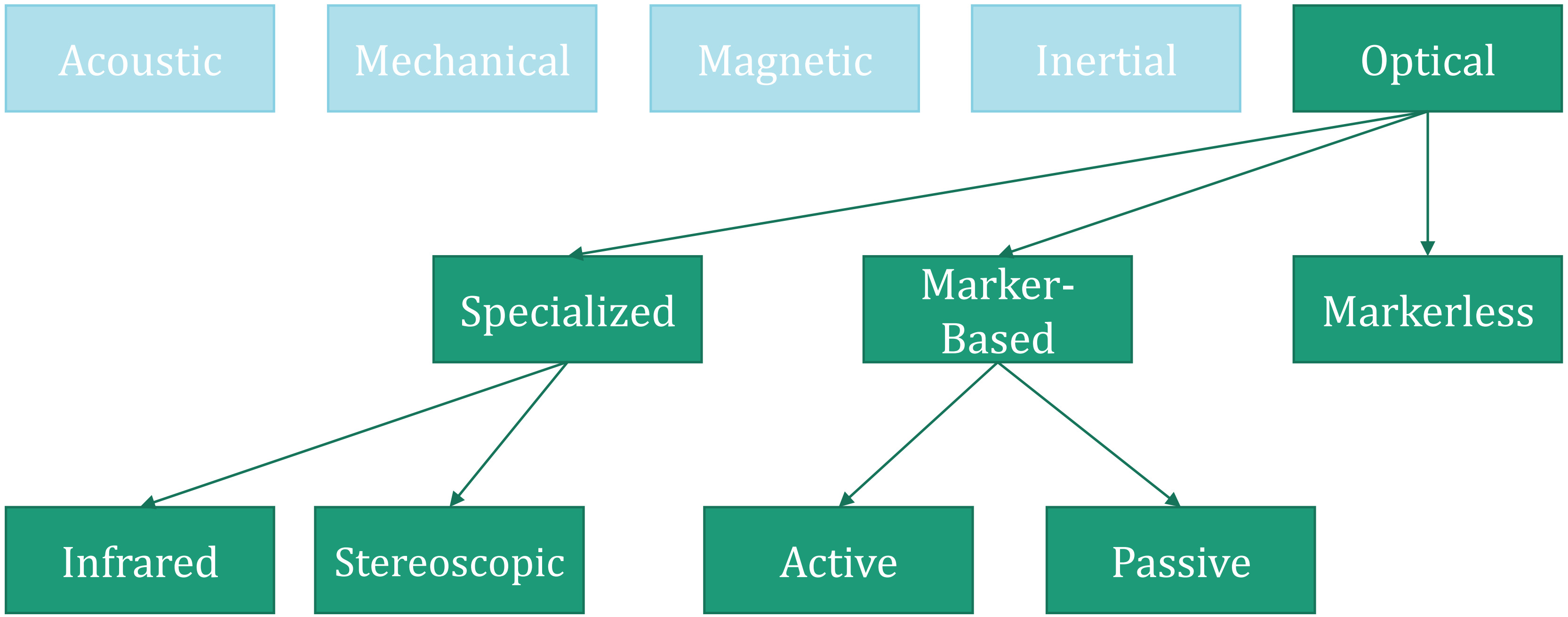
- Static experiment results: representative Allan variances for the tested IMUs: (a) gyroscopes; (b) accelerometers; (c) magnetometer (for yaw axis-Z); (d) drift resulting from gyroscope integration.
- Szczęsna A. et al. Inertial Motion Capture Costume Design Study //Sensors. – 2017. – Т. 17. – №. 3. – С. 612.

Axis Neuron

- 3-axis accelerometer, 3-axis gyroscope sensor and 3-axis magnetometer
- Calculated orientation (quaternion)
- Dimension: 12.5mm*13.1mm*4.3mm
- Weight: 1.2 gram

Optical Tracking & Computer Vision

- Regular video cameras
- Infrared (IR) video cameras
- Depth cameras

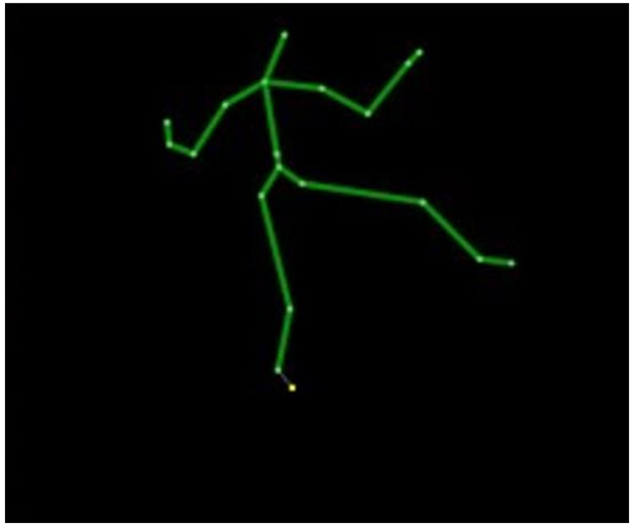


Optical Tracking: Depth (IR) Camera

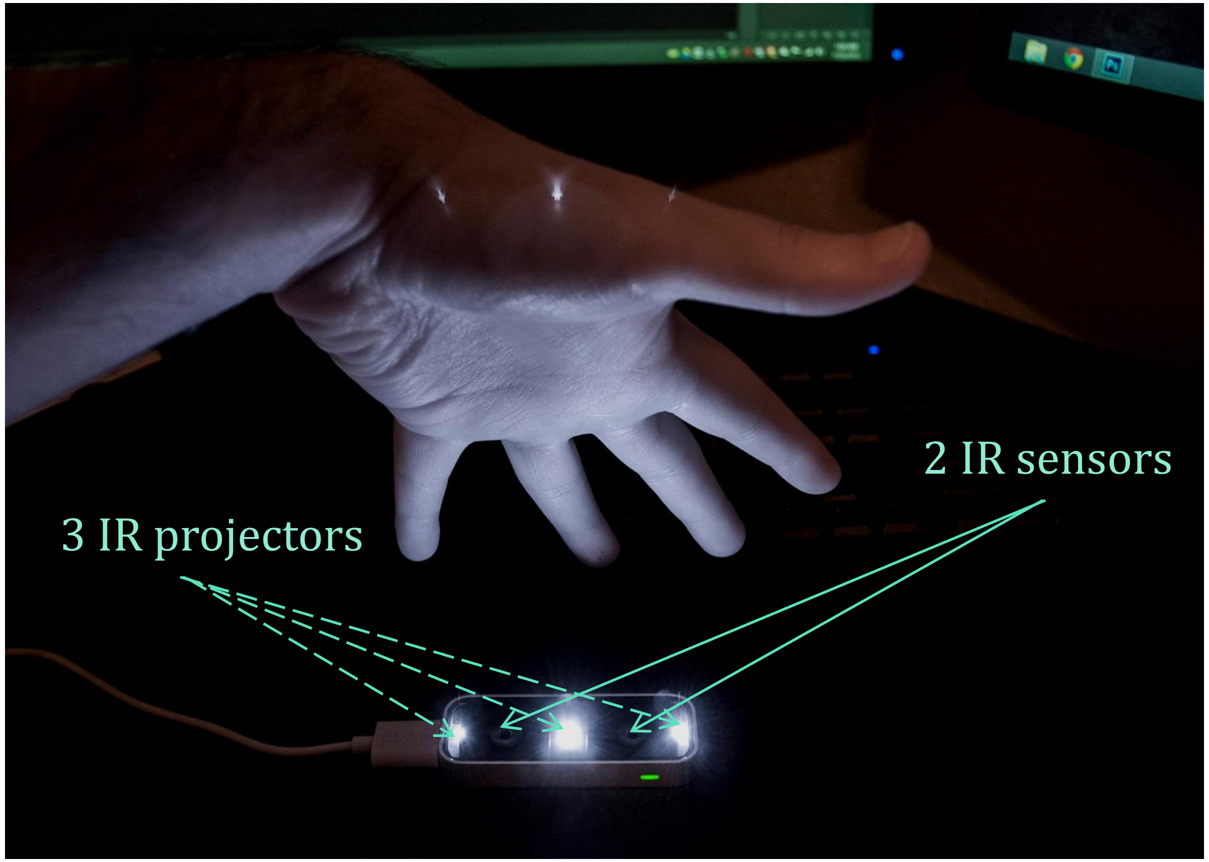
- Microsoft Kinect

Optical Tracking: Depth (IR) Camera

- Kinect uses structured light and machine learning: first it computes a depth map using structured light, then it applies machine learning to infer body position (skeleton).



Leap Motion



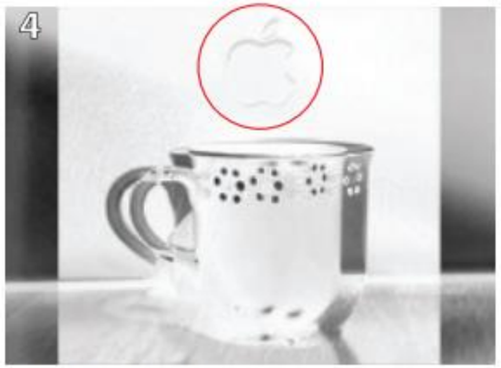
NEURODATA LAB

Optical Tracking: Depth (Stereo) Camera

Left Camera

Right Camera

Both Cameras, Exclusion image

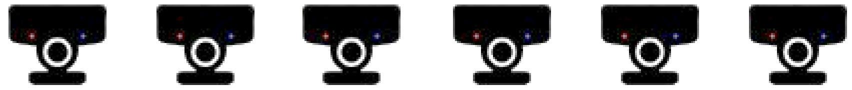


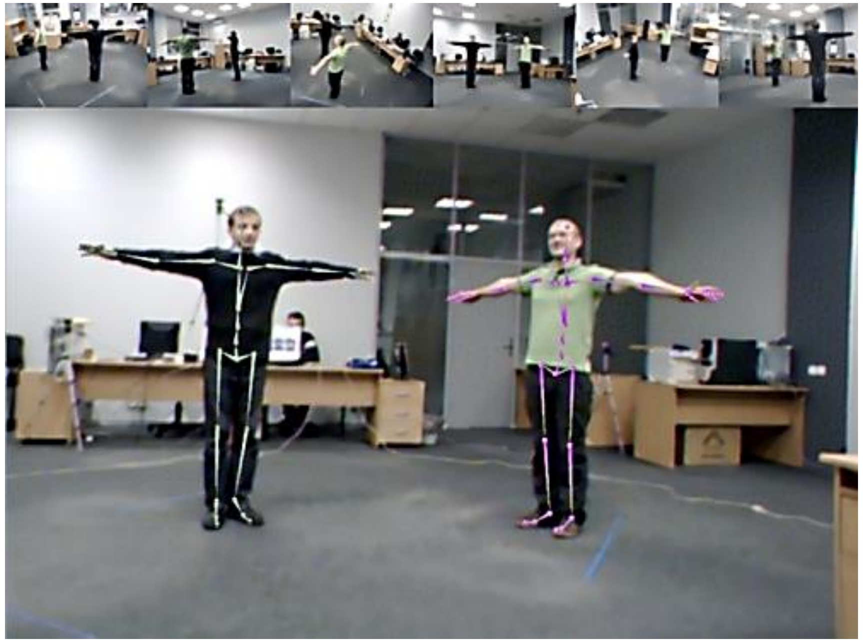
By shifting the images away from each other, the Apple logos in the images overlap

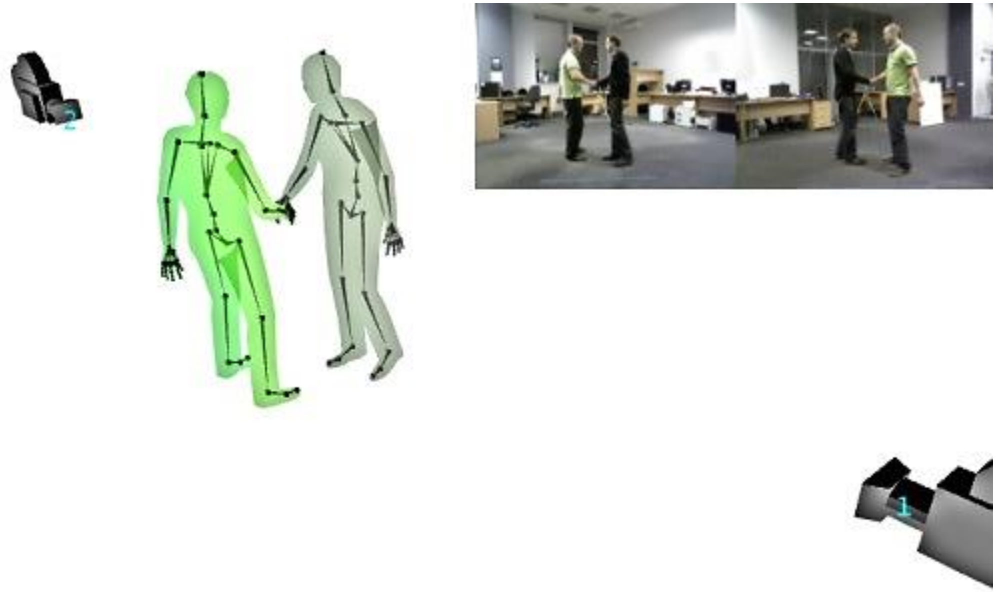
By shifting further, the edges of the mug overlap

Even more, and the flower pattern closest on the mug overlaps

Depth (Stereo) Tracking: iPi Soft







http://ipisoft.com

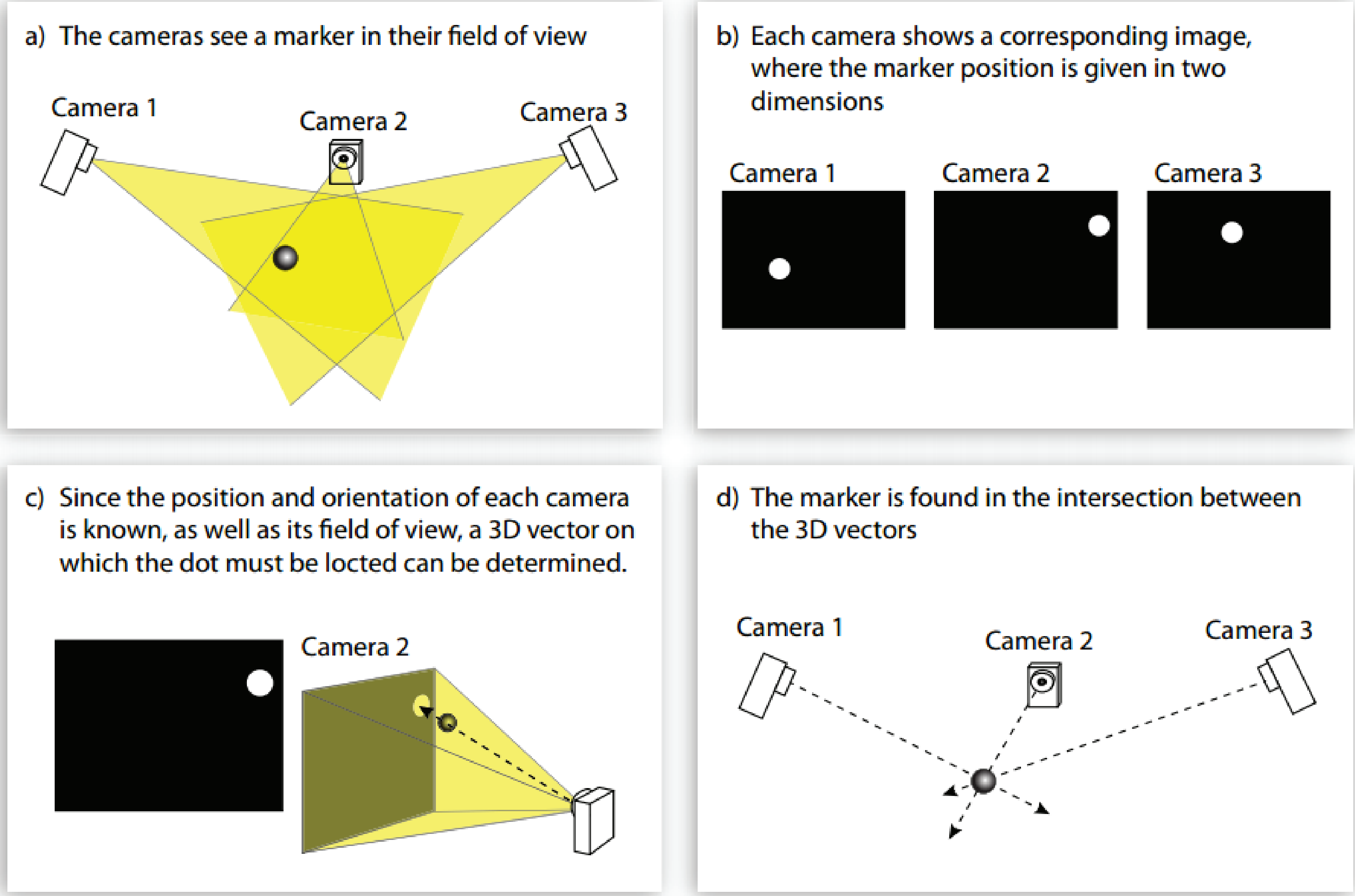
Optical Tracking: Marker-Based

- Passive reflective markers: reflect light from an external source (IR LEDs).
- Active light/IR-emitters.

Mel Slater’s lab, Barcelona

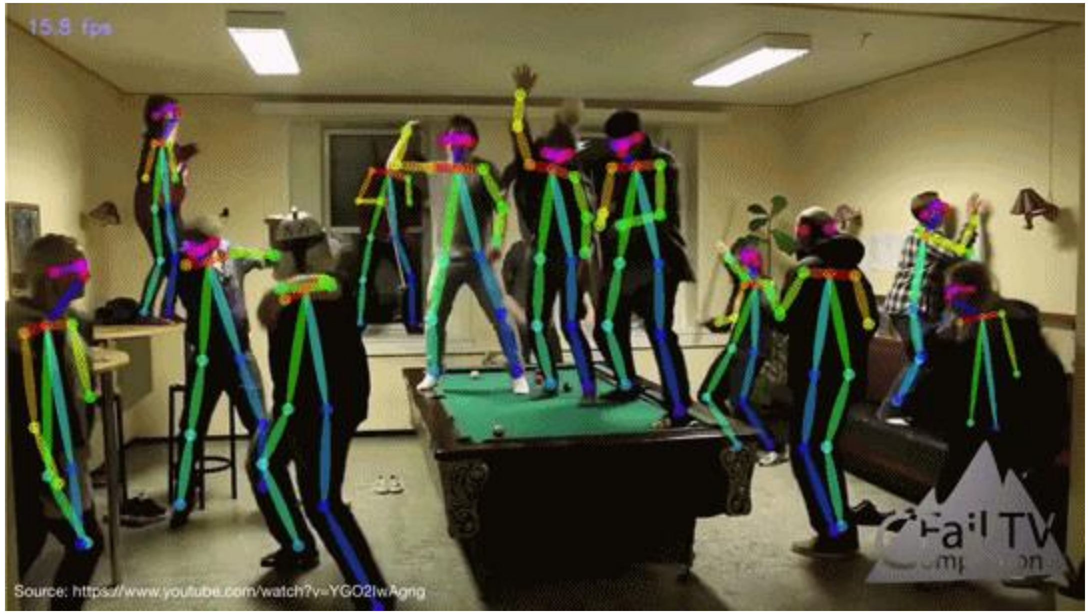
NEURODATA LAB

Optical Tracking: Marker-Based



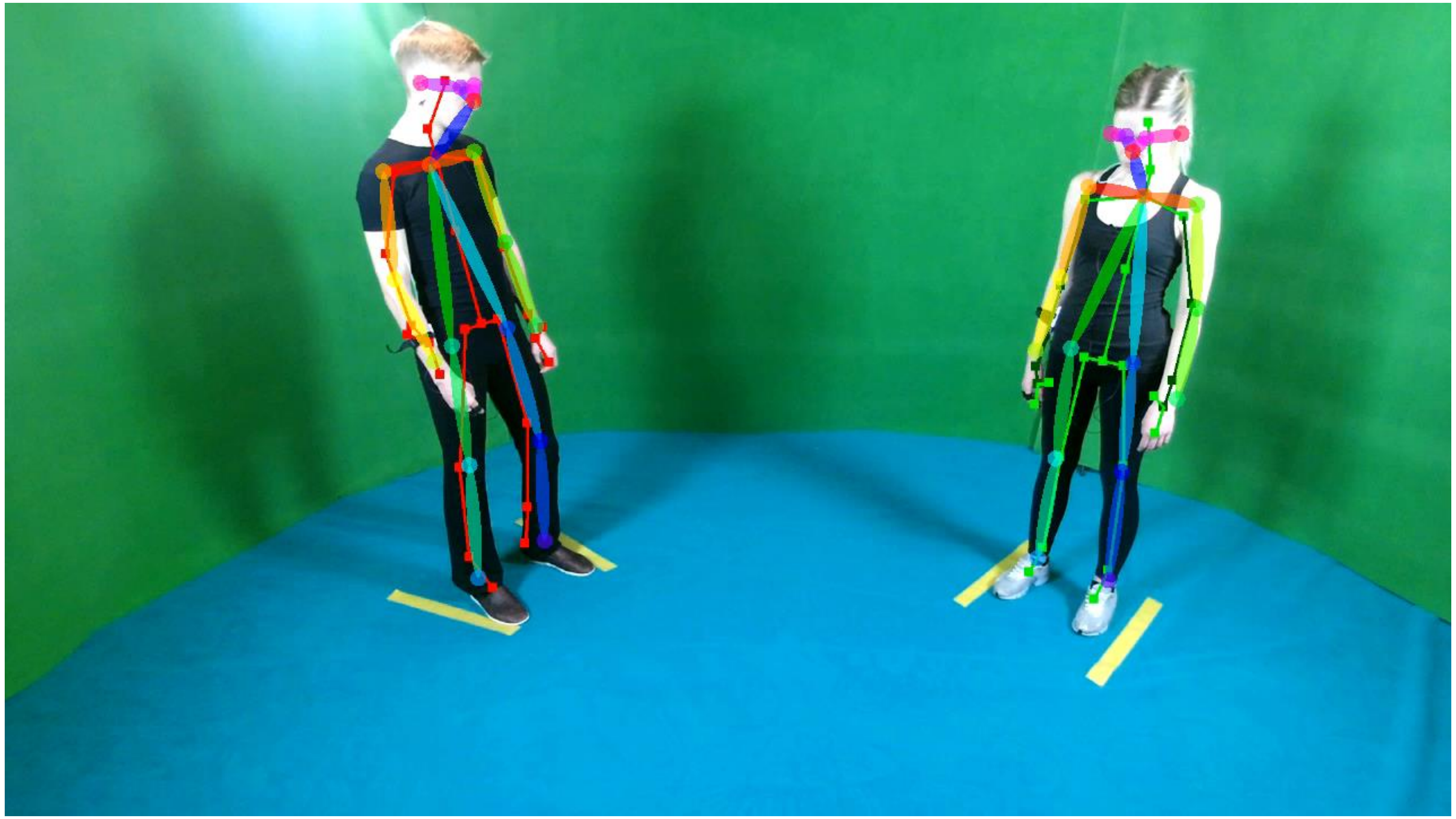
NEURODATA LAB

2D video analisys: Computer Vision



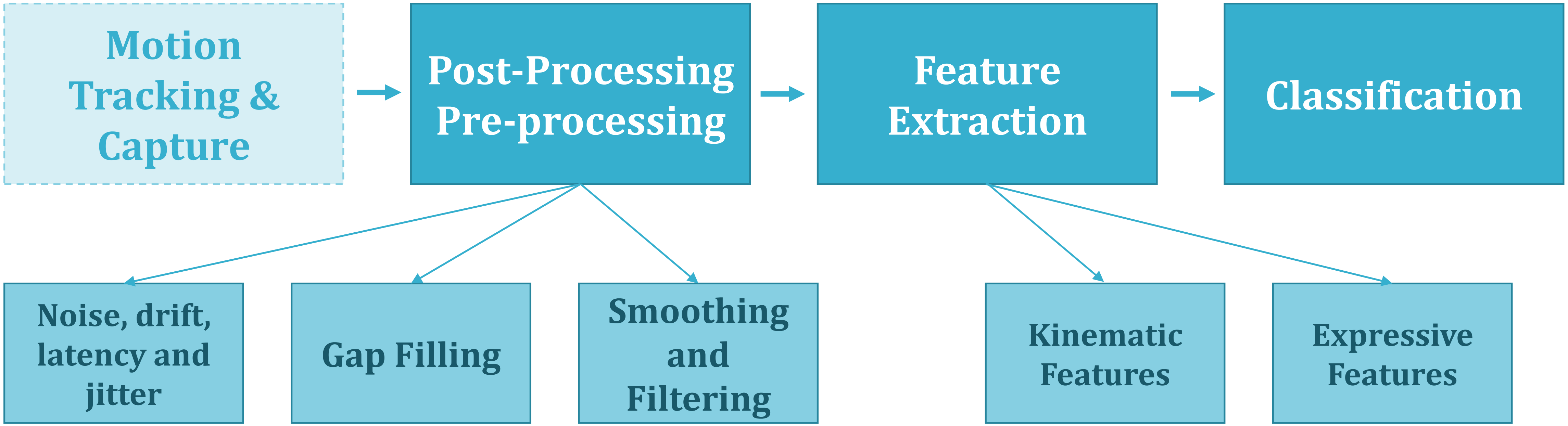
https://github.com/ZheC/Realtime_Multi-Person_Pose_Estimation

Realtime Multi-Person Pose Estimation

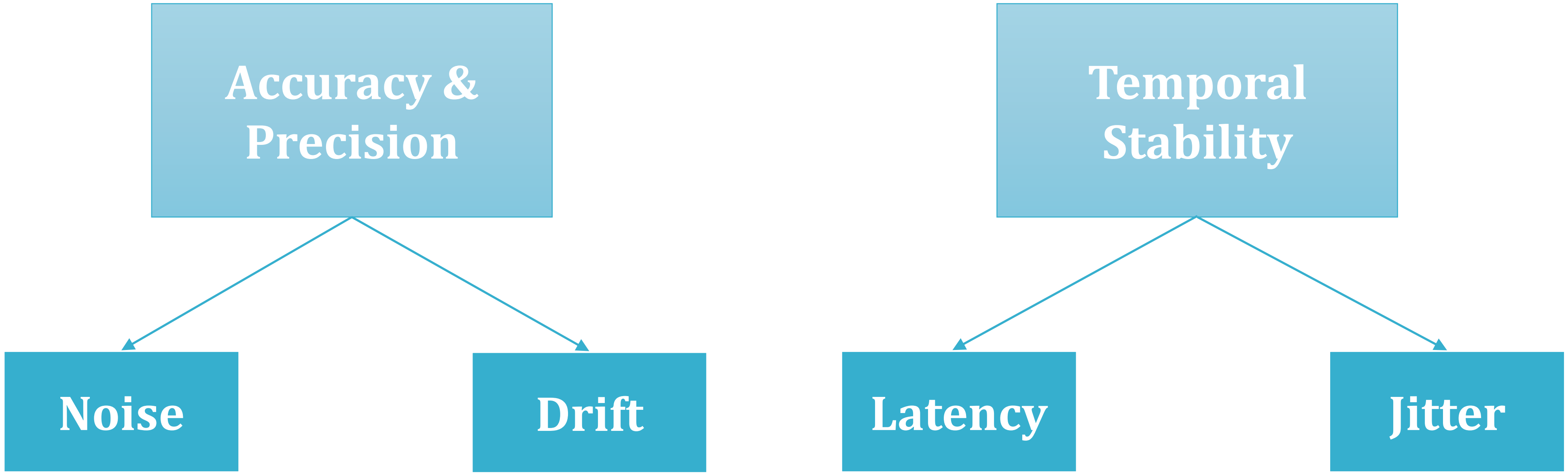


NEURODATA LAB

Data analysis



Post-Processing: tracking performance



Post-Processing: Noise

- The level of noise can be measured by the standard deviation (SD) of a static (i.e. without motion) measurement over a time period.

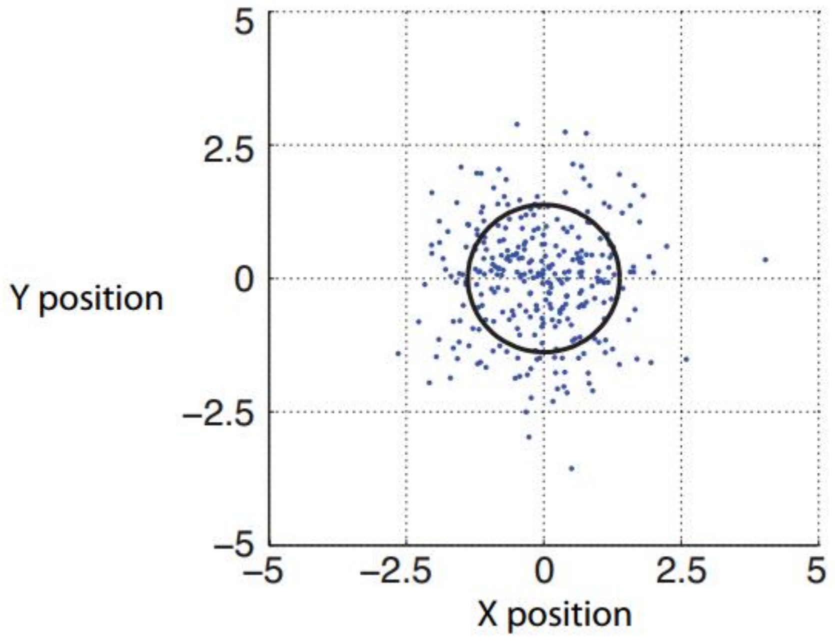
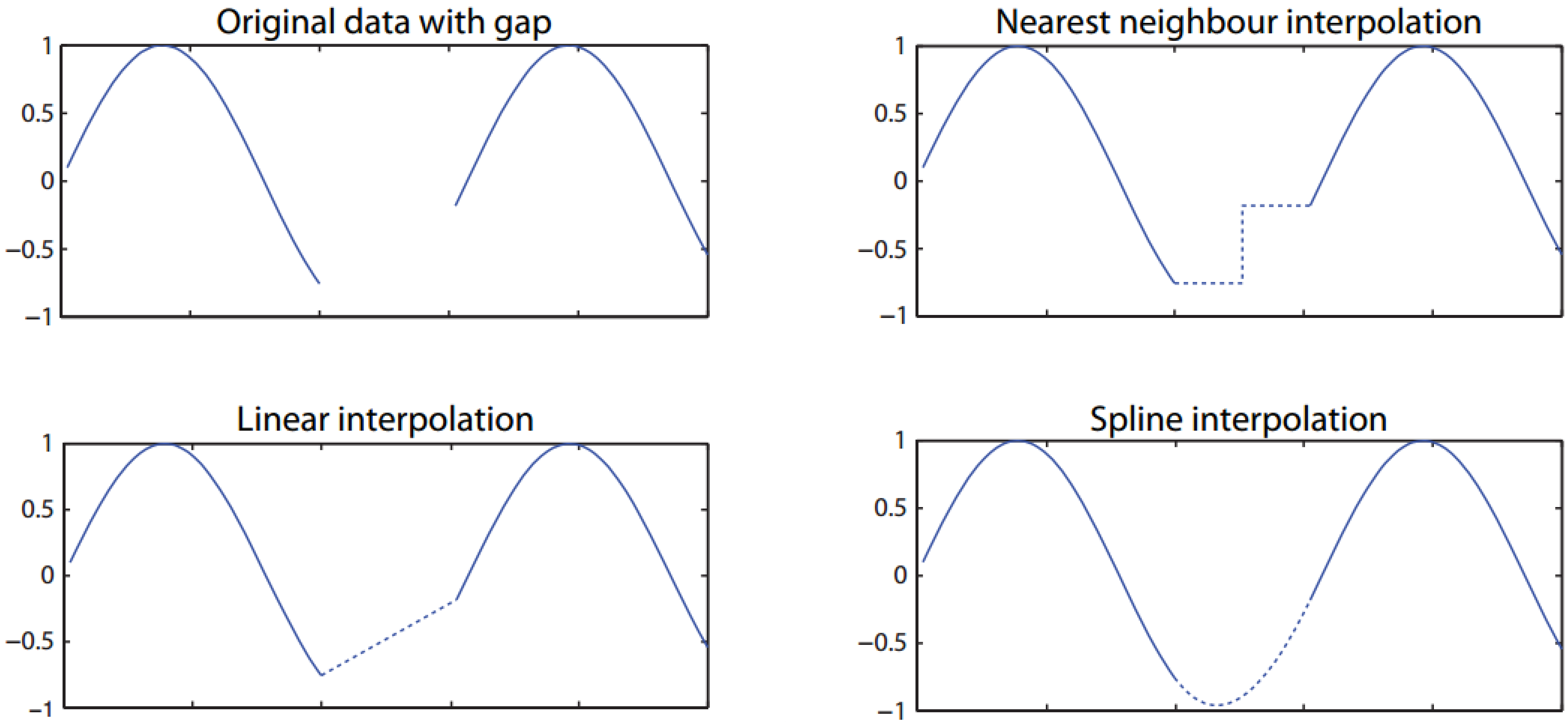


Illustration of how noise can be calculated as the standard deviation of a static position recording. The individual dots display 300 position samples (randomly generated for this example), and the circle has a radius equal to the standard deviation of the position samples.

Post-Processing: Temporal Stability

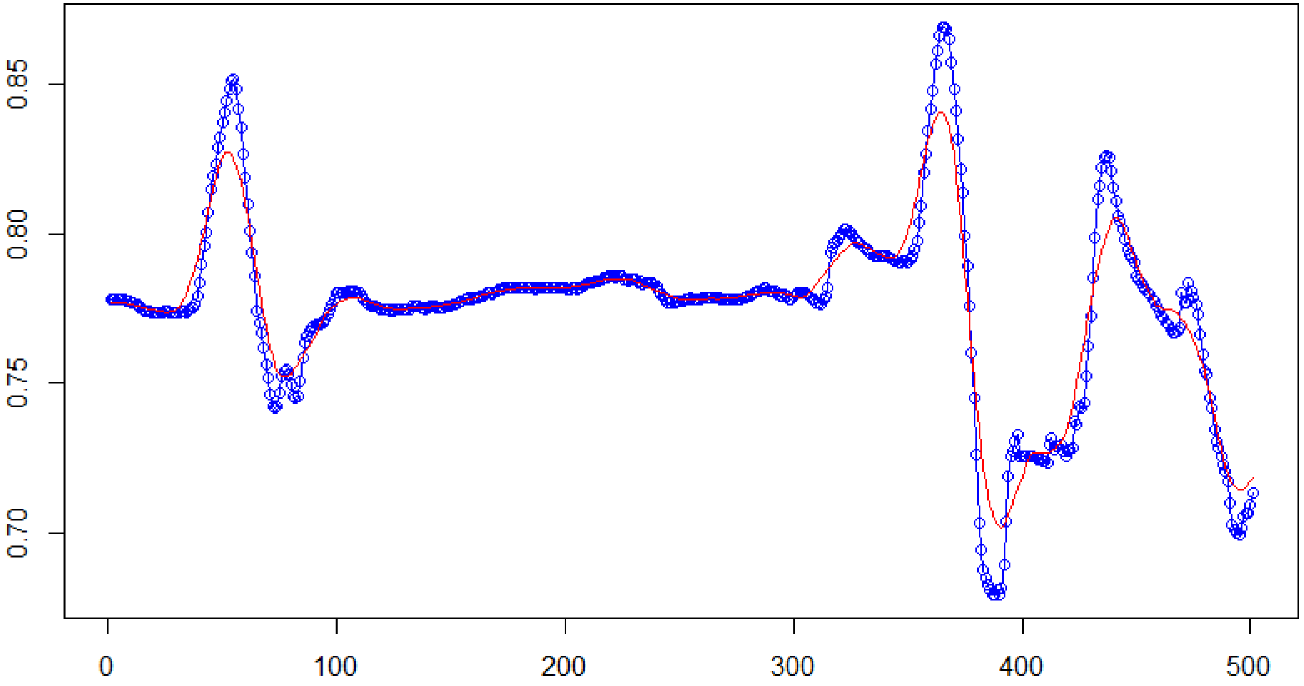
- The latency of an interactive system is the time delay from when a control action occurs until the system responds with some feedback.
- Jitter means any temporal instability in the time interval between data frames. In other words, absence of jitter would mean that the data samples are perfectly periodic.

Post-Processing: gap-filling



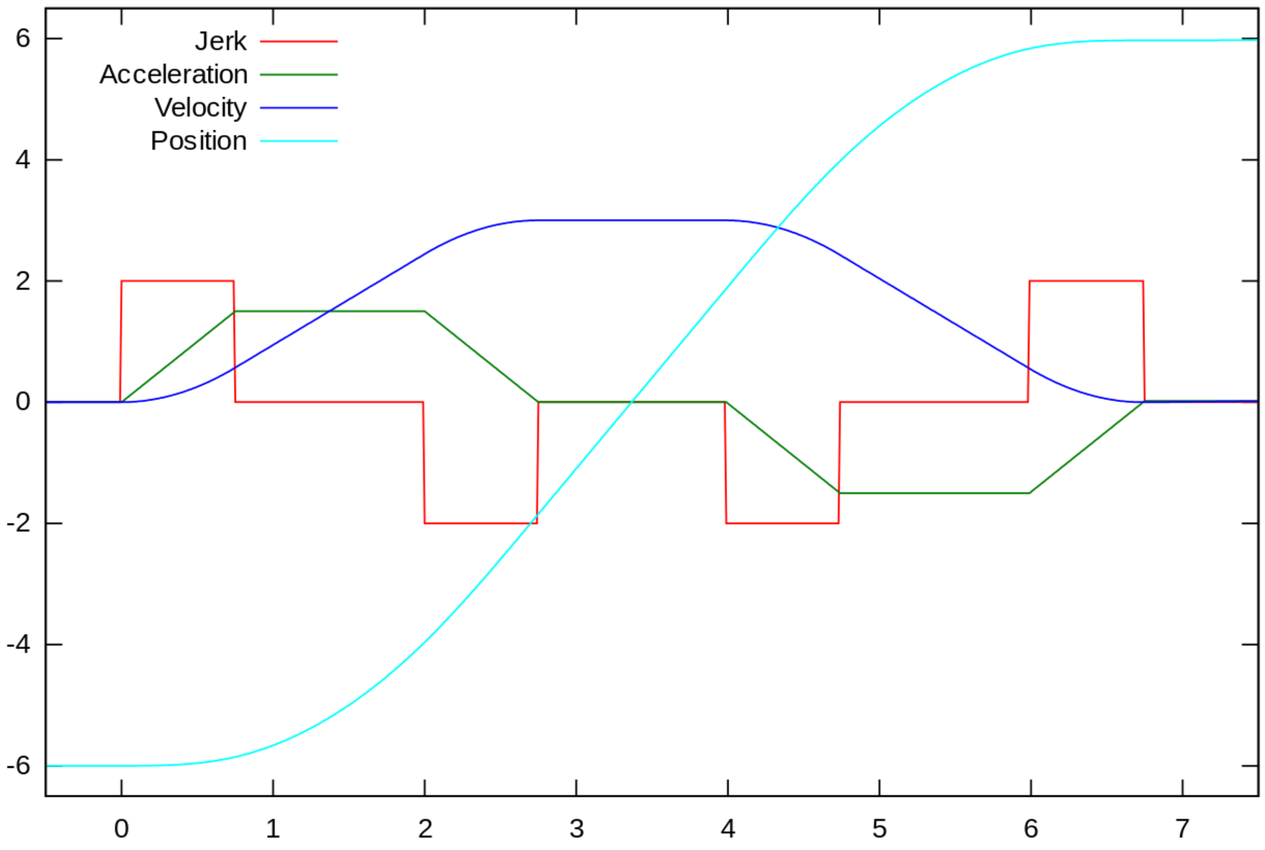
Post-Processing: smoothing and filtering

- Moving Average
- Savitzky-Golay filter
- Low-pass filters
- … etc



Feature Extraction: Kinematic Features

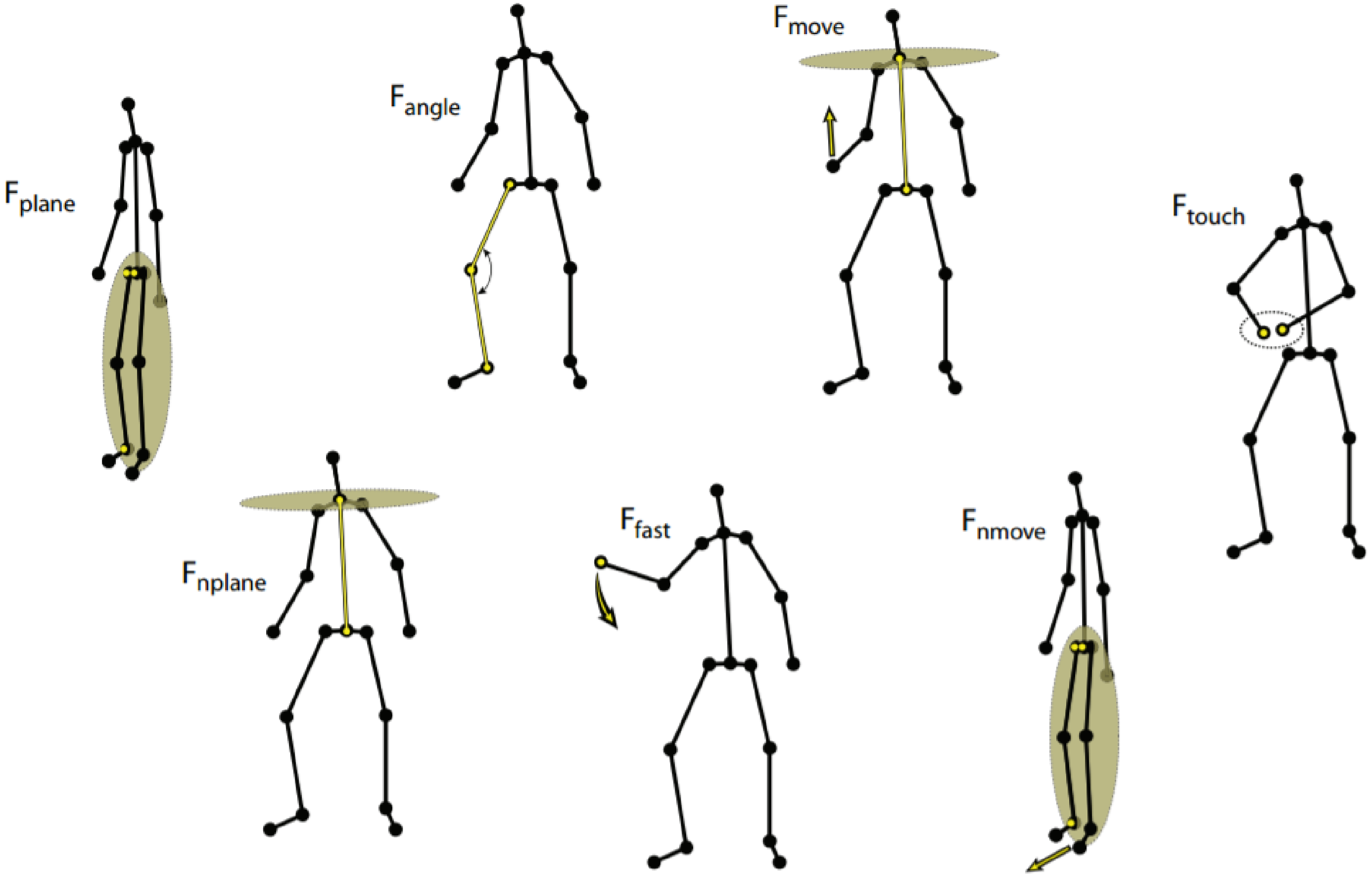
- Positions and Trajectories
- Velocity: $v_i = \dfrac{s_{i+1} - s_{i-1}}{2\Delta t}$
- Acceleration: $(v_i)'$
- Jerk: $(v_i)''$



NEURODATA LAB

Feature Extraction: Kinematic Features

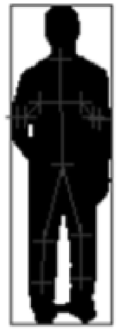
- F_{plane} defines a plane by the position of three joints and determines whether a fourth joint is in front of or behind this plane.
- F_{angle} specifies two vectors given by four joints and tests whether the angle between them is within a given range.
- F_{fast} specifies a single joint and assumes a value of 1 if the velocity of the joint is above a chosen threshold.
- F_{touch} measures the distance between two joints or body segments and assumes a value of 1 if the distance is below a certain threshold.

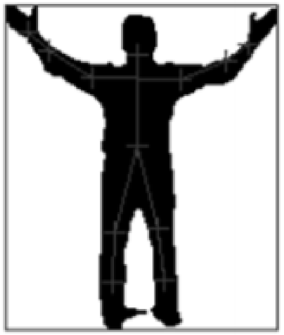


NEUR DATA LAB

Feature Extraction: Expressive Features

- Kinetic Energy: $KE(f) = \frac{1}{2}\sum_{i=1}^{n} m_i v_i^2(f)$
- Contraction Index is a measure of how the user's body uses the space surrounding it.



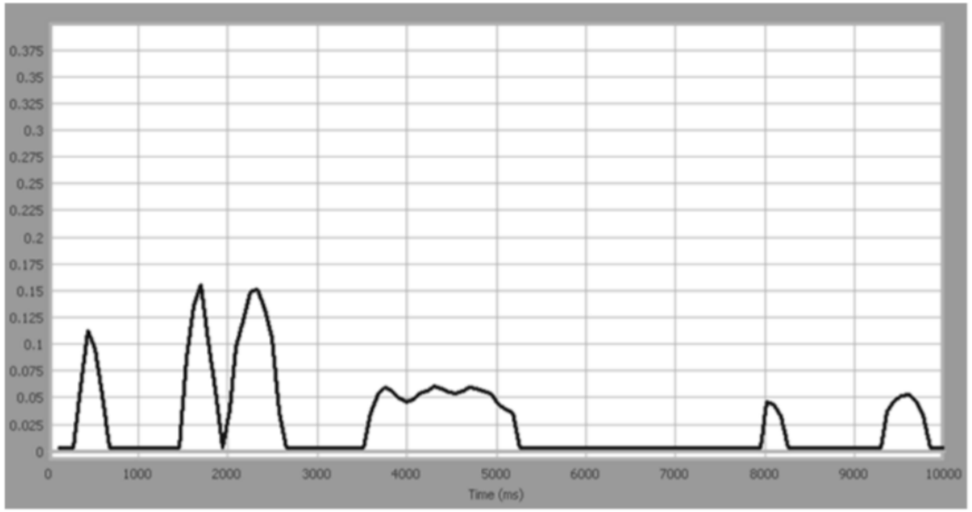


Feature Extraction: Expressive Features

- Symmetry Index
- Periodicity
- Directness
- Impulsivity
- etc.

Movement Segmentation

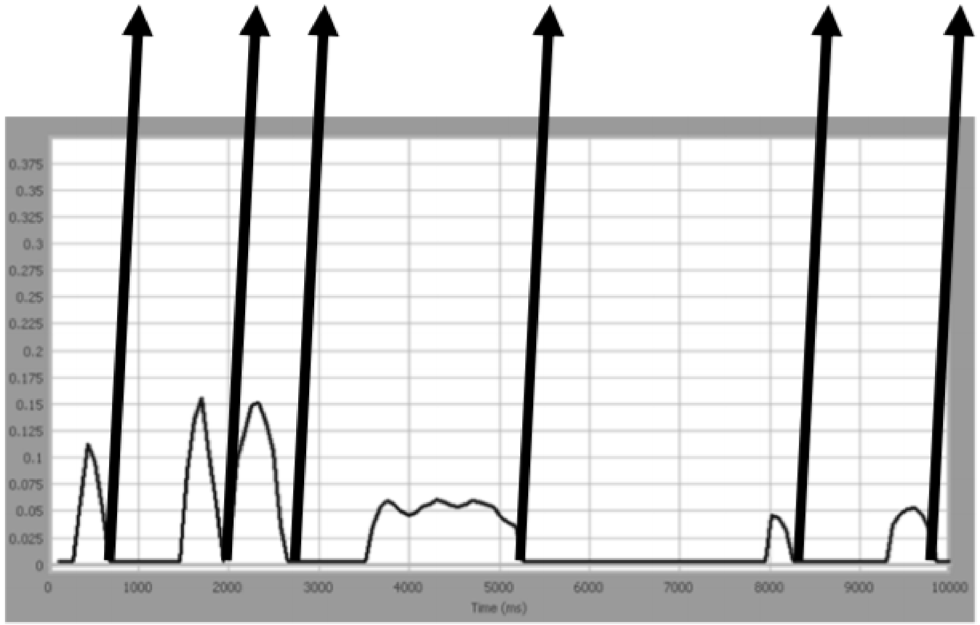
- Motion Phases: the user is moving.
- Pause Phases: the user does not appear to move
- A threshold on the Motion Index / Kinetic Energy.



NEUR DATA LAB

Movement Segmentation

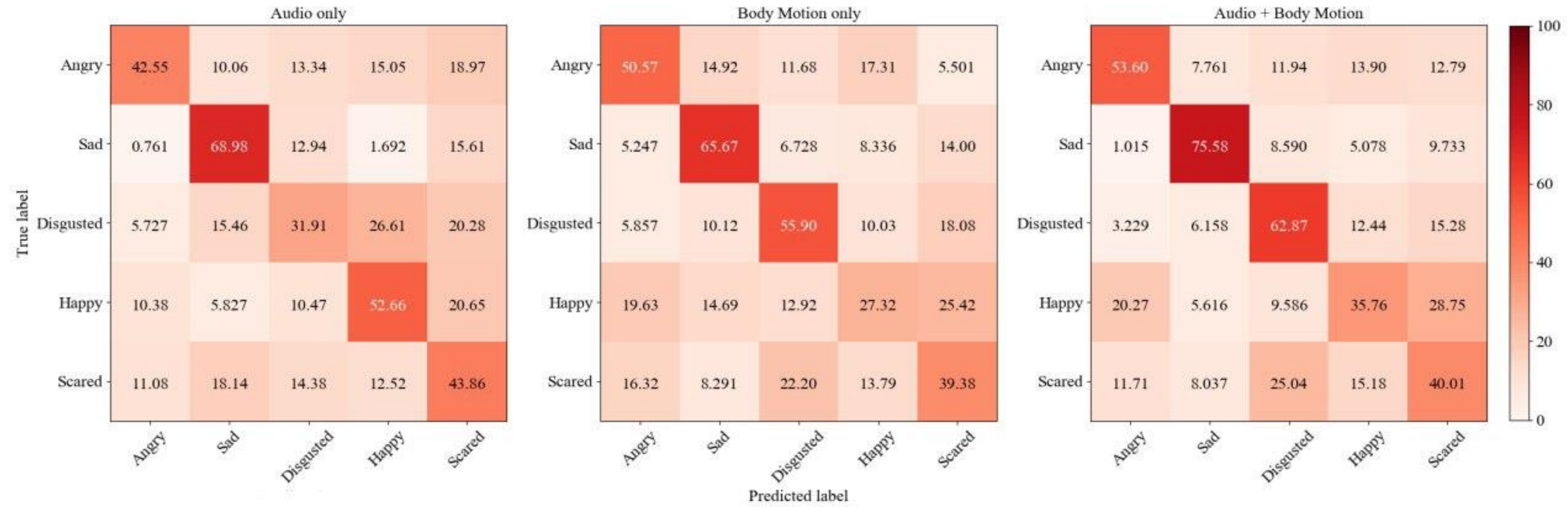
Motion	0.1	0.15	0.15	0.05	0.05	0.07
Contraction	0.3	0.9	0.3	0.5	0.7	0.1
Symmetry	0.8	0.9	0.8	0.1	0.2	0.3



Examples: RAMAS dataset

- 6 basic emotions: angry, disgust, happy, sad, scare, surprise.
- Multimodal: video, audio, motion, physiology.
- Play-acted

Examples: RAMAS dataset



5 classes (random choice 20%): RNN

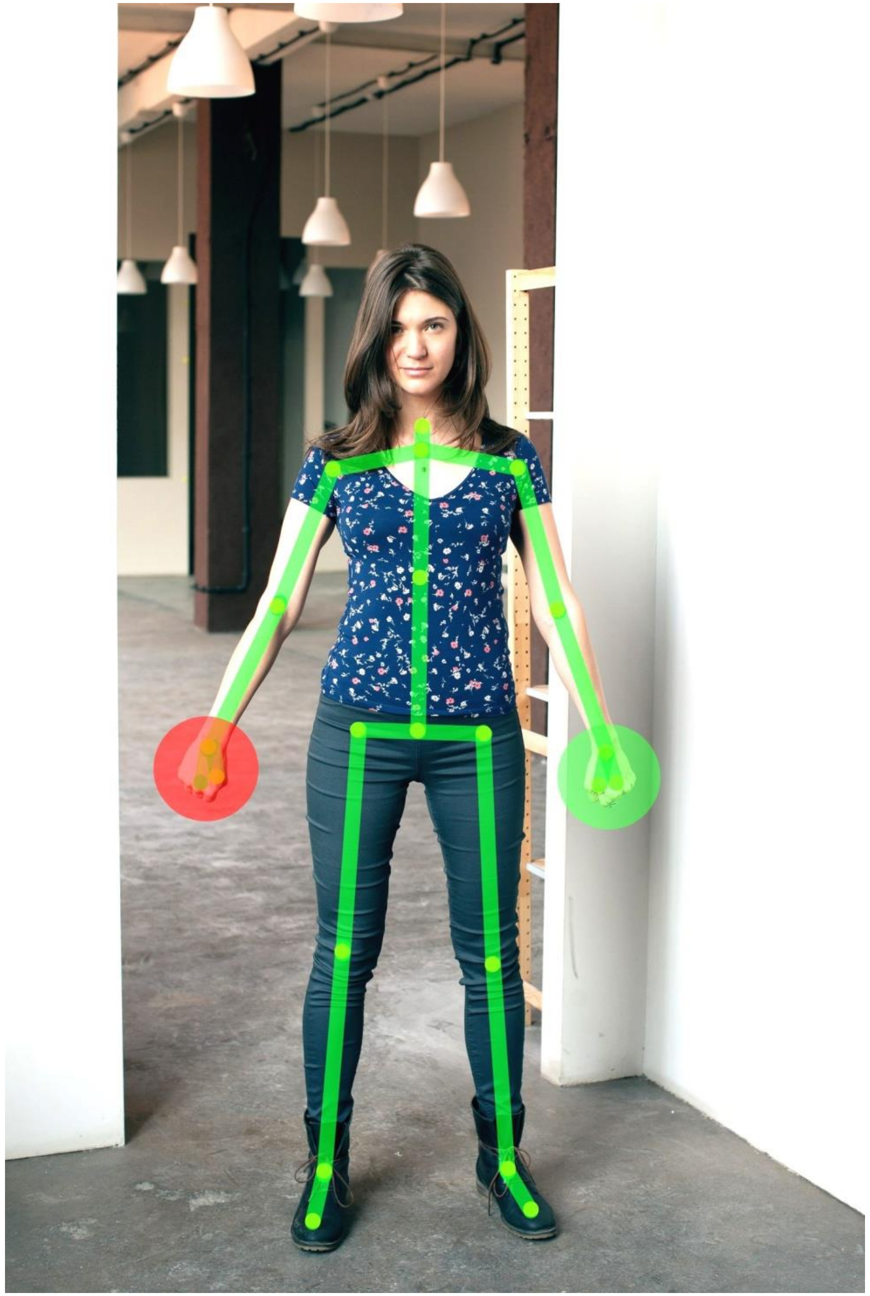
49% for audio and motion

52 % for audio + motion

NEURO DATA LAB

Thank you for the attention!

- Olga Perepelkina
- o.perepelkina@neurodatalab.com
- www.neurodatalab.com



NEURODATA LAB