Augmented Human Biomechanics
from Sport Technology to Medical Rehabilitation
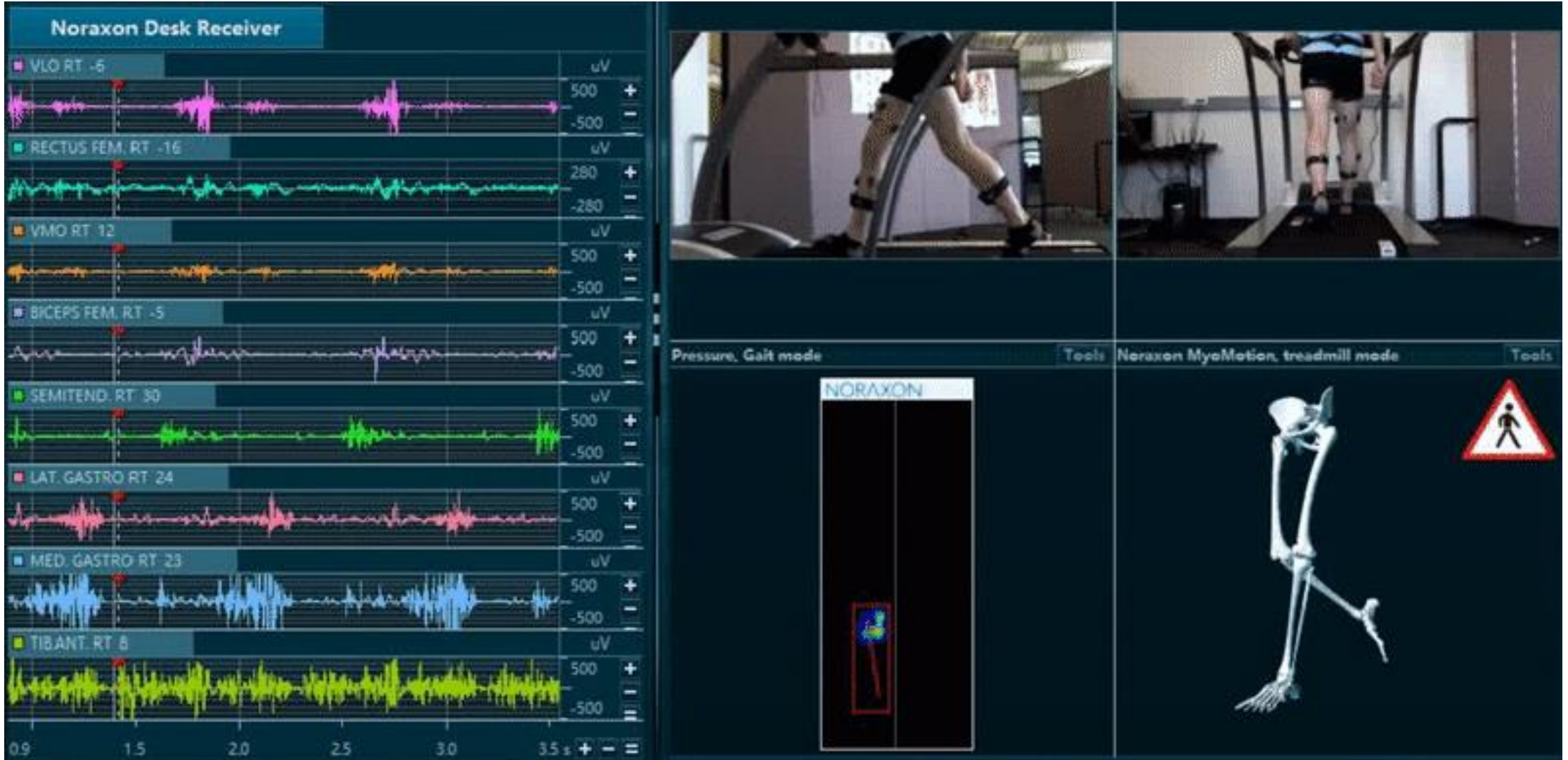
Technische **Hochschule** Ingolstadt

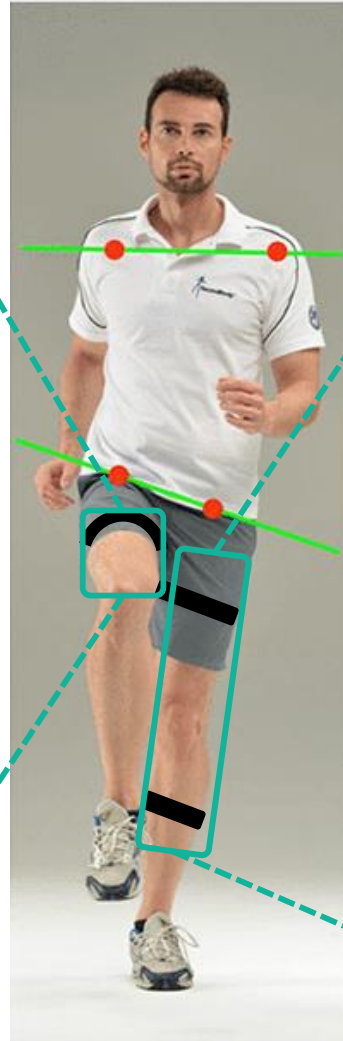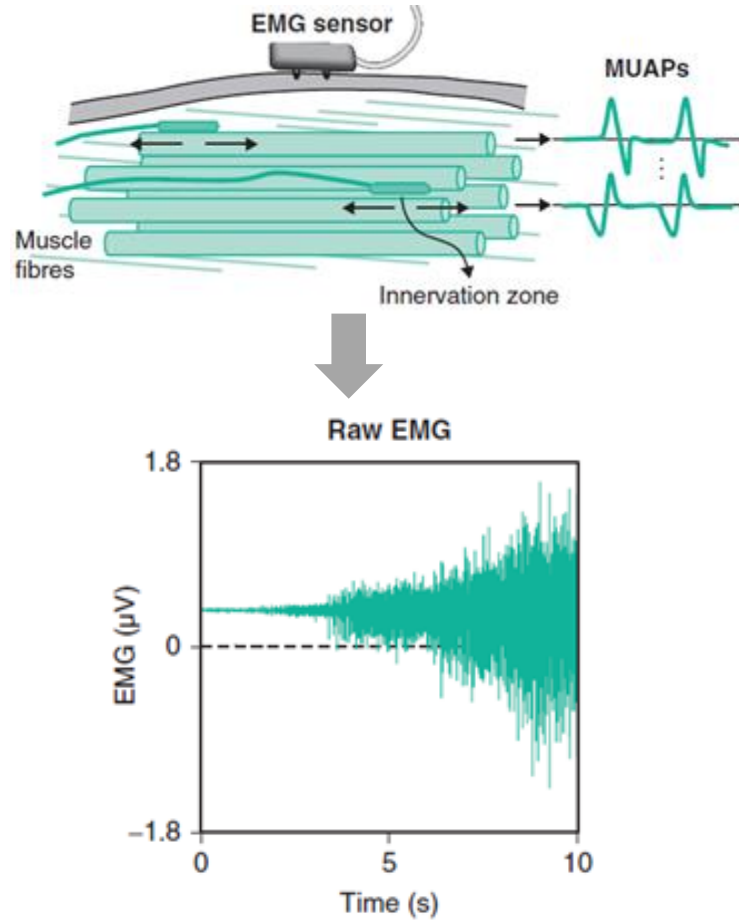Dr. Cristian Axenie

Agenda

- Biomechanics of Human Motion

- Sensors and Data Analysis

- Augmented Biomechanics: From Sports to Medicine

- Conclusions
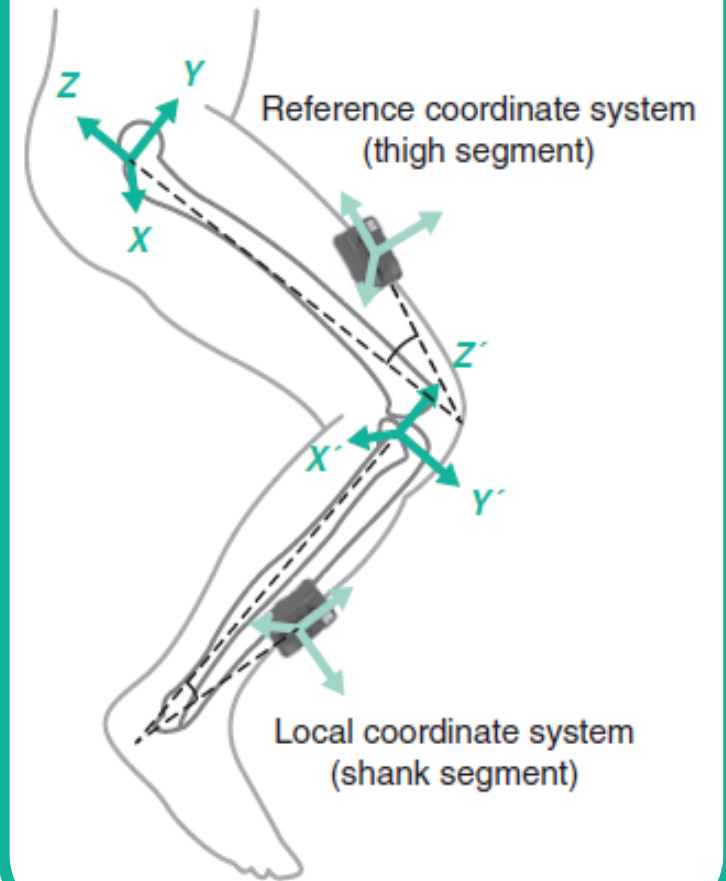
Biomechanics of Human Motion

Biomechanical Analysis & Musculoskeletal Modeling (BAMM) Lab   http://bammlab.okstate.edu/

Sensors and Data Analysis

Electromyography (EMG)

EMG sensor

MUAPs

Muscle fibres

Innervation zone

Raw EMG

Inertial Sensors

Reference coordinate system (thigh segment)
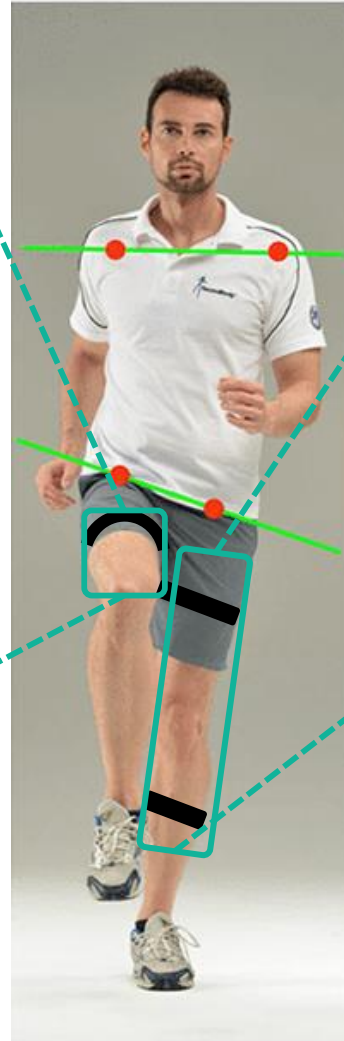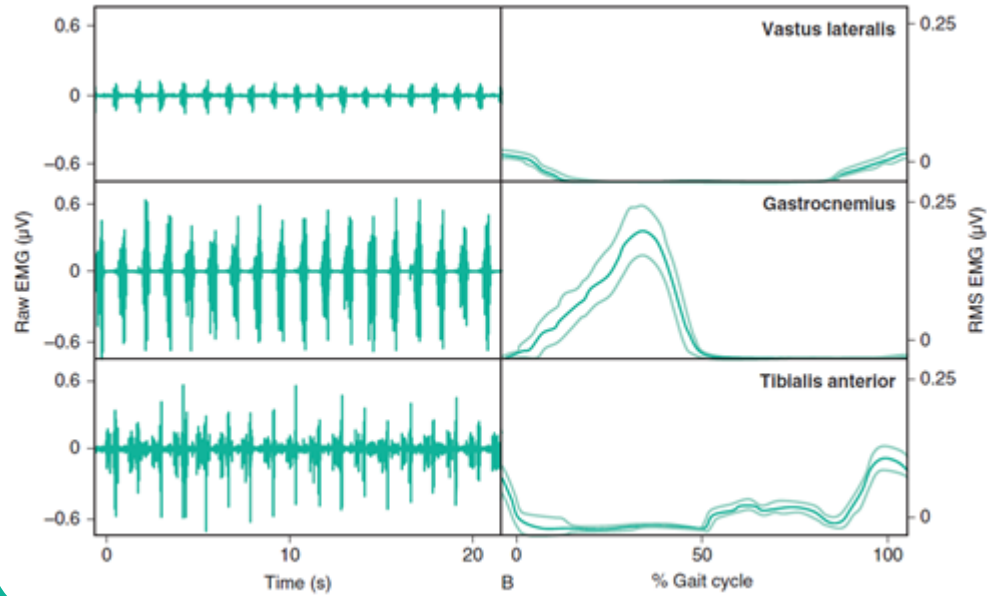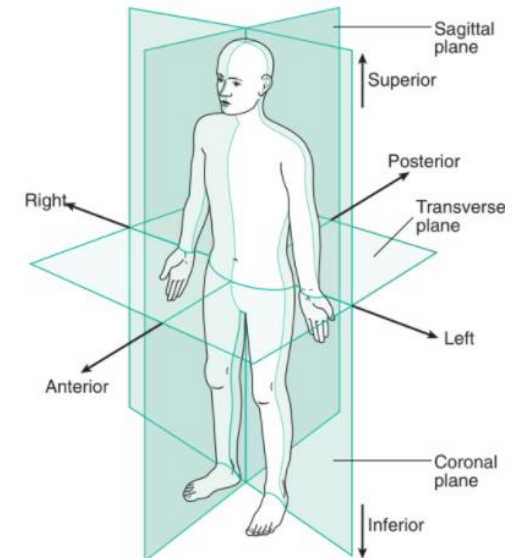
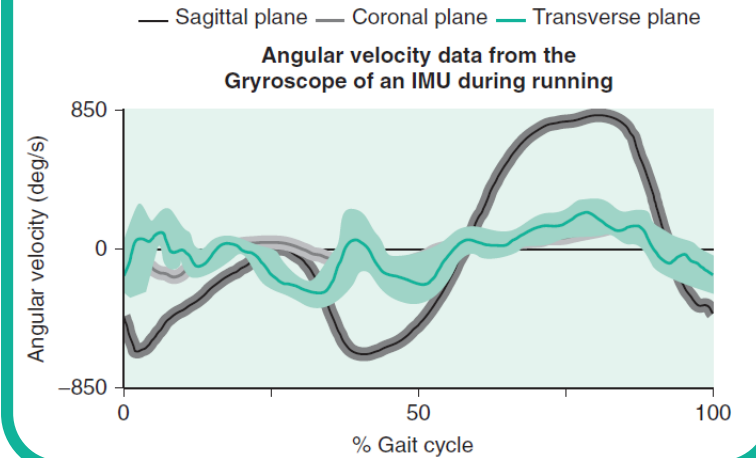Local coordinate system (shank segment)

Sensors and Data Analysis

Electromyography (EMG)

Inertial Sensors

Augmented Biomechanics: Sports

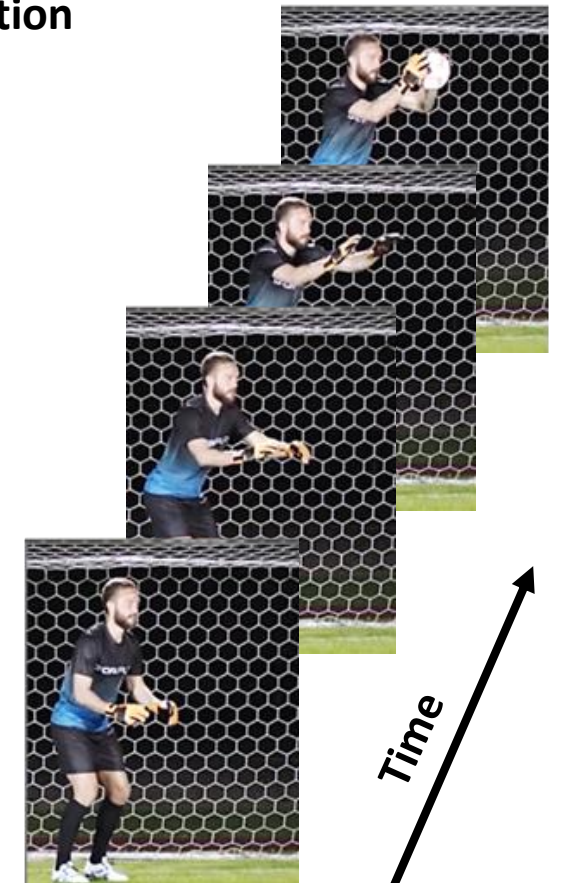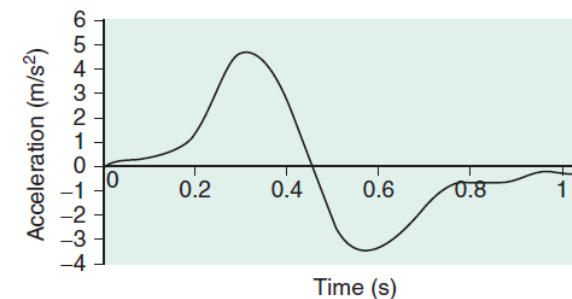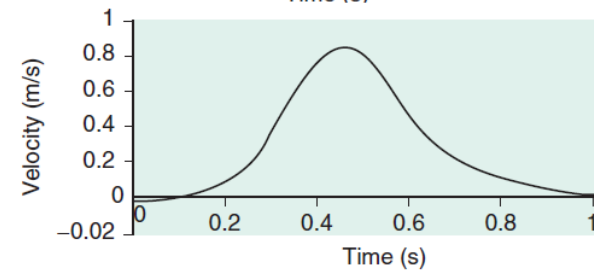**Goalkeeper Biomechanics Extraction from Inertial Sensors in Gloves**

How precise can 2 sensors reconstruct a dive?

Data analysis for a reaching position

Augmented Biomechanics: Sports

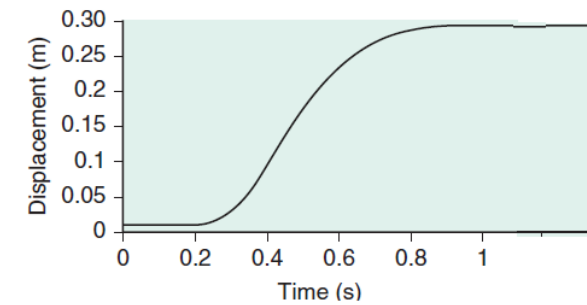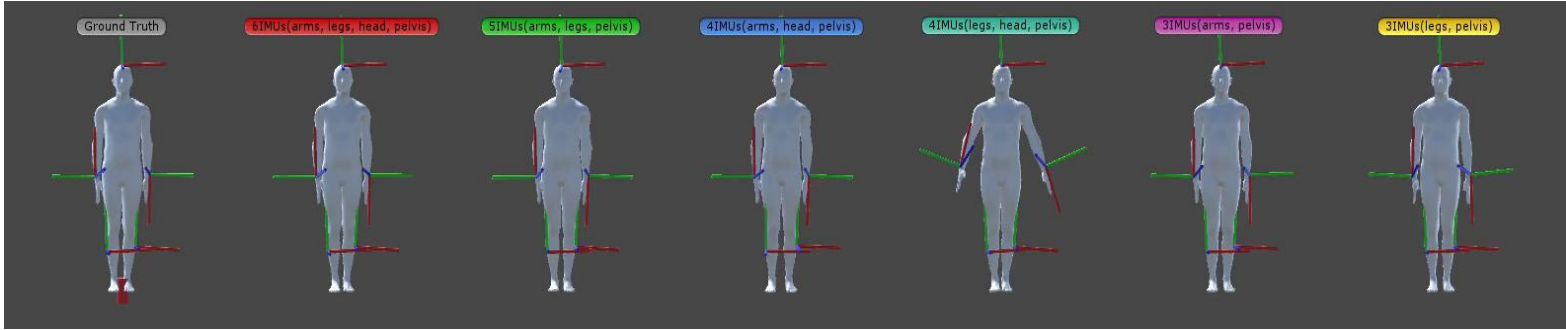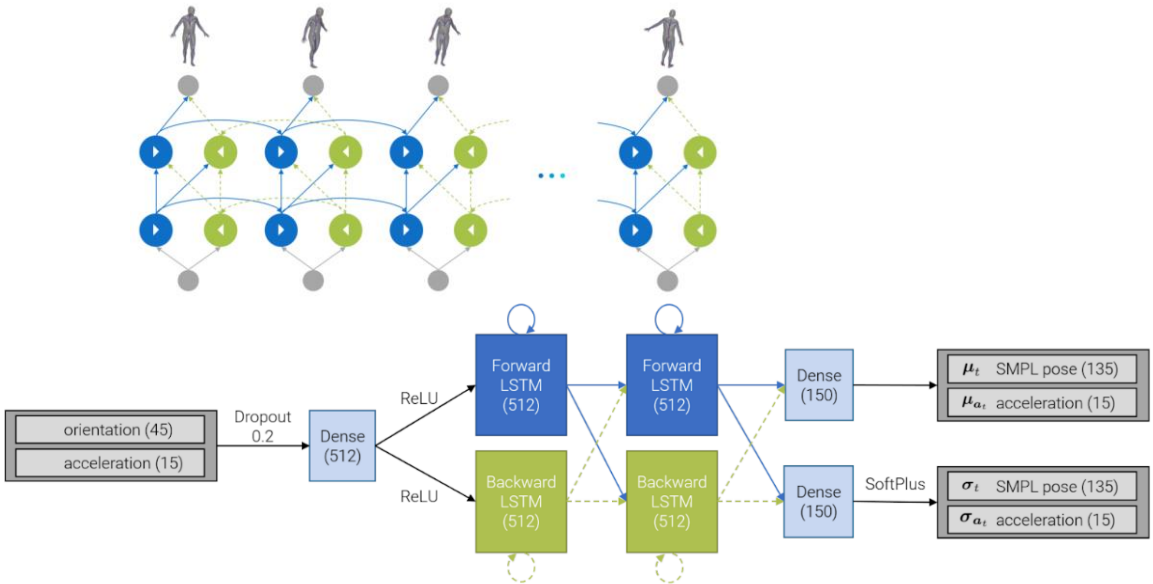**Goalkeeper Biomechanics Extraction from Inertial Sensors in Gloves**

How many sensors can reconstruct a dive?
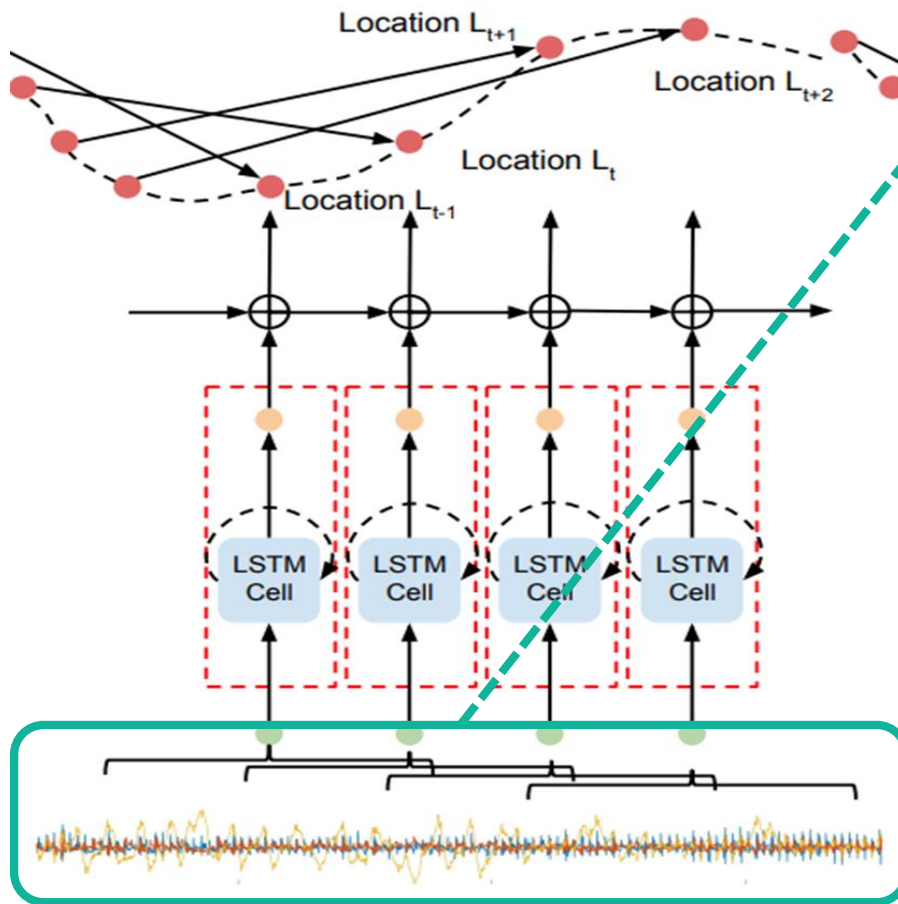

Learning goalkeeper's kinematics

Nr. IMUs	average joint angle error (deg)	average positional error (m)	hands	legs	head	pelvis	
6	13.5874 (+/- 10.331)	0.1273 (+/- 0.102)	x	x	x	x	
5	14.3749 (+/- 10.586)	0.1284 (+/- 0.108)	x	x		x	
4	16.1093 (+/- 12.062)	0.1504 (+/- 0.116)	x		x	x	
4	25.2287 (+/- 16.688)	0.1651 (+/- 0.123)		x	x	x	
3	16.3689 (+/- 12.489)	0.1490 (+/- 0.118)	x			x	
3	26.5287 (+/- 16.919)	0.1717 (+/- 0.127)		x		x	

Pohl, S., Becher, A., Grauschopf, T., & **Axenie, C**. (2019). Neural Network 3D Body Pose Tracking and Prediction for Motion-to-Photon Latency Compensation in Distributed Virtual Reality. In International Conference on Artificial Neural Networks (pp. 429-442). Springer, Cham.
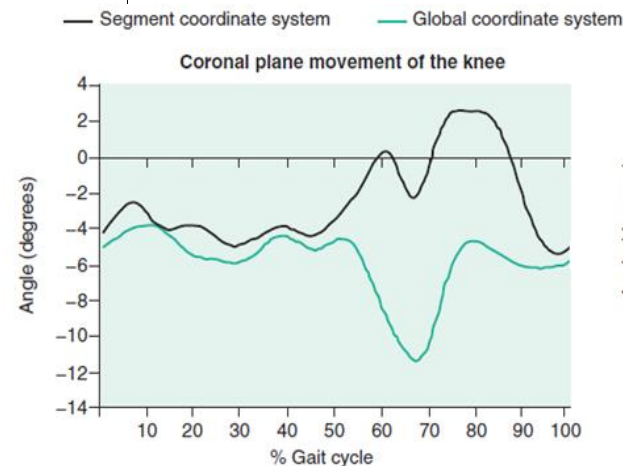
Huang, Y., Ket al. (2018). Deep inertial poser: learning to reconstruct human pose from sparse inertial measurements in real time. *ACM Trans. on Graphics 37*(6).

Augmented Biomechanics: Medicine

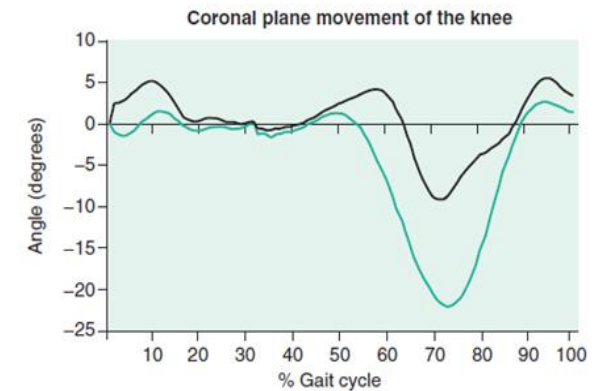**Chemotherapy-induced Neuropathy Biomechanics Deficit Extraction**

Data Analysis

Normal walking

Neuropathic walking

Sánchez-DelaCruz, E., Weber, R., Biswal, R. R., Mejía, J., Hernández-Chan, G., & Gómez-Pozos, H. (2019). Gait biomarkers classification by combining assembled algorithms and deep learning: results of a local study. *Computational and mathematical methods in medicine, 2019.*

Augmented Biomechanics: Medicine

Chemotherapy-induced Neuropathy Biomechanics Deficit Extraction

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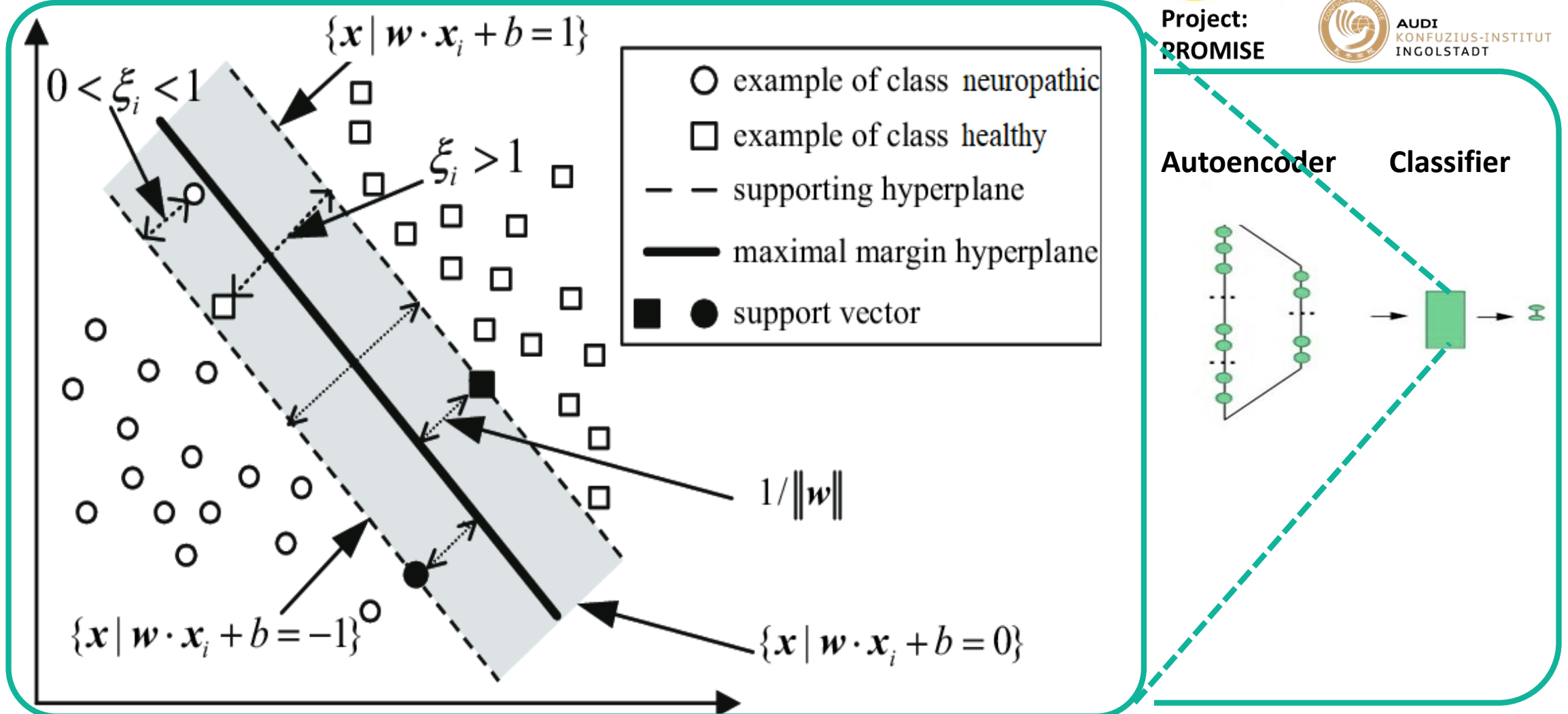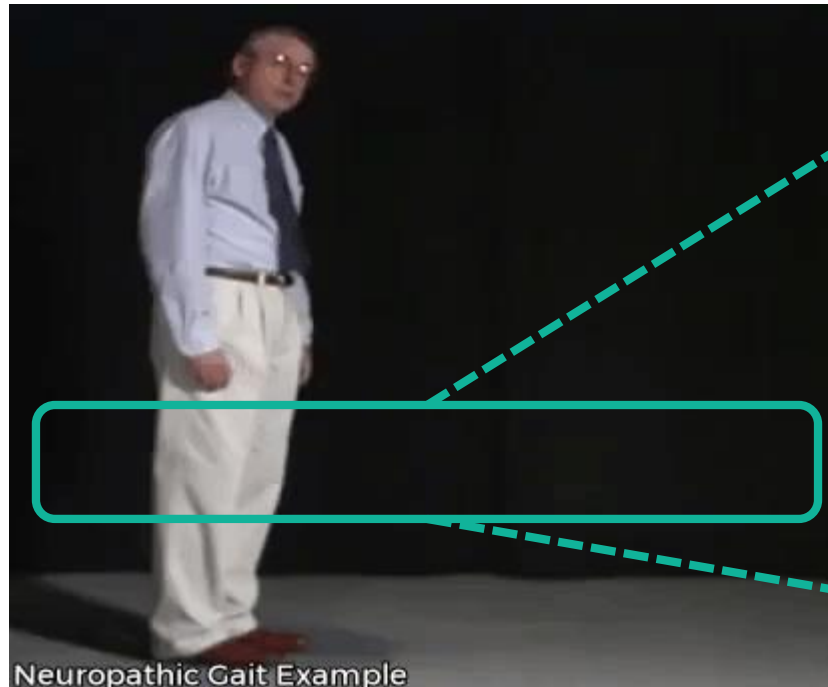
Augmented Biomechanics: Medicine

Chemotherapy-induced Neuropathy Biomechanics Deficit Extraction

Neuropathic Gait Example

Data Analysis

Surface electrode

Skin

α-Motoneurons

Raw sEMG Signal

DECOMPOSITION

t_1
t_2
t_n

sEMG image sequence
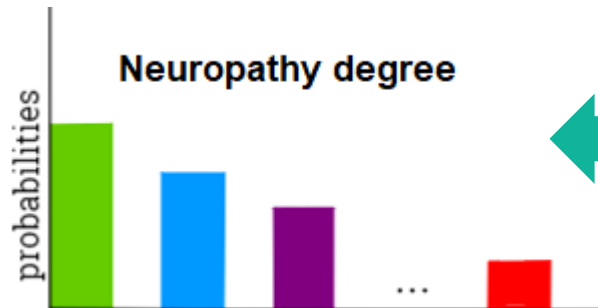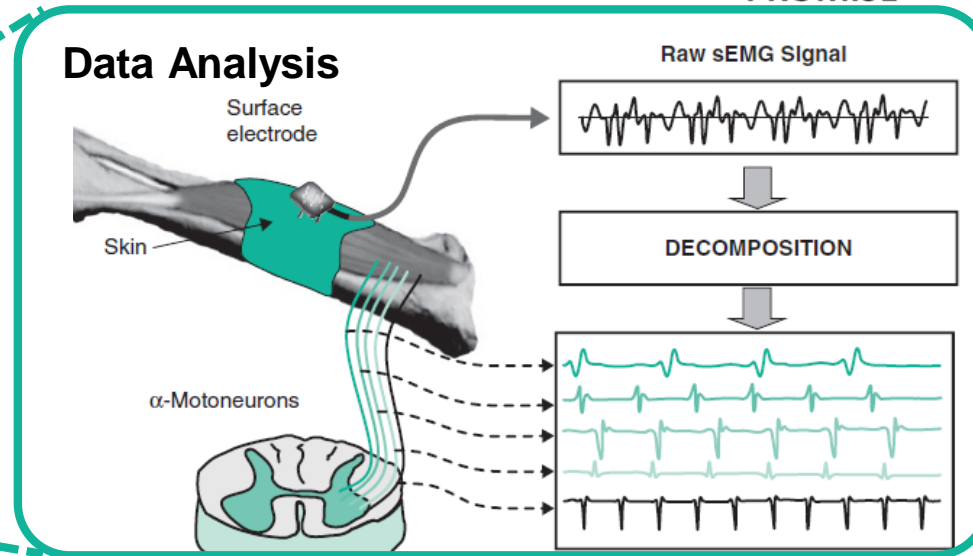
Deep Convolutional Network

Neuropathy degree

probabilities

Gallard, A., Akhmadeev, K., Le Carpentier, É., Aoustin, Y., Gross, R., & Péréon, Y. (2020). Automatic Classification of Intramuscular EMG to Recognize Pathologies. In *Developments and Novel Approaches in Biomechanics and Metamaterials* (pp. 35-48). Springer, Cham.

Eckmann, J. Kamphorst, S. Ruelle, D., Recurrence plots of dynamical systems, EPL (Europhysics Letters) 4(9), 973, 1987.

Augmented Biomechanics: Medicine

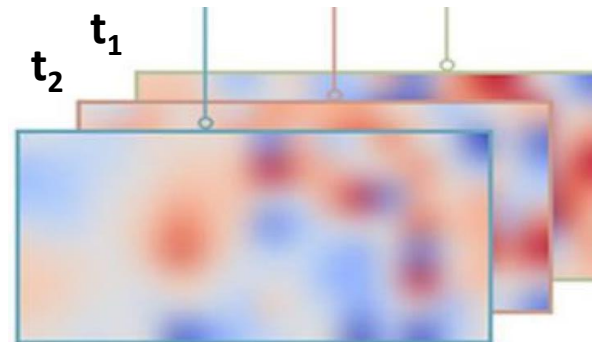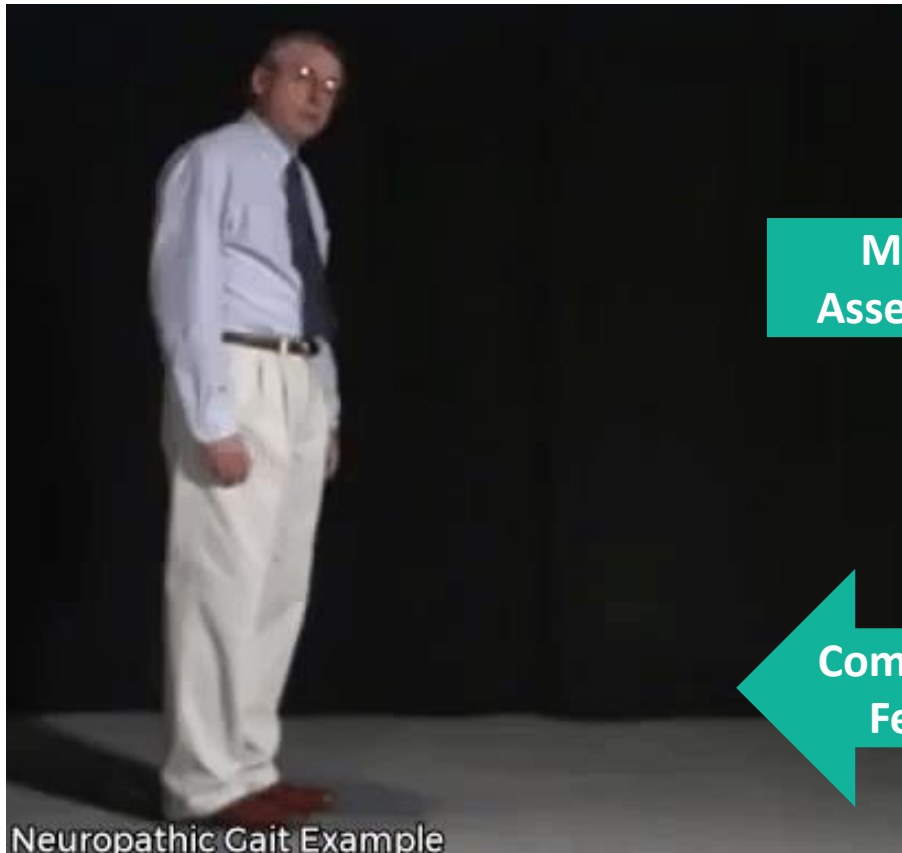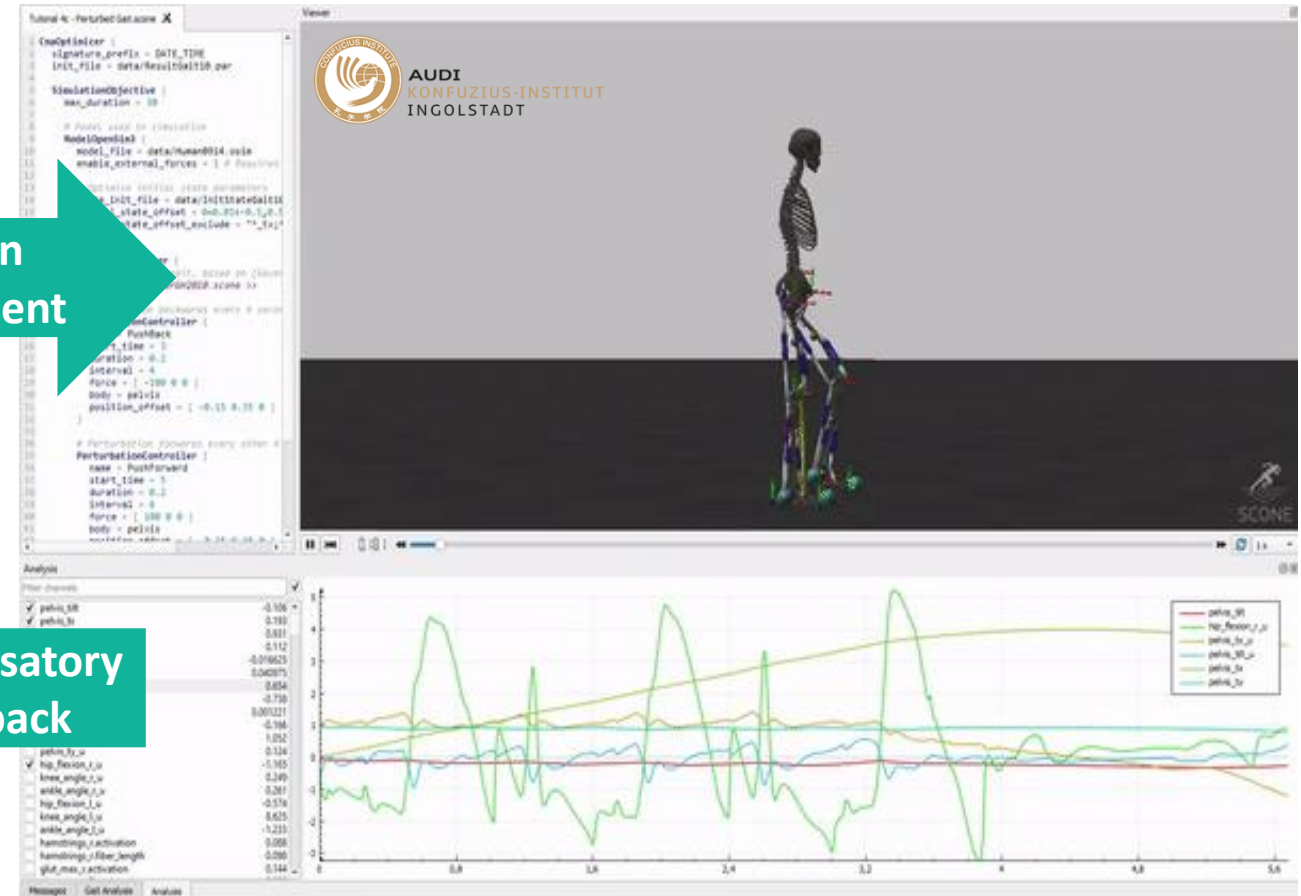**Chemotherapy-induced Neuropathy Biomechanics Deficit Extraction**

Axenie, C.; Becher, A.; Kurz, D.; and Grauschopf, T., Meta-Learning for Avatar Kinematics Reconstruction in Virtual Reality Rehabilitation In 2019 IEEE 19th International Conference on Bioinformatics and Bioengineering (BIBE), pages 617-624, Oct 2019. 2020.

Axenie, C., Kurz, D. (2020). Role of Kinematics Assessment and Multimodal Sensorimotor Training for Motion Deficits in Breast Cancer Chemotherapy-Induced Polyneuropathy: A Perspective on Virtual Reality Avatars. Frontiers in Oncology, 10, 1419.

Conclusions

Biomechanics is an „open field" for innovation where **Sensors and Data Analysis** can:

- provide **insights** into individuals' motion profile
- **complement** and **augment** traditional assessment
- support **performance improvement** in sports
- support **personalized therapy** in rehabilitation

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