B9

Magnetoelectric Sensors for Movement Detection and Analysis

Johannes Hoffmann, Clint Hansen, Walter Maetzler, Gerhard Schmidt

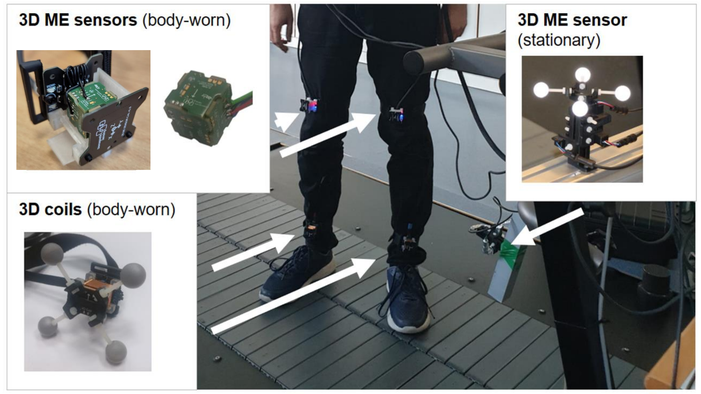
biomagnetic sensing SFB 1261

Motivation and Objectives

Movement assessment for mobility-limiting diseases

Relative tracking of human body parts

- Relevant e.g., in gait stability assessment
- Network of magnetic point-to-point devices
- Novel detection strategy for pathological movements



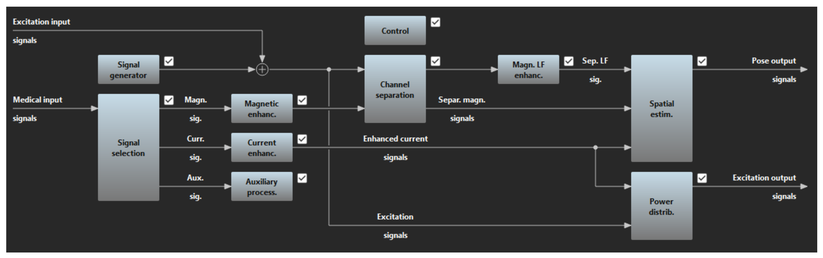
Proof-of concept ME motion sensing system in the motor lab at University Hospital Schleswig-Holstein

New approach: distributed ME sensor and actuator network

Main objectives: system design, algorithm training, and clinical evaluation

Results of the Second Funding Period

Real-time motion sensing platform



Algorithmic structure of the magnetic motion tracking module within the Kiel Real-time Application Toolkit (KiRAT) [B9-2], [B9-6]

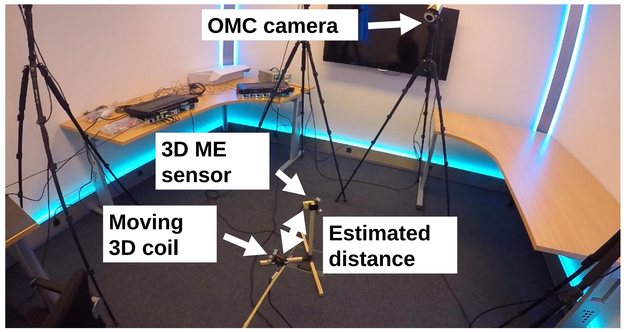
Simulation-supported algorithm development

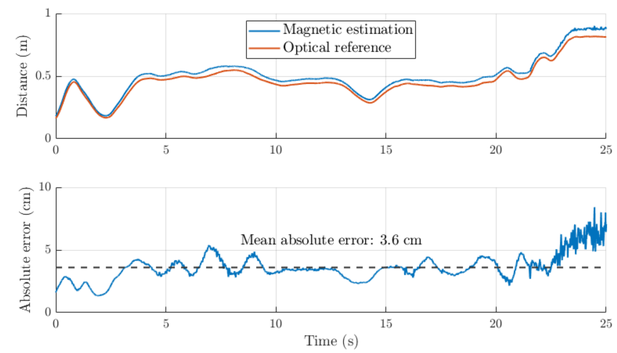
Simulation environment [B9-1]

- To support system and algorithm development
- Based on kinematic and magnetic models
- Arbitrary placement of sensors and actuators

Magnetic distance estimation

- Based on in inverse magnetic model [B9-3]
- Validated against optical motion capture system





Work Plan for Third Funding Period

Work plan

WP 1: ME-movement detection system

- System scale-up and improvements
  - Increased number of 3D ME sensors and 3D
  - Techniques for improved accuracy (e.g., acoustic noise) and efficiency (e.g., power management)

WP 2: Digital twin data analysis and hypothesis generation

- Optical motion capture databases for mobility-limiting diseases
  →Transformation into magnetic training data (digital twin)
- Classifier training (deep neural networks, hidden Markov models) to associate resulting data with specific (pathological) movements

WP 3: Real-life data analysis and clinical implementation

- Data collection based on established assessment protocols for patients with mobility-limiting diseases and controls
- Evaluation of the algorithms developed in WP 2 against gold standard (e.g., detection of specific movement patterns, correlation with established metrics, disease progression and responsiveness to treatment)

		2024		2025				2026				2027				2028	
		3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
WP 1	ME movement detection system																
	A: Scalability																
	B: Accuracy																
	C : Efficiency																
WP 2	Digital twin data analysis and hypothesis generation																
	A: Data extraction																
	B: ME-based movement description																
	C: Association to mobility-limiting diseases																
WP 3	Real-life data analysis and clinical implementation																
	A: Data collection																
	B: Data analysis																

Engineer PhD (100%) Movement scientist (25%) and Clinician (25%)

Collaborations

Z1: Application of resonant ME sensors from sensor production

B1, B2, Z2: Collaborative development and evaluation of measurement systems

B2, B10, B11(N): Collaborative work on real-time signal processing framework

Participation in focus groups

F3: Comparison of sensor concepts

F6: Biomedical applications

Funds Requested

1 Doctoral researcher, 1 Postdoc (25%), 1 medical doctor (25%), consumables: 43.5 k€

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[B9-2] Hoffmann, J., C., **Maetzler, W.,** & **Schmidt, G.** (2023). Sensors, 23(7), 3594.
[B9-3] Hoffmann, J., Hansen, C., **Maetzler, W.,** & **Schmidt, G.** (2022, September). In Current Directions in Biomedical Engineering (Vol. 8, No. 2, pp. 451-454). De Gruyter.
[B9-4] Romijnders, R., Warmerdam, E., Hansen, C., **Schmidt, G.,** & **Maetzler, W.** (2022). Sensors, 22(10), 3859.
[B9-5] Elzenheimer, E., Bald, C., Engelhardt, E., Hoffmann, J., Hayes, P., Arbustini, J., ... & **Schmidt, G.** (2022). Sensors, 22(3), 1018.
[B9-6] Hoffmann, J., Elzenheimer, E., Bald, C., Hansen, C., **Maetzler, W.,** & **Schmidt, G.** (2021). Sensors, 21(23), 8000.
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[B9-8] Warmerdam, E., ...& **Maetzler, W.** (2021). npj Parkinson's Disease, 7(1), 89.
[B9-9] Warmerdam, E., ..., **Maetzler, W.** & Hansen, C. (2021). Sensors, 21(17), 5833.
[B9-10] Warmerdam, E., Romijnders, R., Welzel, J., Hansen, C., **Schmidt, G.,** & **Maetzler, W.** (2020). Sensors, 20(20), 5963.