B9

Magnetoelectric Sensors for Movement Detection and Analysis

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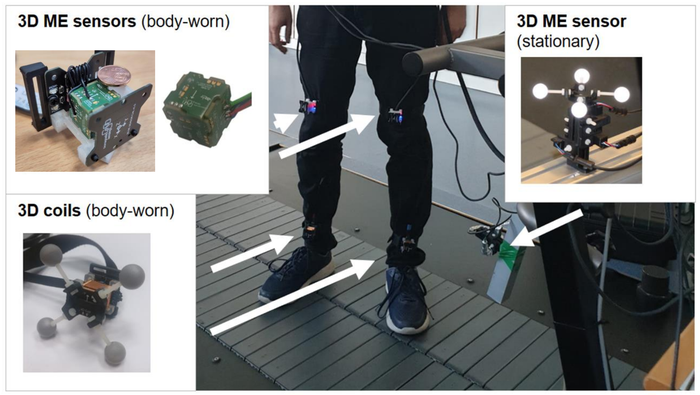
biomagnetic sensing SFB 1261

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



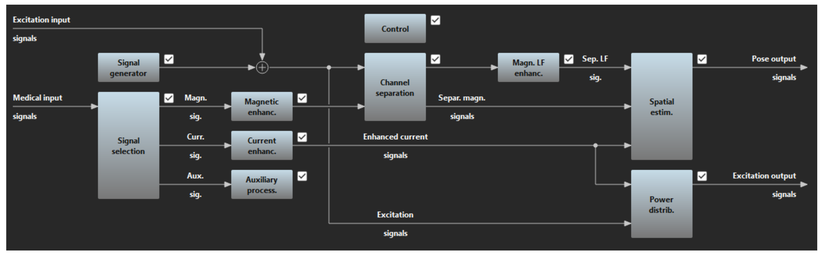
Proof-of concept ME motion sensing system in the motor lab at University Hospital Schleswig-Holstein

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]

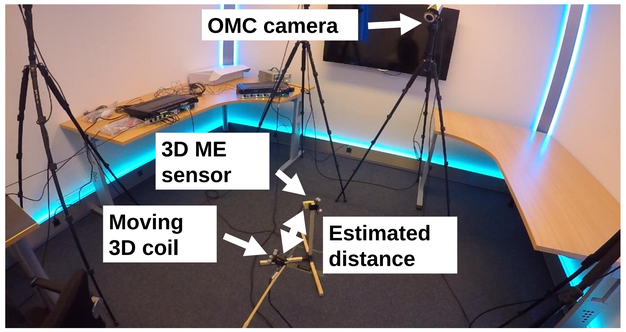
Simulation-supported algorithm development

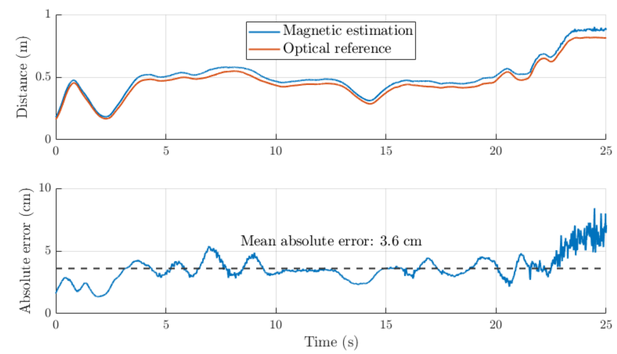
Simulation environment [B9-1]

- 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, 0.25 postdocs, 0.25 medical doctors, consumables: 43.5 k€

[B9-1] Hoffmann, J., Bald, C., Schmidt, T., Boueke, M., Engelhardt, E., Krüger, K., ..., **Maetzler**, **W**. & **Schmidt**, **G**. (2023, September). In *Current Directions in Biomedical Engineering* (Vol. 9, No. 1, pp. 455-458). De Gruyter. - **B2**, **B9, Z1**

[B9-2] Hoffmann, J., Roldan-Vasco, S., Krüger, K., Niekiel, F., Hansen, C., **Maetzler**, W., ... & **Schmidt**, G. (2023). *Sensors*, *23*(7), 3594. - **B9**

[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**

[B9-4] Romijnders, R., Warmerdam, E., Hansen, C., **Schmidt**, **G**., & **Maetzler**, **W**. (2022). *Sensors*, *22*(10), 3859. - **B9**

[B9-5] Elzenheimer, E., Bald, C., Engelhardt, E., Hoffmann, J., Hayes, P., Arbustini, J., ... & **Schmidt**, **G**. (2022). *Sensors*, *22*(3), 1018. - **A7**, **B1**, **B2**, **B9**, **B10, Z2**

[B9-6] Hoffmann, J., Elzenheimer, E., Bald, C., Hansen, C., **Maetzler**, **W**., & **Schmidt**, **G**. (2021). *Sensors*, *21*(23), 8000. - **B9**

[B9-7] Romijnders, R., Salis, F., Hansen, C., Küderle, A., Paraschiv-Ionescu, A., Cereatti, A., ... & **Maetzler**, **W**. (2023). *Frontiers in Neurology*, *14*, 1247532.- **B9**

[B9-8] Warmerdam, E., Romijnders, R., Hansen, C., Elshehabi, M., Zimmermann, M., Metzger, F. G., ... & **Maetzler**, **W**. (2021). *npj Parkinson's Disease*, *7*(1), 89. - **B9**

[B9-9] Warmerdam, E., Romijnders, R., Geritz, J., Elshehabi, M., Maetzler, C., Otto, J. C., ..., **Maetzler**., **W**., & Hansen, C. (2021). *Sensors*, *21*(17), 5833. - **B9**

[B9-10] Warmerdam, E., Romijnders, R., Welzel, J., Hansen, C., **Schmidt**, **G**., & **Maetzler**, **W**. (2020). *Sensors*, *20*(20), 5963. - **B9**