B2

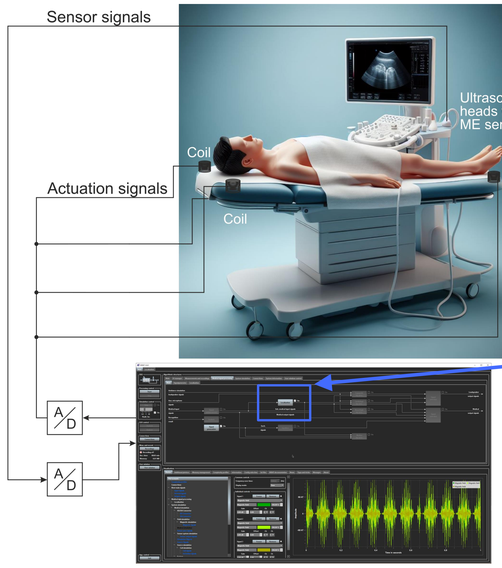
Digital Signal Processing

Moritz Boueke, Robert Bergholz (PI), Mark Ellrichmann (PI), Gerhard Schmidt (PI)

biomagnetic sensing SFB 1261

Motivation and Objectives

Medical device localization has high computational complexity and improvable accuracy



Iterative localization: High computation effort, new approach

- Preprocessing/signal enhancement
- Iterative localization
- Applications

New localization approach:

Gradient descent/particle swarm optimization method, added imaging-based localization

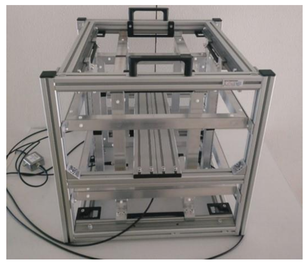
Objectives: Higher localization accuracy at lower computational complexity, for WMCs/ultrasound/endoscope

Online calibration

Signal processing/enhancement for application projects

Results of the Second Funding Period

Adaptive scheme for fast impulse response estimation



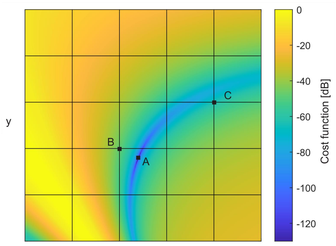
- Helmholtz coil arrangement
- Gradient descent estimation
- Up to 3D directivity and frequency response estimation
- Time and precision gain
- Factor ≈50 faster than conventional measurement

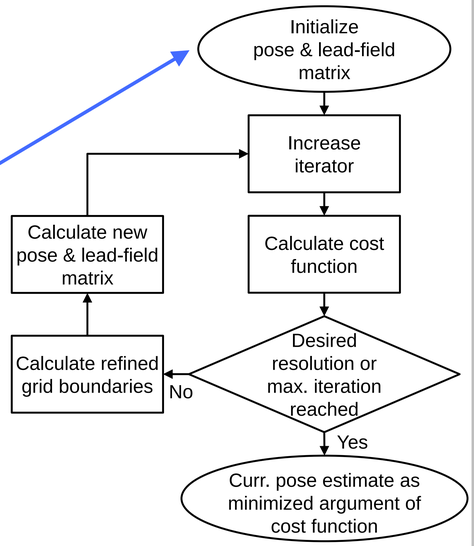
Signal platform enhancement

Module based framework for multiple application projects

Determination of position and orientation of the sensor [B2-1, B2-3, B2-5]

- Excitation with multiplexed, known signals
- Matched filter receive signal
- Trilateration for coarse localization
- Iterative procedure
- Discrete grid: Errors with cost function





Work Plan for Third Funding Period

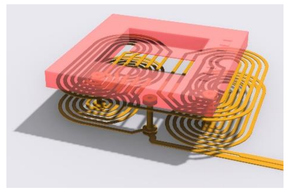
Research methods

- Adaptive signal processing and enhancement stages
- In situ real-time calibration system for ME sensors
- Collaborative research with other B-projects in localization algorithms (different objectives)
- Multimodal processing approaches (medical images + magnetic signals) for mutual improvement

Work plan

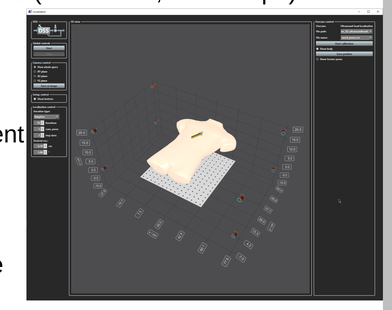
WP1: Adaptive signal enhancement and system development

- Nonlinear and adaptive signal enhancement stages
- Online calibration, e.g., with on-board PCB-coil [Wo23]
- Readout schemes for emerging analog sensor systems



WP2: Hardware and interface development

- Measurement system (bed) with actuators (coils, magnetic cantilevers)
- Sensors in medical devices
- Interface between medical imaging data (ultrasound, endoscope) and localization system



WP3: Magnetic localization algorithm development

- Magnetic localization based on gradient descent/particle swarm methods
- Adaption to multiple scenarios, including WMCs (B13(N))

WP4: Ultrasound and endoscopic image localization

- Localization based on med. images, fusion with magnetic localization

	24/2		2025				2026				2027				28/1	
	1	2	1	2	3	4	1	2	3	4	1	2	3	4	1	2
WP1 – Adaptive signal enhancement and system development																
WP2 – Hardware and interface development																
A – Hardware development																
B – Interface development																
WP3 – Magnetic localization algorithm development																
WP4 – Ultrasound and endoscopic image localization																
A – Localization based on images																
B – Fusion of the algorithms																

Collaborations

A8: Incorporation of modeling into localization algorithms

B1, Z2: Collaboration on sensor frontends and arrays, test measurements

B9, B10, B11(N): Collaborative development of closed-loop real-time framework

B12(N): Collaboration in the sensor system design and readout schemes

B13(N): Localization of endoscopes and wireless motility capsule

Z1: Production of micromagnetic sensors and actuators

Participation in focus groups

F3: Comparison of Sensor Concepts

F6: Biomedical Applications

Funds Requested

1 Doctoral researcher, consumables: 51.5 k€

[B2-1] **Schmidt, G.**, **Bergholz, R.**, Quandt, E., Sun, N., Klinkenbusch, L., Bald, C., Schmidt, T. (2023). Patent application DE 10 2023 116 342.6. - **B2**

[B2-2] Hoffmann, J., Roldan-Vasco, S., Krüger, K., Niekiel, F., Hansen, C., Maetzler, W., Orozco-Arroyave, J.R., **Schmidt, G.** (2023). *Sensors, 23*(7), 3594. - **B9, Z1**

[B2-3] Bald, C., Bergholz, R., & Schmidt, G. (2022, September). In *Current Directions in Biomedical Engineering* (Vol. 8, No. 2, pp. 317-320). De Gruyter. - **B2**

[B2-4] Elzenheimer, E., Bald, C., Engelhardt, E., Hoffmann, J., Hayes, P., Arbustini, J., Bahr, A., Quandt, E., Höft, M., **Schmidt, G.** (2022). *Sensors, 22*(3), 1018. - **A7, B1, B2, B9, B10, Z1**

[B2-5] Bald, C., **Schmidt, G.** (2021). *Sensors, 21*(16), 5675. - **B2**

[B2-6] Spetzler, B., Bald, C., Durdaut, P., Reermann, J., Kirchhof, C., Teplyuk, A., Meyners, D., Quandt, E., **Schmidt, G.**, Faupel, F. (2021). *Scientific reports, 11*(1), 5269. - **A4, B1, B2, Z1**

[B2-7] **Ellrichmann, M.**, Bethge, J., Boesenkoetter, J., Conrad, C., Noth, R., Bahmer, T., Nikolaus, S., Aden, K., Zeissig, S., Schreiber, S. (2021). *Journal of Crohn's and Colitis, 15*(8), 1339-1345.

[B2-8] **Bergholz, R.**, Fromm, F., Meinzer, A., Muehlfeld, C., Boettcher, M., Wenke, K., Tiemann, B., Reinshagen, K., Krebs, T. (2021). *Journal of Laparoendoscopic & Advanced Surgical Techniques, 31*(6), 712-718.

[B2-9] **Bergholz, R.**, Krebs, T., Cremieux, B., Georgi, C., Fromm, F., Boettcher, M., Andreas, T., Tiemann, B., Wenke, K., Reinshagen, K., Hecher, K. (2021). *Surgical Endoscopy, 35*, 745-753.

[B2-10] Ye, L., Yuan, X., Pang, M., Bethge, J., **Ellrichmann, M.**, Du, J., Zeng, X., Tang, C., Schreiber, S., Hu, B. (2019). *Surgical Endoscopy, 33*, 2034-2041.

[Wo23] Wolframm, H., & Höft, M. (2023). Patent application, European Patent Office. - **B1**