



HAL
open science

FQ-06. Magnetic position determination with giant-magnetoresistance and moving field-free point in catheter

Louis Paquet, Aurélie Solignac, Kevin Tse-Ve-Koon, Makoto Ohta, Noriko Tsuruoka, Yoichi Haga, Claude M Fermon, Myriam Pannetier-Lecoeur, Benjamin Ducharne

► To cite this version:

Louis Paquet, Aurélie Solignac, Kevin Tse-Ve-Koon, Makoto Ohta, Noriko Tsuruoka, et al.. FQ-06. Magnetic position determination with giant-magnetoresistance and moving field-free point in catheter. INTERMAG2025 - The 16th Joint Conference on Magnetism and Magnetic Materials and Intermag, IEEE, Jan 2025, Nouvelle Orléans (Louisiane), United States. hal-04912303

HAL Id: hal-04912303

<https://hal.science/hal-04912303v1>

Submitted on 26 Jan 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

FQ-06. Magnetic position determination with giant-magnetoresistance and moving field-free point in catheter

L. Paquet^{1,2,3,4}, A. Solignac⁵, K. Tse Ve Koon², M. Ohta^{3,4}, N. Tsuruoka⁶, Y. Haga^{4,6}, C. Fermon⁵, M. Pannetier-Lecoœur⁵, B. Ducharme^{1,7}

¹ ELYTMax IRL3757, Univ Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai 980-8577, Japan.

² CREATIS, Université Lyon1, CNRS UMR5220, INSERM U1206, INSA-Lyon, 69621 Villeurbanne, France.

³ Institute of Fluid Science, Tohoku University, 2-1-1, Katahira, Aoba-ku, Sendai, Miyagi 980-8577, Japan.

⁴ Graduate School of Biomedical Engineering, Tohoku University, 6-6 Aramaki-aza-aoba, Aoba-ku, Sendai, Miyagi 980-8579, Japan.

⁵ SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif-sur-Yvette, France.

⁶ Graduate School of Engineering, Tohoku University 6-6-01 Aramaki Aza Aoba, Aoba-ku, Sendai, Miyagi 980-8579, Japan.

⁷ Univ Lyon, INSA Lyon, LGEF EA682, 69621 Villeurbanne, France

X-ray fluoroscopic imaging is the standard method to obtain catheter position during catheterization procedures, a minimally invasive surgery for diagnostic and treatment of the vascular network [1]. However, this method exposes both patients and doctors to ionizing radiation. To address this issue, we propose a new method to track the catheter by installing a magnetic sensor at the catheter tip and generating a known magnetic field (MF) around the operative zone.

Due to the mandatory small size of the catheter, we utilized micrometer-sized giant-magneto-resistance (GMR) sensors for this tracking system [2, 3]. GMR sensors require only two connection wires, have a wide bandwidth that allows flexibility in selecting the working frequency and can detect low-intensity MFs down to the nano Tesla range [4]. In this work, a $300\mu\text{m} \times 700\mu\text{m}$ GMR chip (shown Fig.1a) is prepared and installed on a catheter to show the integration feasibility. The presented results are obtained with GMRs connected in a Wheatstone bridge configuration in a larger chip (shown Fig.1b) for ease of manipulation. Both present a similar magnetic response.

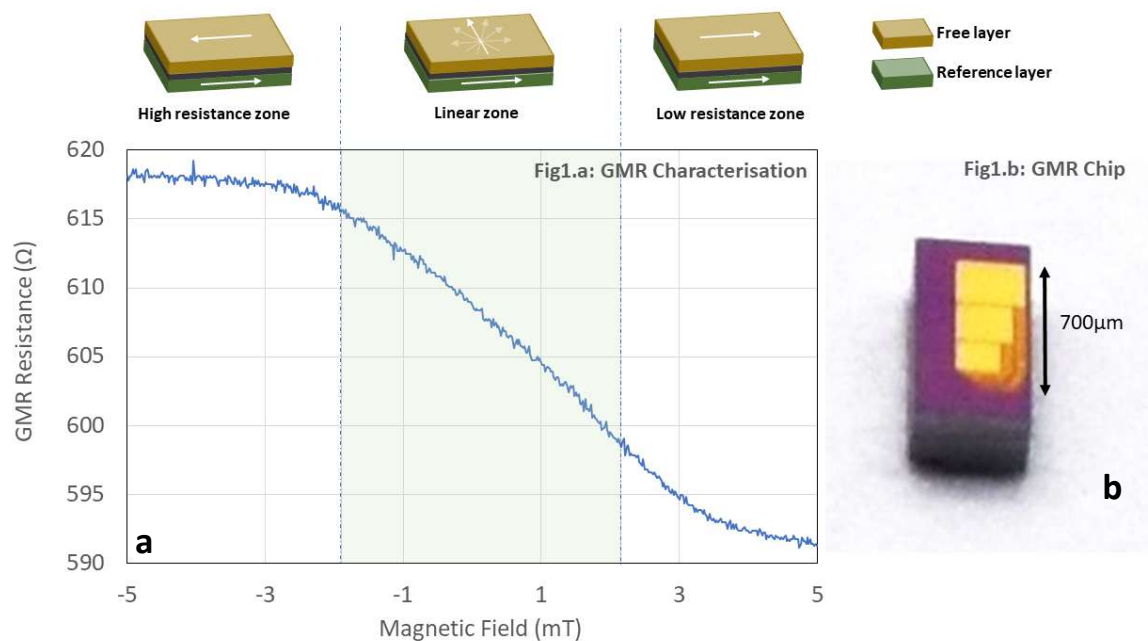


Figure 1: **1a** – Resistance of the GMR alone vs. an external magnetic field. The top sketches show the corresponding ferromagnetic layers' magnetic orientations **1b**. Manufactured chip with 2 GMRs

Our novel tracking method is based on the time detection of a moving null MF, known as the Field-Free Point (FFP) inspired by Magnetic Particle Imaging (MPI) [5]. Rather than measuring the MF intensity to compute the position [6], the time detection of the FFP gives the information on the position. We constructed an experimental setup to demonstrate the feasibility of this method in one dimension [7].

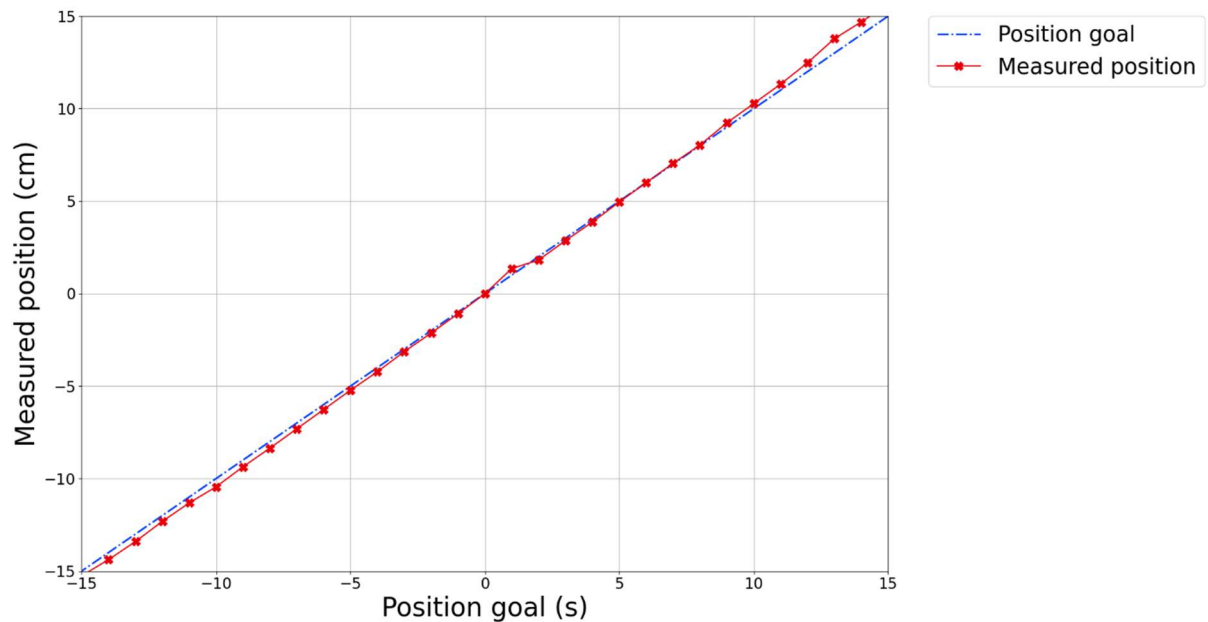


Figure 2: Comparison between the position goal and the measured positions

On a 1D setup, along a line from -15cm to 15cm, we measure the positions and standard variations every cm. The results are shown in Fig 2. The average of all standard deviation is 1.3mm with an average deviation from the actual position of 4.9% showing promising results for further steps.

References

- [1] Davidson, C.J. and Bonow, R.O., 1997. Cardiac catheterization. *Libby P*, 10, p.18.
- [2] Chopin, C., Torrejon, J., Solignac, A., Fermon, C., Jendritza, P., Fries, P. and Pannetier-Lecoeur, M., 2020. Magnetoresistive sensor in two-dimension on a 25 μm thick silicon substrate for in vivo neuronal measurements. *ACS sensors*, 5(11), pp.3493-3500.
- [3] Kouakeuo, S.H.N., Solignac, A., Sabariego, R.V., Morel, L., Raulet, M.A., Toutsop, B., Tsafack, P. and Ducharne, B., 2022. Internal characterization of magnetic cores, comparison to finite element simulations: a route for dimensioning and condition monitoring. *IEEE Transactions on Instrumentation and Measurement*, 71, pp.1-10.
- [4] Moulin, J., Doll, A., Paul, E., Pannetier-Lecoeur, M., Fermon, C., Sergeeva-Chollet, N. and Solignac, A., 2019. Optimizing magnetoresistive sensor signal-to-noise via pinning field tuning. *Applied Physics Letters*, 115(12).
- [5] Gleich, B. and Weizenecker, J., 2005. Tomographic imaging using the nonlinear response of magnetic particles. *Nature*, 435(7046), pp.1214-1217.
- [6] Jaeger, H.A., Franz, A.M., O'Donoghue, K., Seitel, A., Trauzettel, F., Maier-Hein, L. and Cantillon-Murphy, P., 2017. Anser EMT: the first open-source electromagnetic tracking platform for image-guided interventions. *International journal of computer assisted radiology and surgery*, 12, pp.1059-1067.
- [7] Paquet, L., Solignac, A., Koon, K.T.V., Ohta, M., Tsuruoka, N., Haga, Y., Fermon, C., Pannetier-Lecoeur, M. and Ducharne, B., 2025. Magnetic tracking for catheterization procedure, using giant-magnetoresistance and space-varying magnetic field free point. *Sensors and Actuators A: Physical*, p.116199.