PostDoctoral Research Topic

MIAI Cluster IA | INSPECT Chair

Topic: AI-based State Estimation of Continuum Robots

Workplace: TIMC Laboratory, Grenoble, France

Prospective starting date: January, 1st, 2026

Initial Duration: 13 months

Context:

Continuum robots (CR) are slender systems, devoid of joints and rigid link, thus highly miniaturized and inherently compliant. Such properties make them highly relevant candidates for applications requiring to conform and access tortuous paths and confined sites. In particular, CR are intensively investigated for medical applications, where flexibility and miniaturizing are decisive in reducing the operation invasiveness and guaranteeing safety [1, 2]. Nevertheless, one major challenge preventing large scale deployment of CR in medical applications regards perception of their state, such as their entire shape. On the one hand, state prediction based on mechanical models, however accurate they may be, might suffer from unpredicted/non-measurable external contacts and/or loads [3, 4]. On the other hand, state perception based on sensors, however sophisticated they can be, might suffer from integration issues due to the limited dimensions of CR and to compatibility with the environment, or lack sufficient spatial or temporal coverage [5].

Objectives:

In this context, INSPECT (Enhancing Surgery with Deep Learning-Controlled Continuum Robots) chair considers a hybrid approach, bringing together physical models of robots and perception technology, dedicated to shape state estimation [6, 7, 8]. While complying to clinically compatible perception, mainly medical imaging, we aim to investigate physics-aware, AI-based methods for state estimation approaches. This work will benefit from our recent advances on modeling [9, 10], deep/reinforcement learning and medical image processing [11, 12], as well as state estimation in related domains [13, 14].

References:

[1] J. Burgner-Kahrs, D.C. Rucker, H. Choset (2015): "Continuum Robots for Medical Applications: A Survey". IEEE Transactions on Robotics, 31(6): 1261–1280. DOI: 10.1109/TRO.2015.2489500

[2] P.E. Dupont, N. Simaan, H. Choset, D.C. Rucker (2022): "Continuum Robots for Medical Interventions". Proceedings of the IEEE, 11(7): 847–870. DOI: 10.1109/JPROC.2022.3141338

[3] M. T. Chikhaoui and Benoît Rosa (2022): "Modeling and control strategies for flexible devices", Endorobotics, 1st Edition: Design, R&D and Future Trends, pp. 187-213, edited by Luigi Manfredi, Elsevier. Paperback ISBN: 9780128217504. DOI: 10.1016/B978-0-12-821750-4.00008-6

[4] C. Armanini, F. Boyer, A. T. Mathew, C. Duriez and F. Renda (2023): "Soft Robots Modeling: A Structured Overview". IEEE Transactions on Robotics, 39(3): 1728-1748. DOI: 10.1109/TRO.2022.3231360

[5] J. Liu, Y. Duo, X. Chen, Z. Zuo, Y. Liu and L. Wen (2025): "Data-Driven Methods for Sensing, Modeling and Control of Soft Continuum Robot: A Review". IEEE/ASME Transactions on Mechatronics. DOI: 10.1109/TMECH.2025.3566915

[6] W. Talbot, J. Nubert, T. Tuna, C. Cadena, F. Dümbgen, J. Tordesillas, T.D. Barfoot, M. Hutter (2025): "Continuous-Time State Estimation Methods in Robotics: A Survey". IEEE Transactions on Robotics, 41: 4975-4999. DOI: 10.1109/TRO.2025.3593079

[7] S. Lilge, T. Barfoot and J. Burgner-Kahrs (2025): "State Estimation for Continuum Multirobot Systems on SE(3)". IEEE Transactions on Robotics, 41: 905-925. DOI: 10.1109/TRO.2024.3521859

[8] J. M. Ferguson, D. C. Rucker and R. J. Webster (2024): "Unified Shape and External Load State Estimation for Continuum Robots". IEEE Transactions on Robotics, 40: 1813-1827. DOI: 10.1109/TRO.2024.3360950

[9] M. Tummers, V. Lebastard, F. Boyer, J. Troccaz, B. Rosa, and M. T. Chikhaoui (2023): "Cosserat Rod Modeling of Continuum Robots from Newtonian and Lagrangian Perspectives". IEEE Transactions on Robotics, 39(3): 2360-2378. DOI: 10.1109/TRO.2023.3238171

[10] M. Tummers, F. Boyer, V. Lebastard, A. Offermann, J. Troccaz, B. Rosa, and M. T. Chikhaoui (2024): "Continuum concentric push-pull robots: a Cosserat rod model". The International Journal of Robotics Research, 44(2): 216-246. DOI: 10.1177/02783649241263366

[11] T. Dupuy, C. Beitone, J. Troccaz, and S. Voros. (2023): "2D/3D Deep Registration Along Trajectories with Spatiotemporal Context: Application to Prostate Biopsy Navigation." IEEE Transactions on Biomedical Engineering, 70(8): 2338-2349. DOI: 10.1109/TBME.2023.3243436

[12] L. Lenfant, C. Beitone, J. Troccaz, M. Rouprêt, T. Seisen, S. Voros, and P. Mozer (2024) : "Learning curve for fusion magnetic resonance imaging targeted prostate biopsy and three-dimensional transrectal ultrasonography segmentation." BJU International, 133(6): 709-716. DOI: 10.1111/bju.16287

[13] G. Shaaban, H. Fourati, A. Kibangou, and C. Prieur (2025): "Position, Velocity and Attitude Estimation Based on MARG and Position Measurements Under Unknown External Acceleration". IEEE Control Systems Letters, 9: 1423-1428. DOI: 10.1109/LCSYS.2025.3579402

[14] M. Zmitri, H. Fourati, and C. Prieur (2022): "BiLSTM network-based extended Kalman filter for magnetic field gradient aided indoor navigation". IEEE Sensors Journal, 22(6): 4781-4789. DOI: 10.1109/JSEN.2021.3091862

Desired experience and qualification:

The candidate should ideally hold a PhD in Automatic Control, Robotics, or a related field. Strong analytical skills are required, along with intermediate knowledge of deep and reinforcement learning, and prior experience in robot state estimation.

Environment:

The postdoctoral research will take place mainly in TIMC Laboratory and GIPSA-Lab in Grenoble. In the scope of INSPECT chair, visits to our partners at Grenoble Alpes University Hospital, Grenoble and Institut Pascal, Clermont-Ferrand are planned.

CAMI (Computer-Assisted Medical Interventions) team of TIMC Laboratory has been pioneering the development of medical devices assisting medical interventions for the past three decades. Added to our expertise and contributions in terms of perception, reasoning, and action, our team is closely collaborating with clinicians of CHUGA and deeply involved in clinical transfer. Added to CamiTK, a rapid prototyping toolbox for software solutions in CAMI, our team is extending such approach to continuum robotics simulators, as well as prototypes.

Supervision:

M. Taha Chikhaoui, Research Scientist at CNRS, TIMC Laboratory (taha.chikhaoui@univ-grenoble-alpes.fr)

Hassen Fourati, Associate Professor at Grenoble INP, GIPSA-Lab (Hassen.Fourati@univ-grenoble-alpes.fr)

Application:

Application exclusively via

https://emploi.univ-grenoble-alpes.fr/offres/doctorants-chercheurs/chercheur-post-doctoral-en-estimation-d-etat-pour-les-robots-continus-f-h--1682174.kjsp?RH=1135797159702996