Postdoctoral position:

From grasping to dexterous manipulation with multifingered robotic hands - a unified control strategy

Contact:

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This postdoctoral position follows on previous work aimed at robust control design for multifingered hands [Caldas 21]. The present project will focus on the extension and development of 3D task-oriented control strategies from grasping to dexterous manipulation with robotic hands. Multifingered robotic hands are complex mechanical systems with many degrees of freedom (DoFs) allowing in-hand manipulation of a large variety of objects, promising versatile capabilities with contrast to simpler grippers, for industrial or service applications. The challenge lies in precisely controlling these DoFs, especially during complex tasks such as grasping and dexterous manipulation [Ozawa 17] and the transitions between these tasks, in which humans naturally excel. With the complexity reduction objective, synergy-based control is one of possible approaches [Ficuciello 18]. The concept of synergies, inherited from the neurosciences, with a smaller set of synergistic inputs producing the whole movement of the multifingered hand, is particularly adapted to the grasping problem. However, this type of control is not suitable for fine manipulation of the grasped object and task-oriented strategies seem to be preferable [Caldas 15]. In [Ortenzi 18], the authors highlight the role of the (manipulation) task in selecting a grasp. Thus, the transition from grasping to a task-level dexterous manipulation strategy remains an open research subject and the proposal of a complete framework including those two aspects is to be explored.

In this project, we aim to develop new learning-based control strategies that consider the consecutive hand actions from grasping to dexterous manipulation in a unified framework, where learning-based approaches will be used either at the level of the system [Hashimoto 20] or at the level of its controller [Saoud 21]. Stability and performance guarantees of the system will be analyzed using different tools such as Lyapunov-based approaches and reachability analysis. The candidate should be interested in optimization-based control strategies and learning-based control techniques.

An experimental validation of the proposed methodology is envisaged using three to five Geomagic Touch haptic interfaces in the role of robotic fingers, which will permit to freely select their relative position and test different task scenarios. The manipulation objectives will include translation, reorientation and lifting of the objects.

Duration: 1-year postdoc (6 months at L2S, 6 months at ESME Sudria)

Research topics:

- Control: Optimization-based control, Robust control, Learning-based control
- Robotics: Multifingered hand, Grasping, Dexterous manipulation

Qualifications:

Required:

- PhD degree in Control theory, Robotics or related fields
- Experience of publishing high quality research papers
- Speaking and writing English at the scientific and professional level
- Good communication skills and ability to cooperate

Desired but not mandatory:

- Experience in multifingered hand control
- Experience in reinforcement learning

To apply: complete applications are to be transmitted to {*Maria.Makarov@centralesupelec.fr; alex.caldas@esme.fr; Adnane.Saoud@centralesupelec.fr*} **with email subject "Post-doc L2S/ESME - <your surname>"**. Required documents:

1. Detailed curriculum vitae and publication list
2. Cover Letter
3. Names and contact details of 2 referees

Deadline for applications: February 10, 2022

[Caldas 14] Caldas, A., Micaelli, A., Grossard, M., Makarov, M., Rodríguez-Ayerbe, P., & Dumur, D. (2014, July). New metric for wrench space reachability of multifingered hand with contact uncertainties. In *2014 IEEE/ASME International Conference on Advanced Intelligent Mechatronics* (pp. 1236-1242). IEEE.

[Caldas 15] Caldas, A., Micaelli, A., Grossard, M., Makarov, M., Rodriguez-Ayerbe, P., & Dumur, D. (2015, September). On task-decoupling by robust eigenstructure assignment for dexterous manipulation. In *2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 5654-5661).

[Caldas 21] Caldas, A., Grossard, M., Makarov, M., Rodriguez-Ayerbe, P., Task-level dexterous manipulation with multifingered hand under modeling uncertainties. *ASME Journal of Dynamic Systems, Measurement and Control*. (article under review, available on demand).

[Ficuciello 18] Ficuciello, F. (2018). Synergy-based control of underactuated anthropomorphic hands. *IEEE Transactions on Industrial Informatics*, *15*(2), 1144-1152.

[Hashimoto 20] Kazumune Hashimoto, Adnane Saoud, Masako Kishida, Toshimitsu Ushio, and Dimos Dimarogonas. Learning-based symbolic abstractions for nonlinear control systems. arXiv preprint arXiv:2004.01879, 2020

[Ortenzi 18] Ortenzi, V., Controzzi, M., Cini, F., Leitner, J., Bianchi, M., Roa, M. A., & Corke, P. (2019). Robotic manipulation and the role of the task in the metric of success. *Nature Machine Intelligence*, *1*(8), 340-346.

[Ozawa 17] Ozawa, R., & Tahara, K. (2017). Grasp and dexterous manipulation of multi-fingered robotic hands: a review from a control view point. *Advanced Robotics*, *31*(19-20), 1030-1050.

[Saoud 21] Adnane Saoud and Ricardo G Sanfelice. Computation of controlled invariants for non- linear systems: Application to safe neural networks approximation and control. IFAC- PapersOnLine, 54(5):91–96, 2021.