Adaptive Control of underwater robots with Machine Learning

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starting 2019

1 France and Australia PhD

In the context of cooperation between France and Australia, Flinders University, Lab-STICC at ENSTA Bretagne and Naval Group propose a PhD which consists in 18 months in Adelaide (Australia) and 18 months in Brest (France) with some stays at Naval Group Research. This project is supported by **South Australia**, **Region Bretagne** and **Naval Group**.

2 PhD proposal

The control and guidance of an autonomous marine vehicle (including sea keeping and collision avoidance) require the tuning of laws for the steering and guidance part. Even if a large part of the regulators used are PID and even if the tuning of the PID parameters remains a key subject, these regulators quickly reach their limits when the requirements in terms of precision with an uncertain environment.

This project links the advantages of robust PID implementation and adaptive control based on machine learning algorithms in order to develop an implementable adaptive control structure, to give an effective methodology to translate the need via Machine Learning and to analyze the robustness of the GNC algorithms.

To address this topic, we rely on the theoretical tools of **robustness analysis** and **machine learning**, while having a concrete application base: the **marine robotics** [YCM15, ZLSHTL15, LS07].

The *machine learning* paradigm makes possible to learn and adapt itself to create an increasingly robust and reliable model of the studied phenomenon based on observations. Online unsupervised learning and offline supervised using learning data from simulation or previous missions are possible and a trade-off between both approach has to be investigated. The interest is to learn information from the uncertain and fluctuating environment and from the state of the robot to adapt the control law. In particular, the deep learning approach has a good potential in terms of performance and its ability to learn from a large mass of data for a dynamic system. We will take as reference the works synthesized in [NP11].

The work proposed in this PhD consists in taking into account the robustness domain studied by methods presented in [MNC16] and improve the settings by an adaptive control method ([AW95]) from learning. First elements are investigated in a current PhD [SLC18] and the proposed work plan is first evaluate the interest of ML in each function, then merge navigation and control with ML, and to finish evaluate how to include all of this in a machine planning system.

3 Supervisors

- Prof. Benoit CLEMENT, ENSTA Bretagne - Lab-STICC UMR CNRS 6285 (`https://www.ensta-bretagne.fr/clement/`)
- Dr. Estelle CHAUVEAU, Ingenieur de Recherche en Intelligence Artificielle, Naval Group

- Prof. Karl SAMMUT, College of Science and Engineering, Director of Centre for Maritime Engineering, Control and Imaging, Flinders University (`https://www.flinders.edu.au/people/karl.sammut`)

4 Application

4.1 Candidate Profile

Holder of (or near graduation) of a postgraduate diploma, Master of research or engineer diploma in the domains of Computer Science, Control Systems, Robotics or equivalent. The candidate is expected to have a federating role between the collaborating teams and to be strongly motivated along with excellent communication skills.

Theoretical skills Machine learning, Computer Vision, Robotics, Control Systems
Technical skills C++/Python programming, numpy, Scikit, deep learning frameworks, OpenCV, PCL, etc.
Fluency in English is strongly required.

4.2 How to apply

Interested applicants should contact Karl Sammut (karl.sammut@flinders.edu.au) and Benoit Clement (benoit.clement@ensta-bretagne.fr) by email with the reference [ACURML].

References

[AW95] KJ Astrom, B. Wittenback, *Adaptive Control*, Addison Wesley, 1995.

[LS07] Lammas, A., Sammut, K. and He, F., A 6 DoF navigation algorithm for autonomous underwater vehicles. IEEE - Oceans 2007, Aberdeen, Scotland, pp. 1-7, 2007.

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[NP11] D. Nguyen-Tuong, J. Peters, Model learning for robot control: a survey, *Cognitive Processing*, Springer 2011.

[SLC18] Y. Sola, G. Le Chenadec, and B. Clement. Machine learning for robust control of autonomous underwater vehicles. In Moqesm'18, Brest, France, 2018.

[YCM15] R. Rui Yang, B. Clement, A. Mansour, M. Li, N. Wu. Modeling of a Complex-Shaped Underwater Vehicle for Robust Control Scheme. *Journal of Intelligent and Robotic Systems*, Springer Verlag, 2015

[ZLSHTL15] Zeng, Z., Lian, L., Sammut, K., He, F., Tang, Y. and Lammas, A.K., A survey on path planning for persistent autonomy of autonomous underwater vehicles. *Ocean Engineering*, 110(A), 2015.