Master Project / Internship – IRL CROSSING, Adelaide, Australia.
Distributed learning on embedded mobile systems.

Jean-Philippe Diguet, DR CNRS, CNRS International Research Lab. CROSSING, Adelaide Australia
Amer Baghdadi, Prof. IMT Atlantique, Brest, France, Lab-STICC

Keywords: Machine Learning, Multiple-Agents, Distributed Embedded Systems, Visual Navigation, Reinforcement Learning.

Context:
Autonomous vehicles can benefit from growing embedded computing capacities that allow decision making based on multi-sensor fusion [SOU12] and/or complex Visual Navigation based for instance on semantic recognition [MOU19, SHE17], joint mapping and planning [GUP17] and distributed object detection [GUO19]. Some of the current challenges are related to learning issues for both object detection based on offline training of Deep Neural Networks and navigation tasks based on Reinforcement Learning [KUL19, MIR17]. First offline supervised learning and online inference can be efficient but require large labelled data-sets that hardly represent all cases to be experienced by autonomous agents in real-life. So new training phases with updated data-sets may be required according for instance to Edge/Cloud computing paradigm [WAN19]. Navigation tasks can be based on pre-trained models but are more efficient if they can learn online from their own actions [WOR19] while detecting obstacles and multiple-targets [HOA20]. In both cases self-adaptivity is required to improve autonomy. Another important aspect to consider is the inputs from human in the loop when available [THO05, RAM19].

Project:
The first step of the project is a comprehensive study of distributed reinforcement learning for navigation [MAT07] and distributed object detection [GUO19] under communication constraints (intermittent and limited bandwidth between agents) with computing/memory resources [GOU15].
In a second step, the objective is to select a method, configure it for a simple multi-agent navigation problem (Map with static obstacles under Gazebo for instance) with limited inter-agent synchronization capabilities.
In a third step, the proposed solution will be modified to include heterogeneity to consider mobile agents (possibly humans) with different sensors or detection methods. The map will be also upgraded to include mobiles obstacles. Load Balancing over distributed computing resources [GAU20, GUP18] can be also considered if necessary.
The next step that can be out of the scope of the internship is the implementation of the solution as a hardware-in-the loop simulation where agents are running on embedded boards (eg. NVIDIA Jetson2) while agents are evolving the Gazebo virtual world [MOR19,MOR20].

Location: Brest until Feb. 21 and Adelaide, Australia from March to Aug. 22 (supported by Crossing)
PhD Opportunity: An open PhD position will be open on the topic of distributed learning with human in the loop at Crossing, Adelaide in 2022.
Contact : jean-philippe.diguet@cnrs.fr, amer.baghdadi@imt-atlantique.fr

References
[PAR19]] M. Paravisi, D.H. Santos, V. Jorge, G. Heck, L.M. Gonçalves and A. Amory, ”Unmanned Surface Vehicle Simulator with Realistic Environmental Disturbances”. Sensors 2019, 19, 1068. https://github.com/disaster-robotics-proalertas/usv_sim_lsa
[GAU20] P. Gautier, J. Laurent, J-Ph. Diguet, “Comparison of Market-based and DQN methods for Multi-Robot processing Task Allocation (MRpTA)”, IEEE Robotic Computing (IRC), Taiwan, Mar. 2020.
[WOR19] M. Wortsman, K. Ehsani, M. Rastegari, A. Farhadi and R. Mottaghi , “Learning to Learn How to Learn: Self-Adaptive Visual Navigation using Meta-Learning”, CVPR19, arXiv:1812.00971
[WAN19] X. Wang, Y. Han, V.C.M. Leung, D. Niyato, X. Yan, X. Chen, “Convergence of Edge Computing and Deep Learning: A Comprehensive Survey”, arXiv:1907.08349
[GUP17] S. Gupta, J. Davidson, S. Levine, R. Sukthankar and J. Malik, “Cognitive Mapping and Planning for Visual Navigation”, 2017 IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), Honolulu, USA, 2017.
[SOU12] J.R. Souza, G. Pessin, G.B. Eboli, C.C. T. Mendes, F. S. Osòrio and D.F. Wolf “Vision and GPS-based autonomous vehicle navigation using templates and artificial neural networks”, 27th ACM Symp. on Applied Computing (SAC), Italy, 2012.
[SHEN17] T. Shen, G. Lin, C. Shen and I. Reid. ,” Learning Multi-level Region Consistency with Dense Multi-label Networks for Semantic Segmentation”, 26th Int. Joint Conference on Artificial Intelligence (IJCAI), 2017.
[MOU19] A. Mousavian, A. Toshev, M. Fišer, J. Košecká, A. Wahid and J. Davidson, “Visual Representations for Semantic Target Driven Navigation”, Int. Conf. on Robotics and Automation (ICRA), Montreal, Canada, 2019.
[KUL19] J. Kulhánek, E. Derner, T. de Bruin and R. Babuška, “Vision-Based Navigation Using Deep Reinforcement Learning”, European Conference on Mobile Robots (ECMR), 2019.
[MIR17] P. Mirowski, et al. “Learning to navigate in complex environments”. In Int. Conf. on Learning Representations (ICLR), France, 2017
[GUP18] O. Gupta and R. Raskar “Distributed learning of deep neural network over multiple agents”. In arXiv:1810.06060, Oct. 2018
[Hoa20] Hoa Van Nguyen “Methods for Online UAV Path Planning for Tracking Multiple Objects”, PhD Thesis, The University of Adelaide, March 2020.

[MAT07] L.Matignon, G. J. Laurent and N. Le Fort-Piat, “Hysteretic Q-Learning : an algorithm for decentralized reinforcement learning incooperative multi-agent teams.” inIEEE/RSJ International Conferenceon Intelligent Robots and Systems, IROS’07.
[GOU15] D. Gouveia, D. Portugal, D. C. Silva, and L. Marques, “Computation Sharing in Distributed Robotic Systems: A Case Study on SLAM,”IEEE Trans. Automat. Sci. Eng., vol. 12, no. 2, pp. 410–422, Apr.2015.
[MOR19] Drone HIL simulation: Reconfigurable FPGA, ROS and Gazebo. https://github.com/Kamiwan/HPeC-sources
[MOR20] E.Moreac, E.M.Abdali, F.Berry, D.Heller, J-Ph.Diguet, Hardware-in-the-loop simulation with dynamic partial FPGA reconfiguration applied to computer vision in ROS-based UAV, 31st Int. Workshop on Rapid System Prototyping (RSP), ESWeek, Sep. 2020.
[RAM19] Ramya Ramakrishnan, *Error Discovery through Human-AI Collaboration*, MIT PhD Thesis, 2019.
[THO05] A. Lockerd Thomaz, G. Hoffman and C. Breazeal, AAAI Workshop on Human comprehensible Machine Learning, 2005.
[GUO19] Guo, Y, Zou, B, Ren, J, Liu, Q, Zhang, D & Zhang, Y 2019, *Distributed and Efficient Object Detection via Interactions Among Devices, Edge, and Cloud*, *IEEE Transactions on Multimedia*, vol. 21, no. 11, pp. 2903–2915.