ScuDo

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XXXIV Cycle

Machine Learning Algorithms and their Embedded Implementation for Service Robotics Applications

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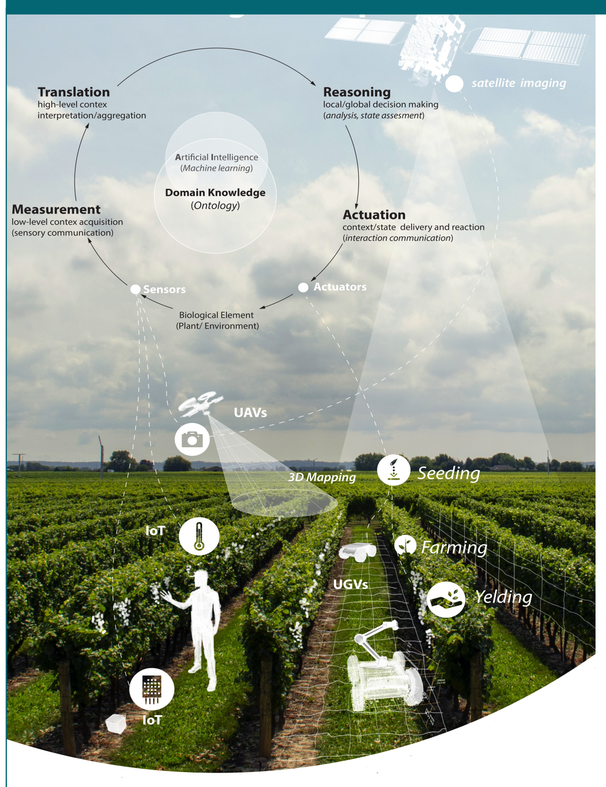
Research context and motivation



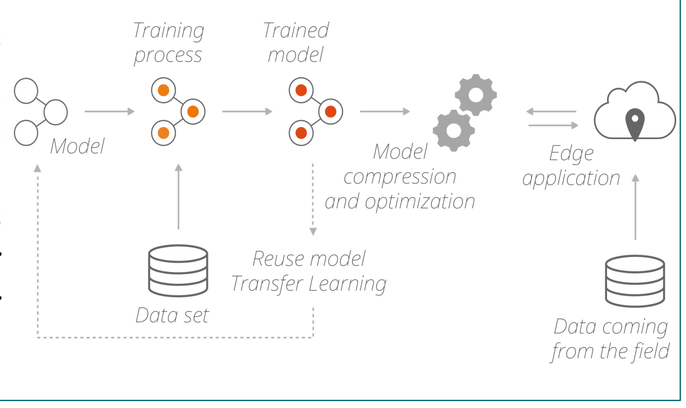
In the last few years, a branch of machine learning (ML), known as deep learning (DL), has greatly revived the entire field of research, achieving major achievements in areas as diverse as Computer Vision (CV), Natural Language Processing (NLP), speech recognition and automated reasoning. This is made possible by its intrinsic capability to learn not only the mapping function from pre-processed input to output, but also the data representations itself. Indeed, distributed representations learned by deep learning architectures are much more disentangled and representative to effectively solve tasks that require high levels of abstraction.

However, up until now, deep learning has always been associated with large quantities of data and especially high computational capacity, drastically reducing its use and fields of application. For example, precision agriculture is one of the several fields that could largely benefit from the application of ML and DL algorithms. Indeed, diverse sources of data coming from remote sensing instruments such as satellites, aerial vehicles (UAV) and terrestrial robots (UGV), if efficiently exploited, they could extremely reduce costs and increase production yield. Moreover, as is common in a considerable amount of domains, getting data from agricultural field is extremely difficult since there is often no power and Internet connection.

In this context, the presented research primarily focuses on ML algorithms for Service Robotics and on Edge AI, finding new effective training objectives and strategies in order to create lightweight and more resilient DL algorithms able to be processed locally on embedded low power hardware devices.

Addressed research questions/problems

- Investigate novel ML and DL applications for service robotics, exploiting data coming from different sources of information.
- Model & compress DL algorithms to be independent from cloud connections, working properly on highly integrated and independent devices.
- Investigate novel training objectives and strategies in order to obtain higher level representations with less power and data.

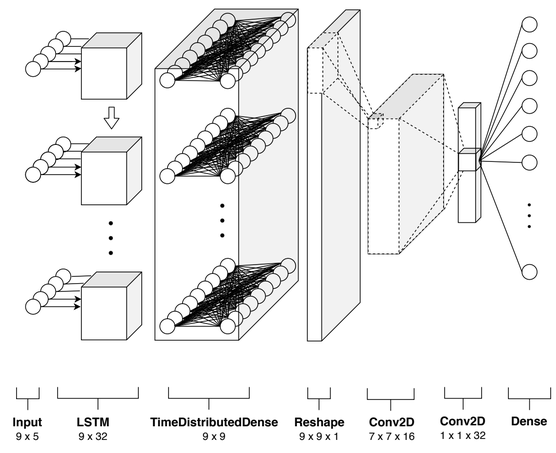


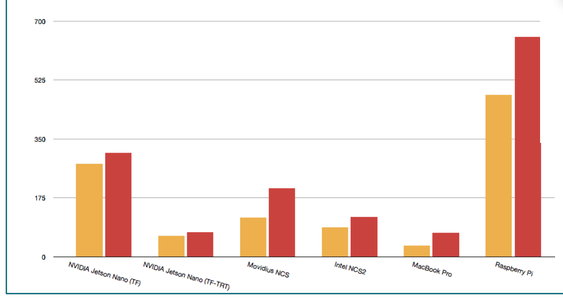
Novel contributions

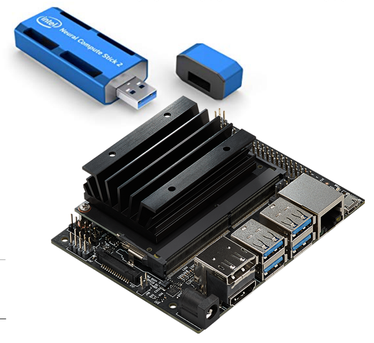
- Pixel based crops classification: Pixel-RCNN
- Refining satellite images using UAV: Rarefy-Net
- Multi-image super resolution: combine multi temporal satellite images with UAV data in order to super resolve new portions of land
- Automatic vineyard extraction for UGV autonomous navigation support
- Object detection from aerial video stream
- Autonomous navigation in vineyards using RGB camera
- DeepQ learning and A2C for autonomous navigation with ultra wideband sensors for precise localization
- Incremental learning algorithm for a fruit object detector
- Pattern recognition of a cluster of ultrasound sensors

Adopted methodologies

- Different types of novel architectures have been devised in order to tackle service robotics related tasks.
- AWS and multi GP-GPU have been used for training experiments.
- Diverse embedded based solutions with hardware accelerators such as Jetson Family, Neural compute sticks have been tested and exploited to achieve performant and reliable edge AI.







Future work

- Further investigate edge and cloud computing collaboration for incremental learning and model optimization.
- Explore self-supervised learning and other training objectives in order to achieve higher level representations with less data and power.
- Exploit deep reinforcement learning to obtain a free cloud independent agent able to autonomously navigate with only a visual inertia sensor.

Submitted and published works

- [1] V. Mazzia, F. Daneshgaran, M. Marina, "*Use of Deep Learning for Automatic Detection of Cracks in Tunnels*", 29th Italian Workshop on Neural Networks (WIRN), Vietri sul Mare, Italy, June 2019
- [2] V. Mazzia, A. Tartaglia, M. Chiaberge, D. Gandini, "*Deep Learning Algorithms for Complex Pattern Recognition in Ultrasonic Sensors Arrays",* 5th International Conference on Machine Learning, Optimization, and Data Science *(LOD),* Certosa di Pontignano, Italy, September 2019
- [3] A. Khaliq, V. Mazzia, M. Chiaberge, "*Refining satellite imagery by using UAV imagery for vineyard environment: a CNN Based approach*", Metrology for Agriculture and Forestry (METROAGRIFOR), Portici, Italy, October 2019
- [4] V. Mazzia, A. Khaliq, M. Chiaberge, "*Improvement in land cover and crop classification based on temporal features learning using Recurrent-Convolutional Neural Network (R-CNN)*", in IEEE Access, September 2019
- [5] A. Tartaglia, V. Mazzia, "*Machine Learning Algorithms for Service Robotics Applications in Precision Agriculture*", in Precision Agriculture, September 2019

List of attended classes

- 01QTEIU – Data mining concepts and algorithms - 05/12/2018, (4 CFU)
- 01TEVRV – Deep learning - 01/04/2019, (6 CFU)
- 01RONKG – Python in the lab - 20/05/2019, (4 CFU)
- 01SCSIU – Machine learning for pattern recognition - 08/03/2019, (4 CFU)
- 03QTIIU – Mimetic learning - 04/07/2019, (4 CFU)
- 01TBXRV – Vision fundamentals in service robotics - 31/05/2019, (4 CFU)
- 01PJHRV – Cloud computing per applicazioni e-science - 21/07/2019, (4 CFU)
- 03SGVRP – Entrepreneurship and start-up creation from university research - 09/11/2017, (8 CFU)
- 01RISRV – Public speaking - 19/02/2019, (1 CFU)
- 02LWHRV – Communication - 26/03/2019, (1 CFU)
- 01SWPRV – Time management - 08/05/2019, (1 CFU)
- 08IXTRV – Project management – 21/09/2019, (1 CFU)
- External Training Activity – Deep Learning for Robotics – NVIDIA GTC 2019, San Jose

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