Saipem S.p.A.
Towards autonomous underwater vehicles

Paolo Bonel
Marco Carraro
R&D - Thesis proposals @ Saipem
Last years have seen a general improvement in the object detection quality from color images using Deep Learning techniques such as YOLO or SSD. While the quality of those techniques is impressive using every day photos and videos, they usually require dedicated hardware solution as high-end GPUs to reach real-time performance. Moreover, the wide majority of the state-of-the-art classifiers have never seen any underwater scenario. This thesis addresses this problem; you are asked to review/design and apply Object Detection algorithms to underwater applications, with limited computing resources.
A common task an intelligent AUV must be able to perform is to follow a pipe. While this task seems rather simple, most times illumination changes, irregular seabed or partially submerged section of the pipe make it a challenging task. This thesis will deal with this problem by analyzing several videos and proposing a solution to obtain the best performance in terms of framerate and detection quality. The solution can involve machine learning or model-based algorithms as well as a combination of both.
A common problem when working with AUVs and ROVs is the necessity to spare power consumption and space inside the control pods of the robots. For this reason, embedded GPUs, such as the ones provided by the Nvidia Jetson series, are often preferred to desktop ones. The scope of this thesis is to implement several Deep Neural Networks architecture addressing different problems and run them in parallel using such hardware.
Each AUV (Autonomous Underwater Vehicle) by definition is equipped with batteries to lengthen its life and making it reliable to perform long missions.

In order to be really autonomous, it is needed it can automatically dock to a base station to recharge its batteries.

This activity is usually performed by infrared transceivers/receivers on everyday robot such as the Roomba robot. This type of sensors are not available nor reliable for underwater environments. For this reason, an AUV needs to be able to autonomously dock by using only visual aids, such as April tags mounted on top of a autonomous docking base.

The aim of this proposal is to achieve this goal by using a simulation env and, possibly, a real robot.
Thesis Proposal 5 - Velocity estimation using visual aids

An ROV or AUV is often equipped with expensive instrumentation such as inertial systems, to provide a reliable and precise position and velocity of the vehicle.

However, in some particular cases these instruments are not usable, such as, when the vehicle is on top of metal objects, causing the INS to return crazy measurements.

The thesis objective is to address this problem, by means of tracking of fiducial points on visual data returned by cameras.

Image courtesy of https://nanonets.com/blog/optical-flow/
HyRO is the robotics middleware developed by Saipem which has different features, like:

- No central entity
- Autodiscovery of services
- Compatibility with different state-of-the-art communication protocols
- Layered infrastructure; from low-level components to high-level mission plan language specification
- Multiple OS compatibility

This thesis is about to study HyRO and ROS2, in order to understand differences, possible missing features and to interface the two different worlds.
Thesis Proposal Bonus - propose your idea!

Are you eager to test your skills / expertise / machine learning fancy new classifier and see if it can be applied to the underwater robotics world?

Drop us an email and let’s discuss a bit about that!

Possible arguments (not already included in the previous slides):

Control
- Advanced control of underwater manipulators
- Integration between inertial dynamic positioning and perception data (visual / sonar)
- Efficient trajectory planning and generation for dynamic positioning of underwater machines
- Control algorithms for ROV efficient lifting operations
- Controllo ROV con thruster e propeller a geometria dinamica per ottimizzare l'efficienza delle operazioni

Simulation
- Augmented and Virtual Reality to assist a remote ROV operator while using unreliable communications
- Advanced modelling of thrusters and ROV tethers in simulated environments.

Hydrodynamics:
- ROV Innovator hydro-dynamic modelling
- ROV thrusters efficiency in presence of obstacles