MONSUN - A Modular Testbed for Swarms of Autonomous Underwater Vehicles

Benjamin Meyer, Christoph Osterloh and Erik Maehle
University of Luebeck, Institute of Computer Enineering, Germany
Email: {meyer, maehle}@iti.uni-luebeck.de

***Abstract*—For analysis and mapping as well as long-term studies of water bodies, Autonomous Underwater Vehicles *(AUVs)* are considered to be a trendsetting opportunity with high potential. Underwater robots combine many benefits differing them from conventional methods like manual explorations with divers and boats or static underwater sensor nets. It is possible to investigate hard-to-reach areas coupled with a significant lower amount of work and costs and the possible applications are getting safer. The use of a robot swarm increases the number of possible applications. The swarm members are simple in construction, nevertheless allowing inspections in a wider area over a longer period. Apart from that the control of a swarm proves to be more complex than for a single robot. As a consequence principles from nature like emergence, self-organisation and self-adaption are becoming increasingly popular.**

A testbed to evaluate the mentioned principles under realistic conditions is illustrated in this paper. The current development and design concept of the underwater robot MONSUN is described, which is based on robustness and modularity to get a submersible platform for use in robot swarms.

The development of the MONSUN underwater robot is based on the criteria defined by Dorigo and Şahin [1]. The robot swarm should be scalable and consist of simple uniform robots operating locally together. The principles of emergence as well as robustness based on modularity and adaptability are formulated as main goals of the development of swarm robots. These criteria extended with a simple and fast possibility to build a robot provide a promising base to cross the so-called reality gap.

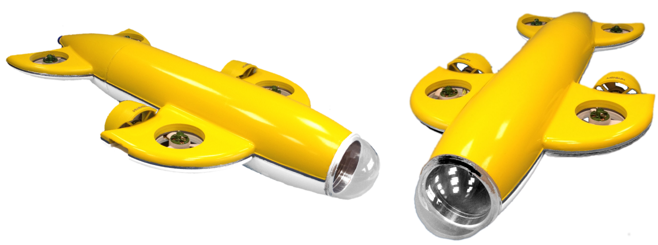

Fig. 1. MONSUN Underwater Robots designed for e.g. environmental monitoring tasks in a swarm. They are small in size with a length of 60 cm and a diameter of 10 cm which makes it easy to handle by one person. [2]

The MONSUN Underwater Robot is currently released in the third generation. Due to the experiences of the previous version illustrated in [3], the building is accelerated by manufacturing methods like 3D-printing and Computer Aided Design *(CAD)* techniques (*see Fig. 1*). Furthermore the design concept can be sectioned as follows:

1) Robustness: The vehicles bipartite hull is made of glass fibre reinforced plastic sealed by a bayonet closure. The total weight is calculated to achieve a positive buoyancy. If the full system or the actuators fail, the robot will surface to rescue the vehicle and possible collected data. The robot is actuated by six brushless motors, two orientated horizontally for driving in a plain and four orientated vertically four depth and posture control. This achieves a high redundancy to be forearmed concerning breakdowns of arbitrary thrusters.

2) Modularity: The electronics is designed as a bus-based architecture. The control boards, sensors and periphery are connected by uniform sockets and not bound on specific places. This enables the robot to be customized to any specific mission task with a unique choice of sensors and control units. Furthermore this makes it possible to exchange the uniform pcb-boards among the robots to shorten the time in failure cases to get the robot back in action.

3) Adaptability: The software of the robot is based on the Robot Operating System *ROS* which allows a high adaptability to new software methods and various mission tasks using open source community packages e.g. swarm algorithms or prior home developed algorithms for other underwater robots. The reusability and node-based software architecture speeds up the software design and integrated network features are predestined for swarm behaviour.

4) Scalability: The robot is equipped with a home developed low-cost acoustic modem capable of communicating with a high scalable number of up to 63 swarm members. The modem uses Frequency Hopping Spread Spectrum *(FHSS)* techniques and a forward error correction code achieving a bandwith of 2 kBit/s. Furthermore, the robot uses an embedded ARM processor running Linux, which is installed on an 8 GB SD card. Hence the full operating system can be exchanged quickly among the robots by duplicating the SD-cards, the software exchange progress between the swarm robots gets rather easy.

To summarize this paper presents the third generation of the MONSUN underwater robot as a testbed for swarm algorithms in underwater environments. Due to its simple modular design it allows successful full-scale deployments in real world application environments.

Tests with two robots have been successfully performed yet. The robots recognize each other visually and swim in predefined distances to each other. The next steps are the completion of five MONSUN and the development of swarm communication and localization algorithms for high-level behaviours.

REFERENCES

[1] Dorigo, M.; Şahin, E.: *Swarm robotics - special issue editorial*, Autonomous Robots, 17(2-3), 111–113, 2004.

[2] Osterloh, C.; Pionteck, T.; Maehle, E.: *MONSUN II: A small and inexpensive AUV for underwater swarms*, 7th German Conference on Robotics (ROBOTIK 2012),325–330, München, 2012

[3] Osterloh, C.; Meyer, B.; Amory, A.; Pionteck, T.; Maehle, E.: *MONSUN II - Towards Autonomous Underwater Swarms for Environmental Monitoring*, IROS 2012, Workshop on Robotics for Environmental Monitoring, 1-6, Vilamoura, Portugal, 2012.