Paper

# Design of Communication and Control for Swarms of Aquatic Surface Drones

**Topics:** Autonomous Systems; Collective Intelligence; Cooperation and Coordination; Evolutionary Computing; Multi-Agent Systems; Physical Agents; Robot and Multi-Robot Systems; Self Organizing Systems

In **Proceedings of the International Conference on Agents and Artificial Intelligence - Volume 1: ICAART,** 548-555, 2015 , Lisbon, Portugal

## Design of Communication and Control for Swarms of Aquatic Surface Drones

Anders Lyhne Christensen[1,2,3], Sancho Oliveira[1,2,3], Octavian Postolache[1,2], Maria João de Oliveira[2,4], Susana Sargento[1,5], Pedro Santana[1,2], Luís Nunes[1,2], Fernando Velez[1,6], Pedro Sebastião[1,2], Vasco Costa[1,2,5], Miguel Duarte[1,2,3], Jorge Gomes[1,3,7], Tiago Rodrigues[1,2,3] and Fernando Silva[1,3,7]

[1]*Instituto de Telecomunicações, 1049-001 Lisbon, Portugal*
[2]*Instituto Universitário de Lisboa (ISCTE-IUL), 1649-026 Lisbon, Portugal*
[3]*BioMachines Lab, 1649-026 Lisbon, Portugal*
[4]*Vitravias FabLab-IUL, 1649-026 Lisbon, Portugal*
[5]*Universidade de Aveiro, 3810-193 Aveiro, Portugal*
[6]*Universidade da Beira Interior, 6201-001 Covilhã, Portugal*
[7]*LabMAg, Faculdade de Ciências da Universidade de Lisboa, 1749-016 Lisbon, Portugal*

Keywords: Robotics Platform, Digital Manufacturing, Mesh Networks, Evolutionary Robotics, Decentralized Control.

Abstract: The availability of relatively capable and inexpensive hardware components has made it feasible to consider large-scale systems of autonomous aquatic drones for maritime tasks. In this paper, we present the CORATAM and HANCAD projects, which focus on the fundamental challenges related to communication and control in swarms of aquatic drones. We argue for: (i) the adoption of a heterogeneous approach to communication in which a small subset of the drones have long-range communication capabilities while the majority carry only short-range communication hardware, and (ii) the use of decentralized control to facilitate inherent robustness and scalability. A heterogeneous communication system and decentralized control allow for the average drone to be kept relatively simple and therefore inexpensive. To assess the proposed methodology, we are currently building 25 prototype drones from off-the-shelf components. We present the current hardware designs and discuss the results of simulation-based experiments involving swarms of up to 1,000 aquatic drones that successfully patrolled a 20 km-long strip for 24 hours.

### 1 INTRODUCTION

Maritime tasks are usually expensive to carry out due to the use of manned vehicles with large operational crews. While effort has been made to adapt unmanned vehicle technology for use in maritime tasks, such systems are currently relatively expensive to acquire and operate, and only a single or a few vehicles are typically deployed (Yan et al., 2010).

An alternative approach is the use of autonomous systems composed of large numbers of relatively simple and inexpensive drones (swarms). The use of swarms is advantageous given that many maritime tasks such as environmental monitoring, sea life localization, and sea-border patrolling require distributed sensing. The goals of our ongoing HANCAD and CORATAM projects are to overcome fundamental challenges related to communication and control in large-scale swarms of aquatic surface drones. In the HANCAD project, we propose to use a heterogeneous network architecture in which only a subset of the drones are required to carry long-range communication equipment. As part of the project, we will study and develop novel routing algorithms to achieve effective communication in such ad-hoc heterogeneous networks. In the CORATAM project, we propose to use a novel hybrid approach (Duarte et al., 2014a) to the semi-automatic synthesis of self-organized behavior for swarms of aquatic drones. The potential benefits of decentralized control based on self-organization include scalability and robustness to faults (Brambilla et al., 2013), both of which are essential in many real-world scenarios.

In this paper, we present the major components of our ongoing work, namely: (i) the design of our prototype hardware, (ii) the heterogeneous communica-


Lyhne Christensen A., Oliveira S., Postolache O., João de Oliveira M., Sargento S., Santana P., Nunes L., Velez F., Sebastião P., Costa V., Duarte M., Gomes J., Rodrigues T. and Silva F.
Design of Communication and Control for Swarms of Aquatic Surface Drones.
DOI: 10.5220/0005561705480555
In Proceedings of the International Conference on Agents and Artificial Intelligence (ICAART-2015), pages 548-555
ISBN: 978-989-758-074-1

**Authors:** Anders Lyhne Christensen [1] ; Sancho Oliveira [1] ; Octavian Postolache [2] ; Maria João de Oliveira [3] ; Susana Sargento [4] ; Pedro Santana [2] ; Luis Nunes [2] ; Fernando Velez [5] ; Pedro Sebastião [2] ; Vasco Costa [1] ; Miguel Duarte [1] ; Jorge Gomes [6] ; Tiago Rodrigues [1] and Fernando Silva [6]

**Affiliations:** [1] Instituto de Telecomunicações, Instituto Universitário de Lisboa (ISCTE-IUL) and BioMachines Lab, Portugal ; [2] Instituto de Telecomunicações and Instituto Universitário de Lisboa (ISCTE-IUL), Portugal ; [3] Instituto Universitário de Lisboa (ISCTE-IUL) and Vitruvius FabLab-IUL, Portugal ; [4] Instituto de Telecomunicações and Universidade de Aveiro, Portugal ; [5] Instituto de Telecomunicações and Universidade da Beira Interior, Portugal ; [6] Instituto de Telecomunicações, BioMachines Lab, LabMAg and Faculdade de Ciencias da Universidade de Lisboa, Portugal

**ISBN:** 978-989-758-074-1

**ISSN:** 2184-433X

**Keyword(s):** Robotics Platform, Digital Manufacturing, Mesh Networks, Evolutionary Robotics, Decentralized Control.

**Related Ontology Subjects/Areas/Topics:** Agents ; Artificial Intelligence ; Artificial Intelligence and Decision Support Systems ; Autonomous Systems ; Collective Intelligence ; Computational Intelligence ; Cooperation and Coordination ; Distributed and Mobile Software Systems ; Enterprise Information Systems ; Evolutionary Computing ; Knowledge Engineering and Ontology Development ; Knowledge-Based Systems ; Multi-Agent Systems ; Physical Agents ; Robot and Multi-Robot Systems ; Self Organizing Systems ; Soft Computing ; Software Engineering ; Symbolic Systems

**Abstract:** The availability of relatively capable and inexpensive hardware components has made it feasible to consider large-scale systems of autonomous aquatic drones for maritime tasks. In this paper, we present the CORATAM and HANCAD projects, which focus on the fundamental challenges related to communication and control in swarms of aquatic drones. We argue for: (i) the adoption of a heterogeneous approach to communication in which a small subset of the drones have long-range communication capabilities while the majority carry only short-range communication hardware, and (ii) the use of decentralized control to facilitate inherent robustness and scalability. A heterogeneous communication system and control allow for the average drone to be kept relatively simple and therefore inexpensive. To assess the proposed methodology, we are currently building 25 prototype drones from off-the-shelf components. We present the current hardware designs and discuss the results of simulation-based tests.



**Paper citation in several formats:**

Harvard | Bibtex | EndNote

Lyhne Christensen, A.; Oliveira, S.; Postolache, O.; João de Oliveira, M.; Sargento, S.; Santana, P.; Nunes, L.; Velez, F.; Sebastião, P.; Costa, V.; Duarte, M.; Gomes, J.; Rodrigues, T. and Silva, F. (2015). **Design of Communication and Control for Swarms of Aquatic Surface Drones**. In *Proceedings of the International Conference on Agents and Artificial Intelligence - Volume 1: ICAART,* ISBN 978-989-758-074-1 ISSN 2184-433X, pages 548-555. DOI: 10.5220/0005281705480555

## Reviews

Login or register to post comments.

**Comments on this Paper:** Be the first to review this paper.