Institute for Systems and Robotics
Lisboa

NTNU
Norwegian University of Science and Technology

TII Technology Innovation Institute

Cooperative Distributed Control and Estimation of Networked Marine Robots: Theory and Applications

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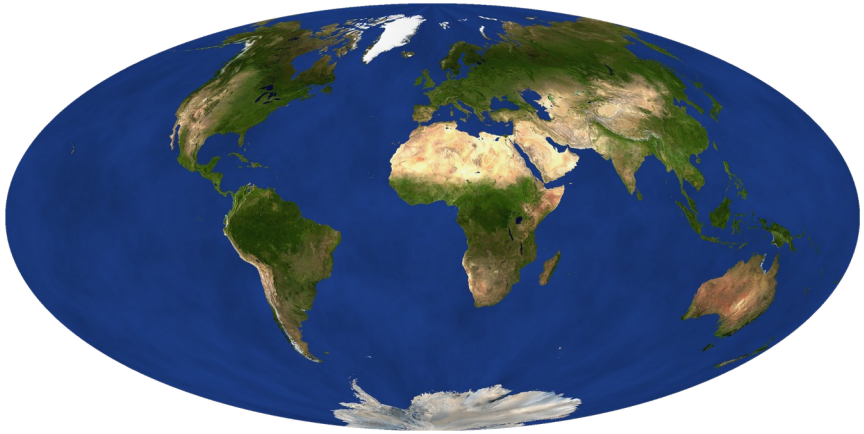
Introduction

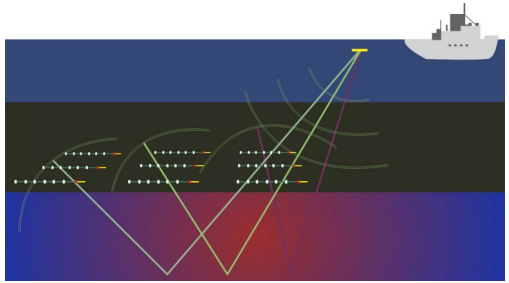
Networked marine robotic vehicles:

- Where and why
- Challenges in design and Implementation
- Examples with field experiments

Netwworked Marine Robotic Vehicles: Where and Why



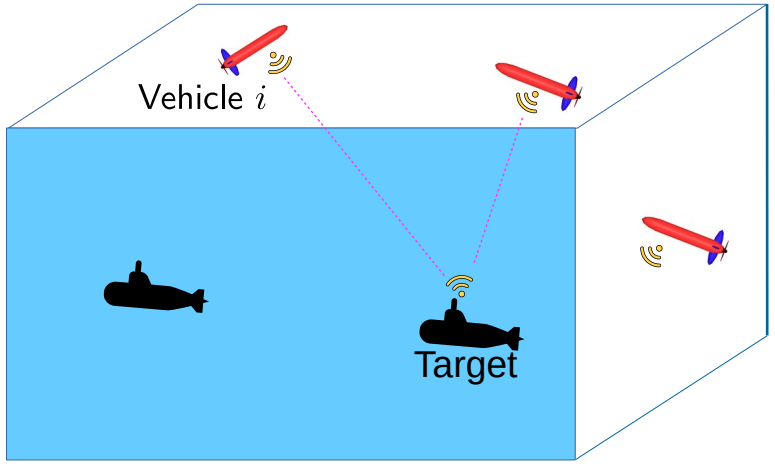
- 70% of the earth is covered by ocean
- Only 5% of the ocean was explored



Netwworked Marine Robotic Vehicles: Challenges

Designs and and implementation (from a control standpoint)

1. Networked robotic system is complex
2. Inter-vehicle network constraints
   - Network topology
   - Bandwidth
3. Stability guanrantees



Netwworked Marine Robotic Vehicles: Challenges

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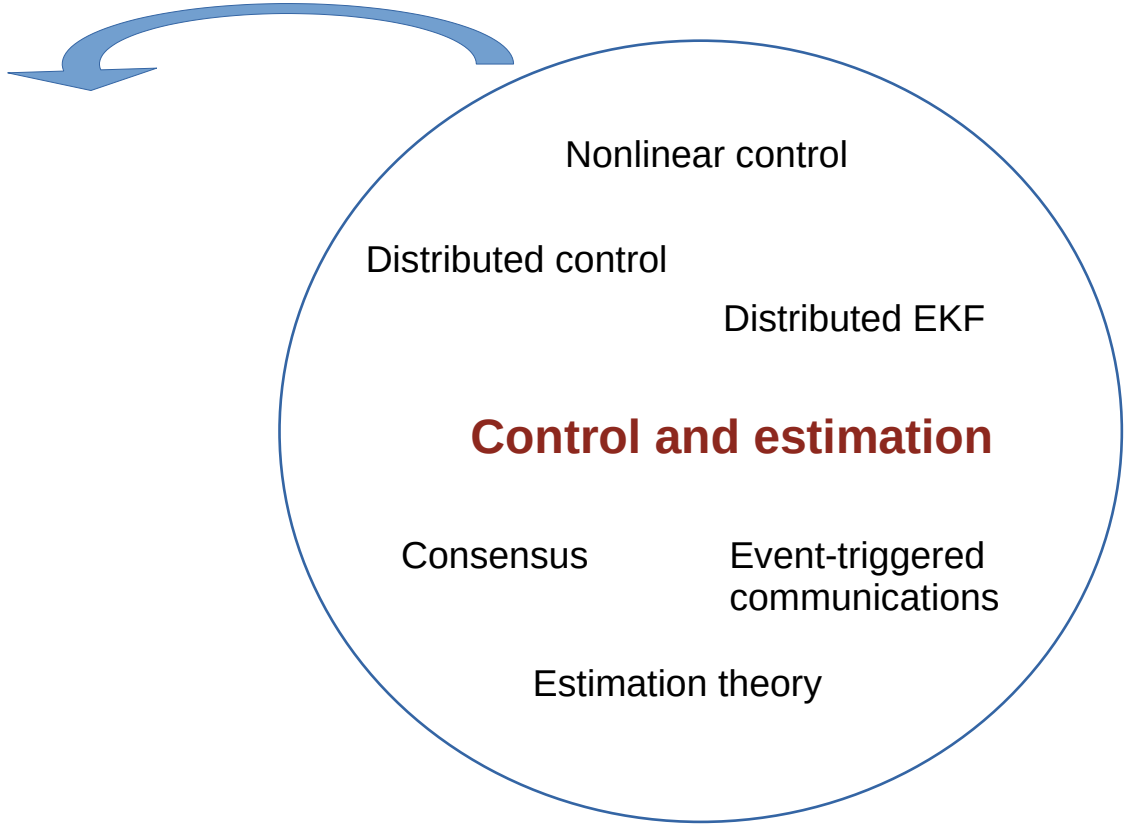
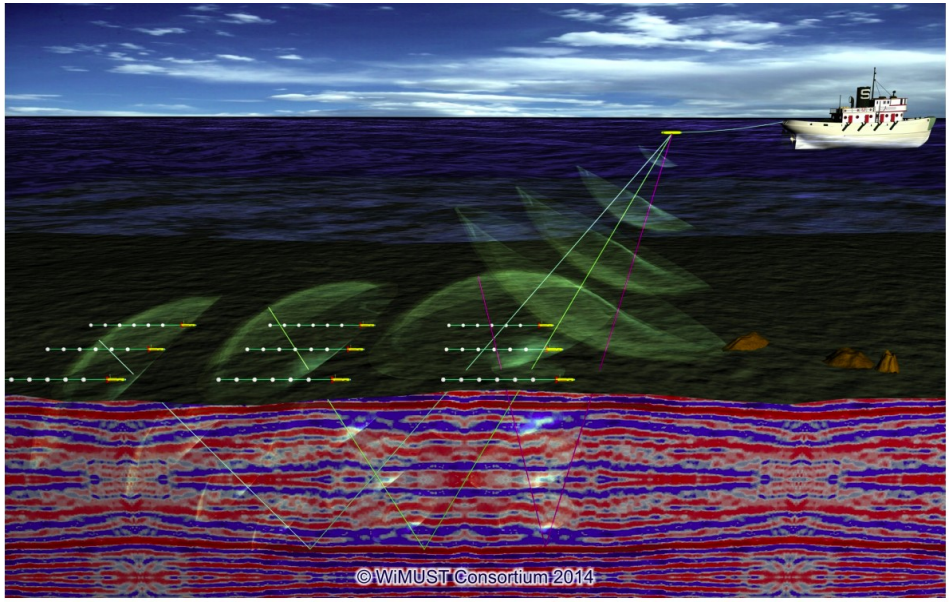


Project 1: Wimust (EU funded)

Wimust: Widely scalable Mobile Underwater Sonar Technology

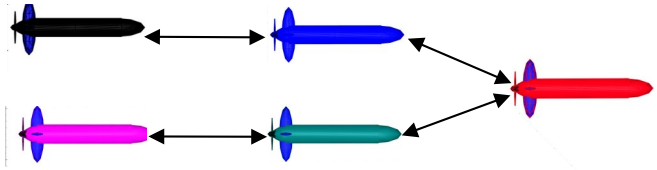
Classical approach

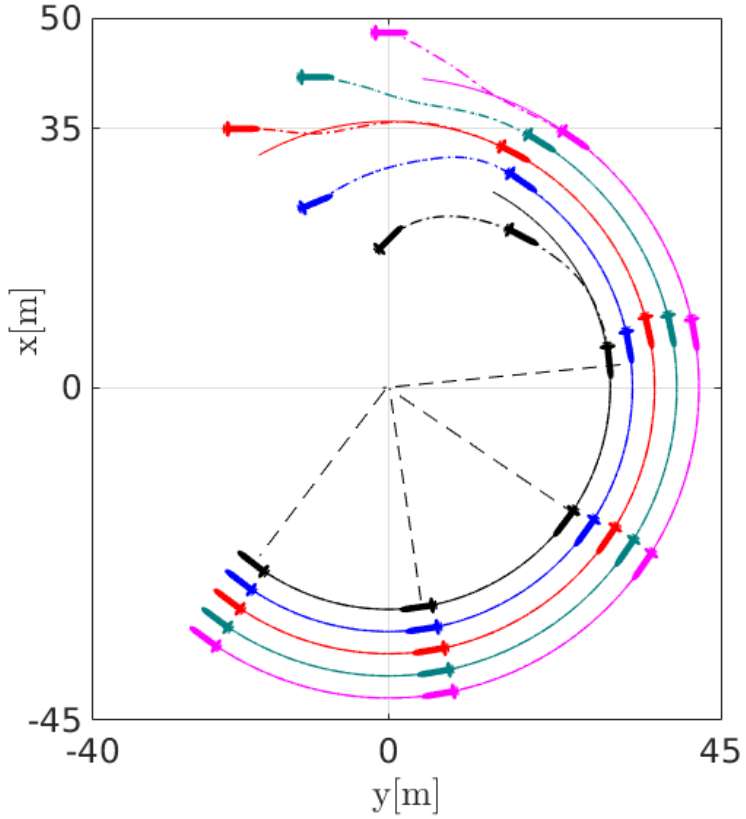


Wimust proposal

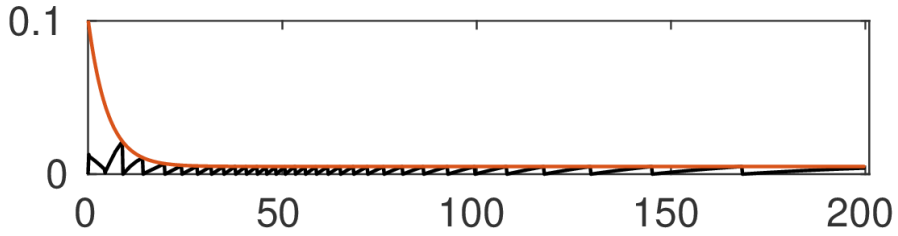
(with cooperative path following
of autonomous AUVs)

Cooperative Motion control

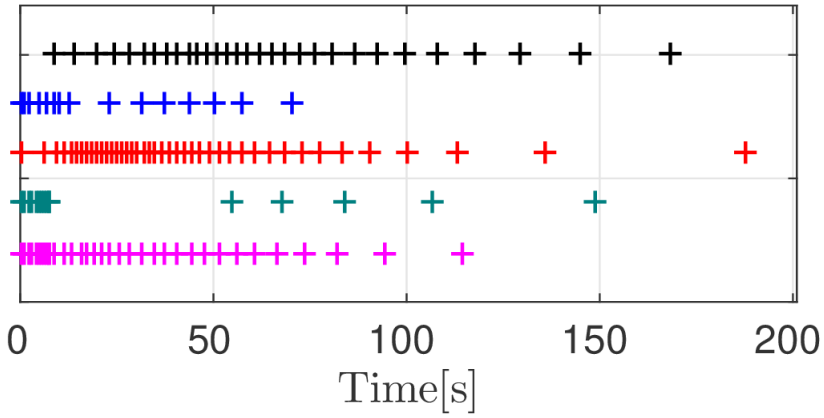




Estimation error of the black vehicle



Time instants the vehicles broadcast

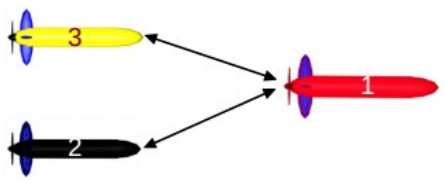


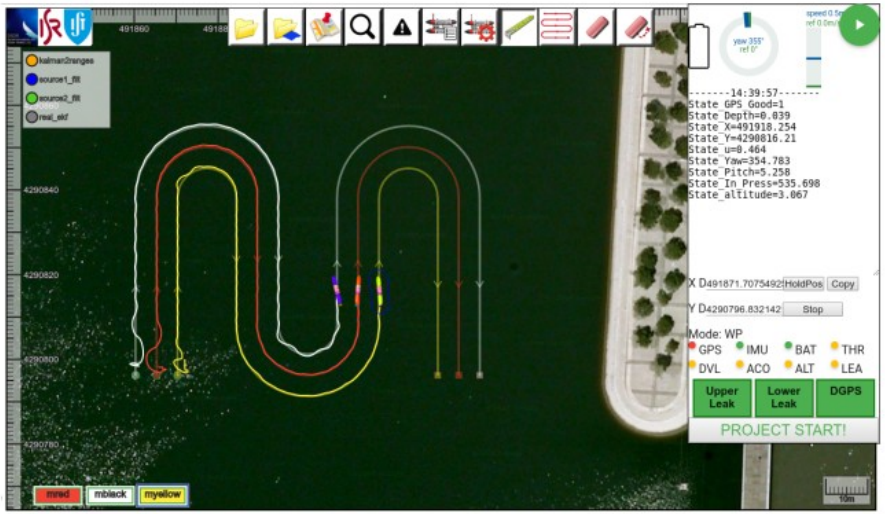
Papers Video Video

Cooperative Motion control

Setup (Rego et al. (2019))

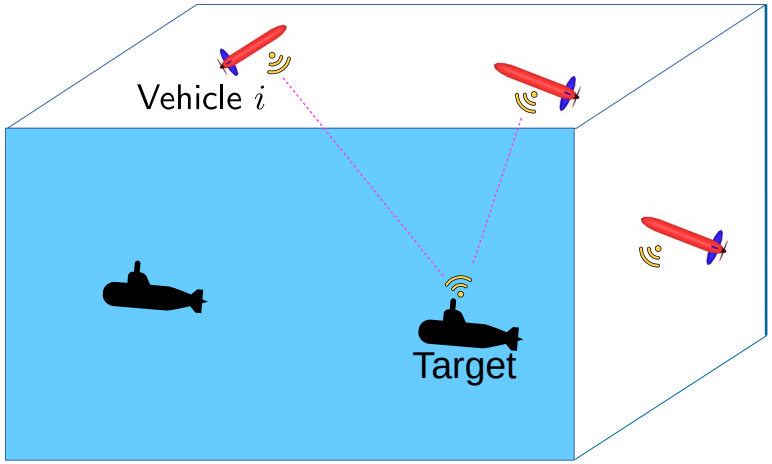
- 3 Medusa class AUVs
- PF controller: Lyapunov based controller





Video Video Papers

Project 2 – Underwater target localization and pursuit (EU funded)



Problem:

Simultaneous targets **L**ocalization **A**nd **P**ursuit (SLAP)

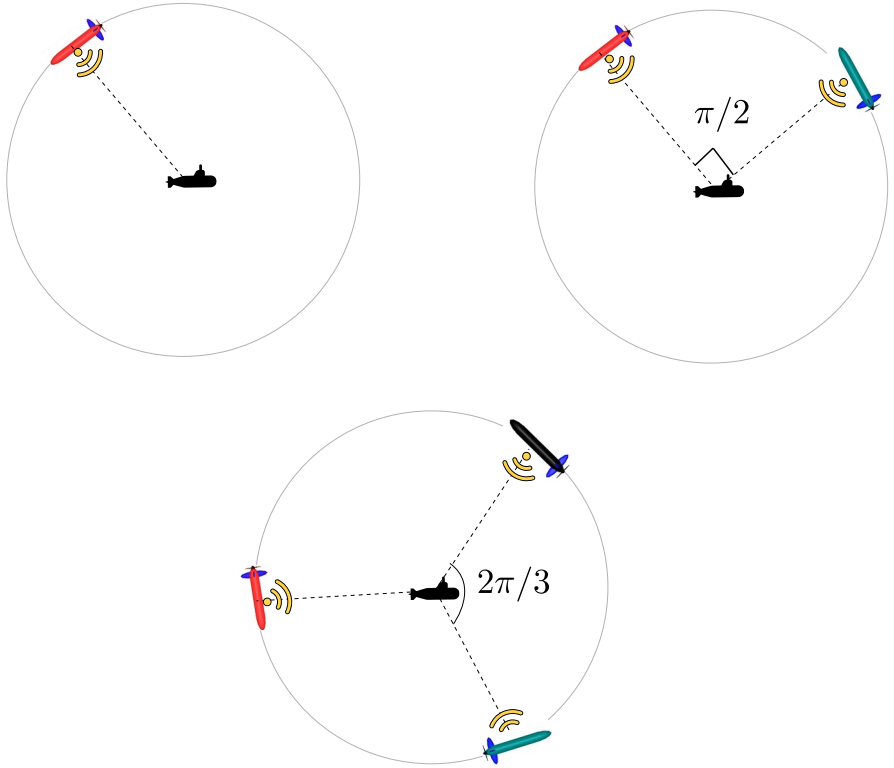
Assumptions:

1. Vehicles can measure ranges to targets
2. Vehicles can exchange information with the other via a communication network

Project 2 – Underwater target localization and pursuit

Motion planning level

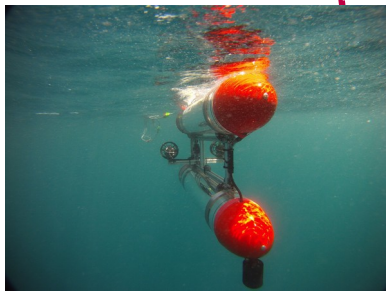
Estimation theory
(Fisher Information)

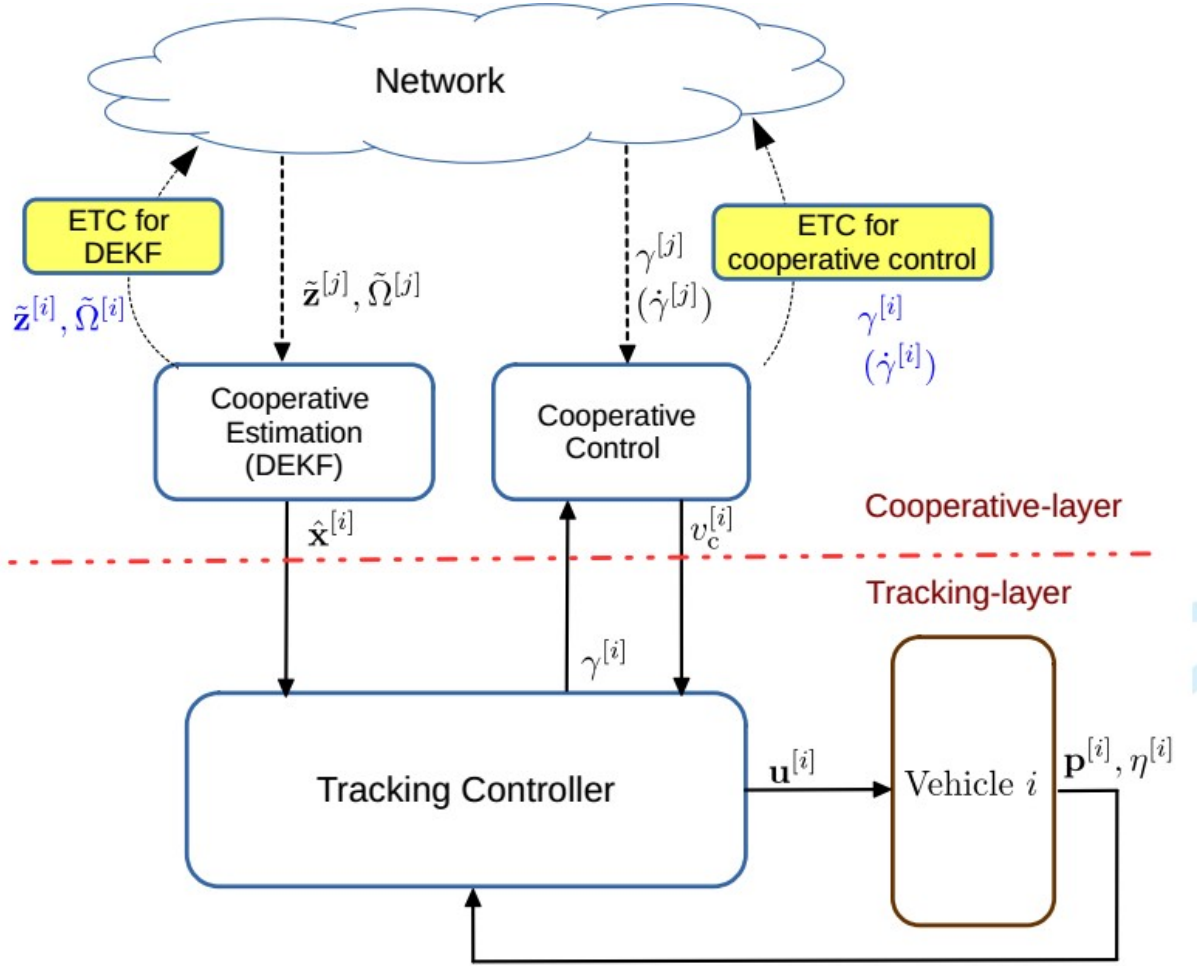


Reference: Nguyen T. Hung, et al., “Range-based target localization and pursuit with autonomous vehicles: An approach using posterior CRLB and model predictive control”, Robotics and Autonomous Systems, 2020.

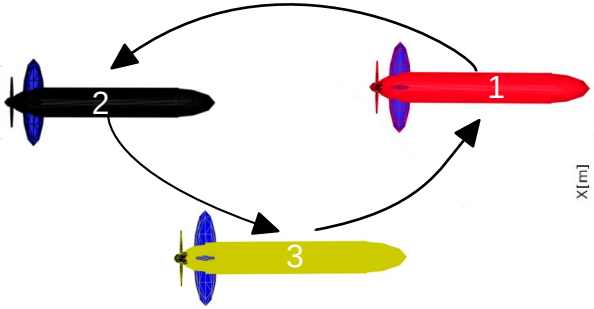
Project 2 – Underwater target localization and pursuit

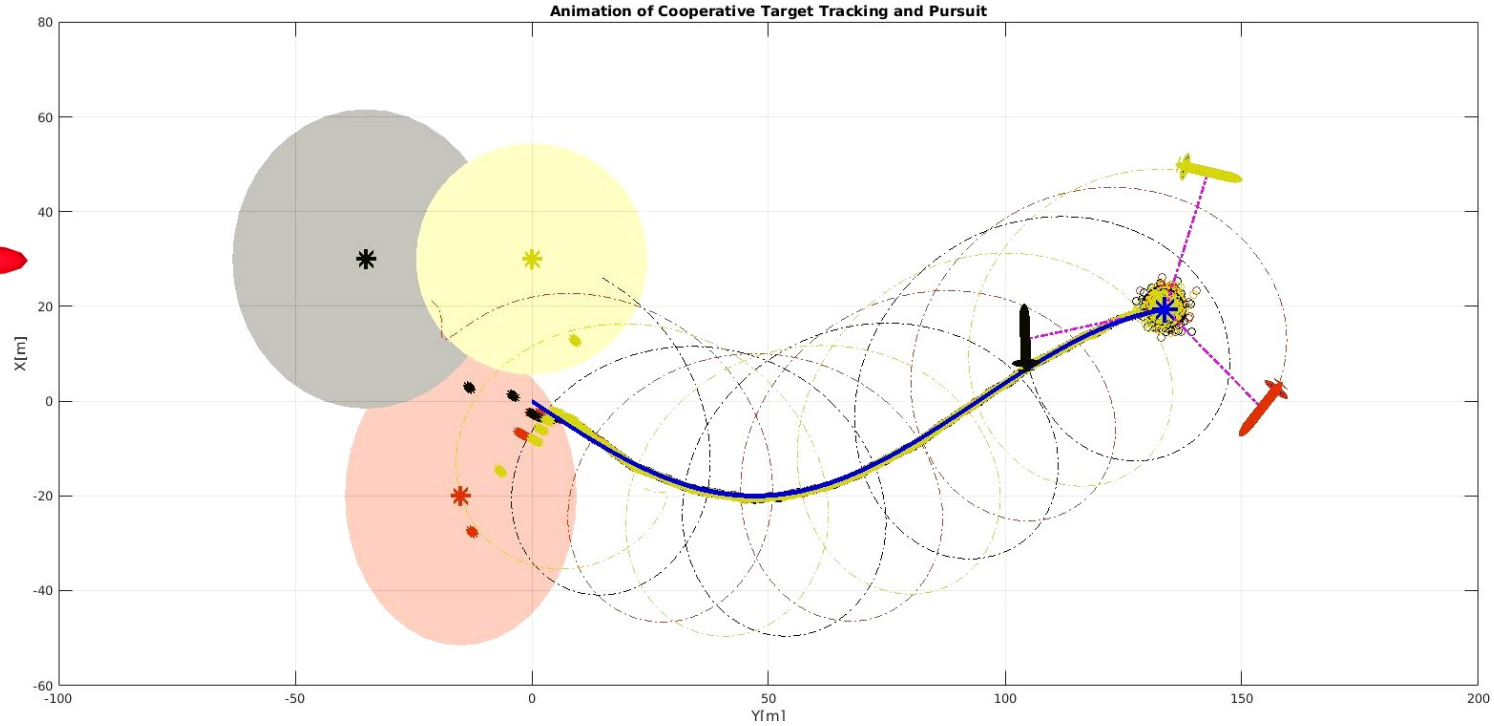
Cooperative GNC for robot i





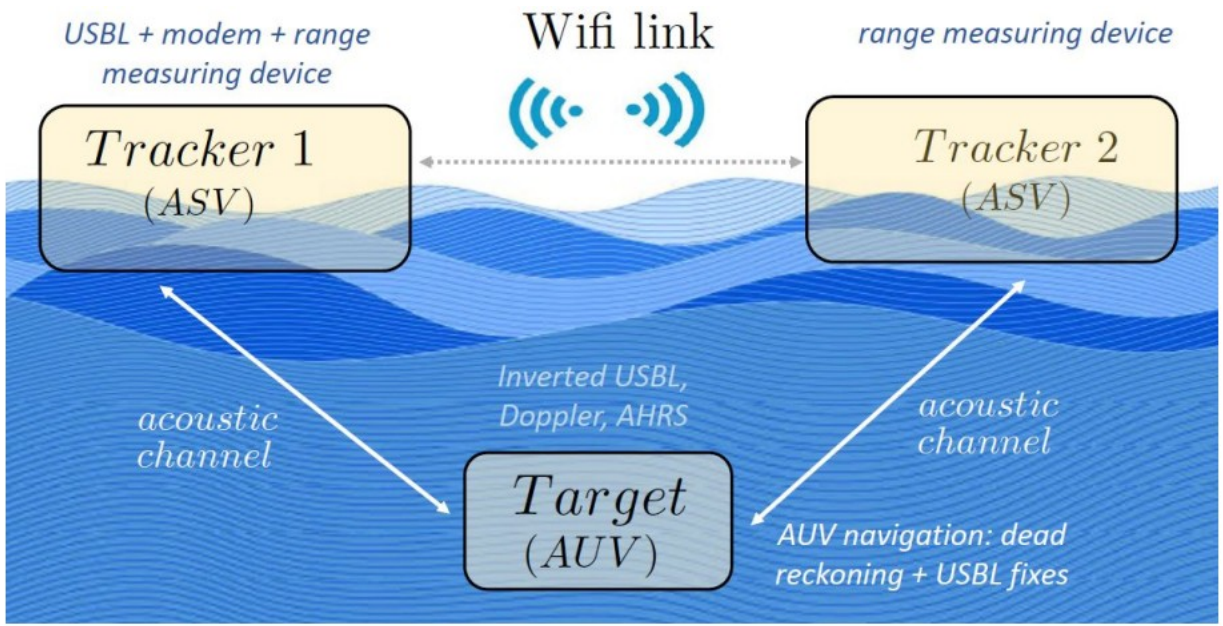
Project 2 – Underwater target localization and pursuit





Video Papers Video

Project 2 – Underwater target localization and pursuit



Medusa-class AMVs (IST, Lisbon)

Computer board: NANO-PVD5251
OS: Ubuntu 18.04,
ROS1 (C++ & Python)

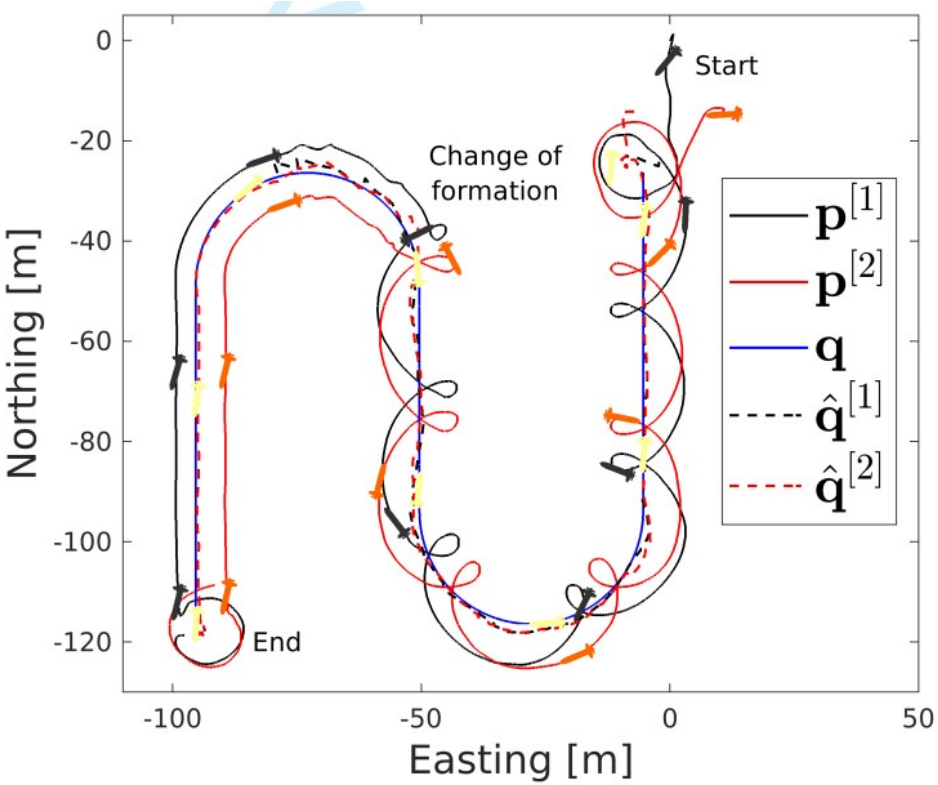
Links:

Video

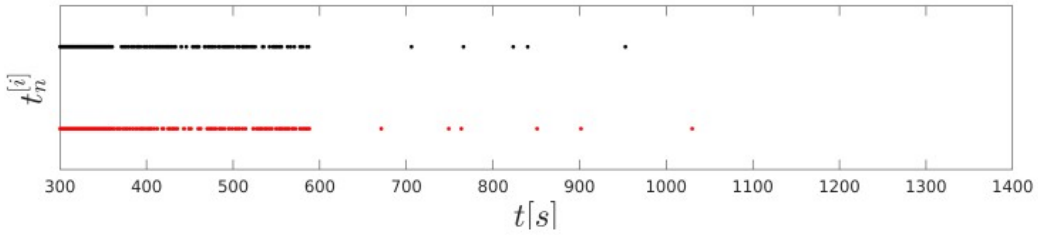
- Video 1
- Video 2

Papers

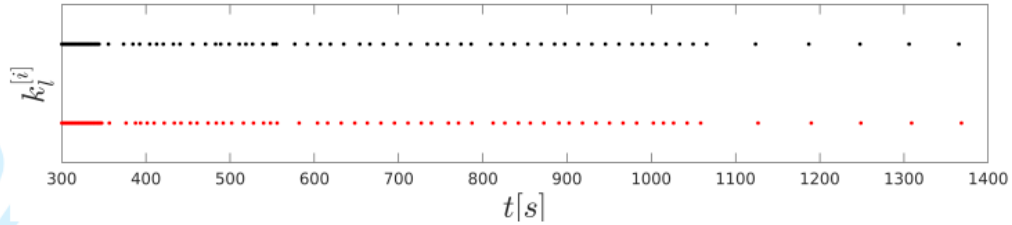
Project 2 – Underwater target localization and pursuit



Communications for cooperative control

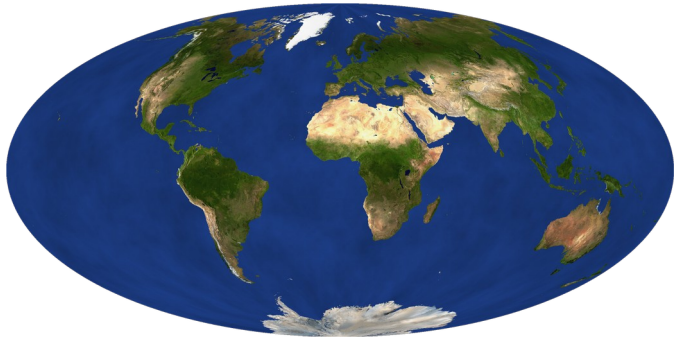


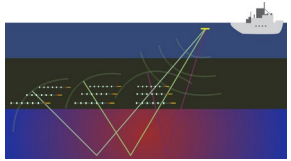
Communications for cooperative estimation

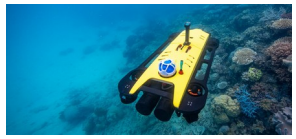


Papers

Summary







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Thank you !

Publication & codes: nt-hung.github.io

Nonlinear control

Distributed control

Distributed EKF

Control and estimation

Consensus

Event-triggered communications

Estimation theory