ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ • ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING • UNIVERSITY OF IOANNINA

# ΠΑΡΟΥΣΙΑΣΗ
# ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ

**ΗΜΕΡΟΜΗΝΙΑ:** Παρασκευή, 23 Οκτωβρίου 2026

**ΩΡΑ:** 10:00 - 12:00

**ΑΙΘΟΥΣΑ:** Αίθουσα Σεμιναρίων, ΤΜΗΥΠ

**ΟΜΙΛΗΤΗΣ:** **Piyabhum Chaysri**

## Θέμα

## *« Advanced Reinforcement Learning Methods for Autonomous Navigation of Unmanned Surface Vessels»*

**Επταμελής Εξεταστική Επιτροπή:**

1. **Κωνσταντίνος Μπλέκας**, Καθηγητής, Τμήμα Μηχανικών Ηλεκτρονικών Υπολογιστών και Πληροφορικής, Πανεπιστήμιο Ιωαννίνων (επιβλέπων)
2. **Γεώργιος Βούρος**, Καθηγητής, Τμήμα Ψηφιακών Συστημάτων, Παν. Πειραιά.
3. **Κωνσταντίνος Βλάχος**, Επίκ. Καθηγητής, Τμήμα Μηχανικών Η/Υ & Πληροφορικής, Παν. Ιωαννίνων (μέλος τριμελούς επιτροπής)
4. **Λυσίμαχος Κόντη**, Καθηγητής, Τμήμα Μηχανικών Η/Υ & Πληροφορικής, Παν. Ιωαννίνων
5. **Αριστείδης Λύκας**, Καθηγητής, Τμήμα Μηχανικών Η/Υ & Πληροφορικής, Παν. Ιωαννίνων (*μέλος τριμελούς επιτροπής*)
6. **Χριστόφορος Νίκου**, Καθηγητής, Τμήμα Μηχανικών Η/Υ & Πληροφορικής, Παν. Ιωαννίνων
7. **Κωνσταντίνος Σκιάνης**, Επίκ. Καθηγητής, Τμήμα Μηχανικών Η/Υ & Πληροφορικής, Παν. Ιωαννίνων

## Περίληψη

The increasing development of autonomous maritime systems has created a need for intelligent navigation methods capable of operating reliably in complex, dynamic, and uncertain environments. Unmanned Surface Vehicles (USVs) are particularly challenging autonomous platforms because their navigation is affected by environmental

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ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
Τ.Θ. 1186, ΙΩΑΝΝΙΝΑ 45110
T: 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

DEPT. OF COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF IOANNINA
P.O. BOX 1186, IOANNINA
GR - 45110 GREECE
T: +30 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

disturbances, moving vessels, limited perception, and the requirement to maintain safe separation from surrounding obstacles. While deep reinforcement learning (DRL)provides a promising framework for learning navigation policies through interaction with an environment, its application to autonomous maritime navigation remains constrained by issues related to safety, the availability of expert knowledge, generalization, and coordination among multiple autonomous vessels. Overall, the dissertation contributes to the development of intelligent, adaptive, and safety-aware learning frameworks for autonomous maritime navigation, addressing key challenges in both single-agent and multi-agent USV operations.

The research establishes an experimental foundation through the design and construction of a small-scale autonomous USV platform, to support the development, validation, and eventual transfer of learning-based navigation methods to physical hardware. Furthermore, a comprehensive simulation framework is developed to enable efficient training and systematic evaluation without exposing the physical platform to the risks associated with trial-and-error learning.

Within this framework, DRL-based methods are investigated for autonomous USV navigation to enable goal-directed navigation and collision avoidance under environmental disturbances and dynamic maritime traffic. Generative Adversarial Imitation Learning (GAIL) is further investigated to incorporate expert demonstrations into policy learning, reducing reliance on trial-and-error exploration. This provides an alternative mechanism for incorporating prior navigation knowledge into the learning process and demonstrates the applicability of adversarial imitation learning to autonomous USV navigation.

The dissertation subsequently addresses safety as an explicit requirement of the learning process. A central contribution concerns the development of safety-aware reinforcement learning methods based on Constrained Markov Decision Processes (CMDPs) and adaptive Lagrangian optimization. These methods explicitly incorporate safety constraints associated with static and moving obstacles, enabling navigation policies to balance operational performance with collision avoidance. In addition, the learned Lagrange multiplier networks provide an interpretable view of the safety mechanism by revealing how the influence of individual constraints varies across navigation states and environmental conditions.

Finally, the dissertation extends autonomous navigation to multi-USV environments through a Cross-Agent Multi-agent Soft Actor-Critic (CROSSMASAC)framework, supporting decentralized decision-making and improved coordination among autonomous vessels. This establishes a transition from single-agent navigation toward scalable multi-agent maritime autonomy, where multiple vessels must simultaneously navigate and respond to one another within a shared environment.

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