Open PhD Position

Information Selection and Learning for Autonomous Decision-Making

Program: PhD in Electrical, Electronic, and Information Engineering (ETIT), University of Bologna (UNIBO, Italy)

Supervisors: Prof. Anna Guerra, Dr. Francesco Guidi

Project Context: Autonomous agents navigating complex environments rely on sensed data to build internal representations of the world and to make decisions for localization, navigation, and cooperation.
Within the **ERC Starting Grant project CUE-GO** – Contextual Radio Cues for Enhancing Decision-Making in Networks of Autonomous Agents, agents use radio sensing to construct semantic radio maps of the environment. These maps provide a description of the surroundings, but their true value lies in enabling the extraction of informative radio signal patterns that can be exploited for decision-making. In this project, such patterns are referred to as ***contextual radio cues***.
Rather than being physical elements of the map (e.g., walls or obstacles), contextual radio cues are radio-derived features that are predictive of future outcomes, such as improved localization accuracy, safer navigation, or higher expected reward.
In this sense, contextual radio cues play a role analogous to conditioned stimuli: they are signals that, once learned, allow the agent to anticipate the consequences of its actions.

Scientific Motivation: Learning-based navigation strategies for autonomous agents often rely on trial-and-error exploration to associate actions with rewards. While flexible, this process can be slow, data-hungry, and inefficient, especially in complex or dynamic environments. At the same time, radio sensing and semantic mapping provide access to rich signal-level information that implicitly contains predictive structure. Certain radio features, although not directly encoding rewards, may reliably anticipate favorable or unfavorable outcomes when acting in specific regions or configurations.
A key open research question is therefore:
How can autonomous drones identify radio signal features that predict future outcomes and use them to guide and accelerate learning?
This PhD project addresses this question by studying how agents can:

- *extract radio-derived features from semantic radio maps;*
- *learn which features act as reliable predictors of rewards or outcomes;*
- *associate these features with predictive models that guide decision-making;*
- *exploit such cue–outcome associations to bias and accelerate navigation learning.*

The focus is not on learning a navigation policy from scratch, but on learning which signals are worth trusting when predicting the consequences of actions.

Illustrative Example: Consider a drone navigating an environment using radio sensing. From its measurements, the drone estimates a semantic radio map and continuously observes radio signal features, such as variations in multipath or propagation condistions and signal strength patterns.

Individually, these features do not represent obstacles or targets. However, some of them may consistently predict navigation outcomes. For example, a specific radio signal pattern may be associated with reliable localization and stable motion, while another pattern may anticipate poor positioning accuracy or increased risk.

By learning these associations, radio signal features become contextual cues: signals that allow the drone to anticipate the outcome of its actions before executing them.

Instead of learning navigation purely through trial and error, the drone can use these cues to guide exploration and decision-making, focusing on actions that are more likely to yield positive outcomes and learning faster from experience.

This PhD project investigates how such radio signal cues can be identified, selected, and integrated into learning-based navigation frameworks.

Research Objectives: The PhD candidate will investigate methods that enable autonomous drones to:

- extract radio signal features from semantic radio maps;
- learn cue–outcome associations that predict navigation rewards or performance;
- select radio cues that are informative for decision-making under uncertainty;
- integrate cue-based predictions with learning-based navigation strategies;
- assess how cue-guided learning accelerates navigation and improves robustness.

Working Environment: The PhD will be conducted at the University of Bologna in collaboration with the National Research Council of Italy (CNR-IEIIT), within a multidisciplinary research team working on wireless sensing, localization, and autonomous systems.

Candidate Profile: We are looking for motivated candidates with the following background:

- MSc (or equivalent) in Electrical Engineering, Computer Science, Telecommunications, Applied Mathematics, or related fields;
- Solid background in probabilistic modeling, Bayesian inference, information theory, and/or machine learning;
- Experience with signal processing or decision-theoretic models is a plus;
- Proficiency in programming (e.g., Python, Matlab, C++);
- Strong interest in fundamental research on autonomous systems and decision-making.
- No prior knowledge of contextual radio cues is required; the necessary concepts will be introduced during the PhD.

Salary: Standard Italian PhD scholarship.
Application Window: May 30 - June 30, 2026
Application Website: https://www.unibo.it/en/study/phd-professional-masters-specialisation-schools-and-other-programmes/phd/phd-programme

Contacts: Interested candidates are welcome to contact: **anna.guerra3@unibo.it**; francesco.guidi@cnr.it