



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 1 - Computer Science and Engineering

**PNRR_352 Research Field: DEVELOPMENT OF ARTIFICIAL INTELLIGENCE ALGORITHMS
FOR DRONES COLLABORATIVE DRIVING**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

The effective coordination of autonomous unmanned vehicles (e.g., drones) is crucial in many application fields of national interest. This is particularly challenging whenever the drones have different capabilities and therefore they can be complementary when addressing a task. Furthermore, another crucial dimension concerns the communication among the drones which can be limited (or corrupted) in some situations due to the environment. From a scientific point of view, several challenges are open and need to be faced. This research project mainly focuses on the problem of developing coordination techniques for cooperative intelligent agents in uncertain settings. While it is widely recognized that machine learning (in particular, reinforcement learning) can allow the design of planning strategies more robust than those produced by customary planning algorithms (e.g., HTN planning), many research tasks are currently open.

The main objectives concern the design of learning algorithms capable of generating plans that can generalize in presence of uncertainty. More precisely, uncertainty can dramatically affect the environment in which an agent is operating so as to make plans generated for a specific environment be unfeasible when



	<p>applied to a different environment (intuitively, the specific environment in which an agent operates is randomly drawn from a probability distribution describing the uncertainty). The peculiarity of reinforcement learning tools adopted in planning problems concerns the capabilities of generating parametric plans which can be tailored to the actual environment in which the agent is operating. More precisely, data generated from different environments are given in input to those techniques, which can generalize the planning policy to unobserved environments (since generating data from every possible realization of the uncertainty is unaffordable). In this way, those approaches allow facing instances that have not been observed before.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research project will resort to artificial intelligence and machine learning to address the goal. In particular, traditional planning techniques (such as, e.g., hierarchical task networks) will be studied and compared with more flexible approaches such as hierarchical reinforcement learning tools. Several questions will be investigated. For instance, a question concerns the capability of generating plans that can generalize in the presence of uncertainty and then profiling the plan according to the actual environment. Another question concerns how the coordination strategy among the drones will vary when the communication capabilities are totally (i.e., for every pair of drones) or partially (i.e., for a subset of drones) corrupted and how switching from one coordination strategy to another if the corruption of the communication happens at runtime. Furthermore, automatic tools will be developed to generate automatically the hierarchical decomposition of tasks. A common issue over all these questions concerns the efficiency of the learning process. Indeed, it is known that reinforcement learning tools need a huge amount of data and, whenever the simulator requires a long time to complete a simulation, the learning process is unfeasible. In the research project, an important goal concerns the design of learning algorithms minimizing the data complexity thus to allow the adoption of this techniques in real-world environments.</p>



	<p>The techniques developed in the research project will be evaluated in a wide spectrum of scenarios, including the protection of the territory, integrated logistics, and security and defense. More precisely, by using the simulators provided by MBDA company, the candidate will generate several testbedding and benchmarking scenarios. These scenarios will allow us to understand the advantages and drawbacks of the techniques and how they relate to the specific settings (e.g., which are the characteristics of the scenarios in which the proposed techniques perform well and why, and, conversely, when the proposed techniques perform poorly and why). As a result, the candidate will provide an accurate assessment of reinforcement learning techniques in the scenarios mentioned above.</p>
Educational objectives	<p>The candidate will learn artificial intelligence and machine learning tools. In particular, he/she will learn theoretical groundings (algorithms and their theoretical guarantees in terms of computational and sample/data complexity), available tools, and language programming to develop and deploy real-world applications with critical constraints.</p>
Job opportunities	<p>Artificial intelligence and machine learning tools are nowadays crucial for many companies. The candidate will acquire strong expertise in drone control by artificial intelligence tools. So, any company working in that field will be interested in the candidate. Furthermore, the expertise in artificial intelligence will allow the candidate to work in any company with open positions in data science, data engineering, and machine learning science/engineering.</p>
Composition of the research group	<p>0 Full Professors 1 Associated Professors 4 Assistant Professors 1 PhD Students</p>
Name of the research directors	<p>Prof. Nicola Gatti</p>

Contacts

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	BDA (https://www.mbda-systems.com/)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	King's College (https://www.kcl.ac.uk/)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Attinenza alle tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352, art.6</p> <p>L'obiettivo della ricerca è quello di sviluppare tecniche robuste ispirate dagli strumenti di intelligenza artificiale e apprendimento automatico (machine learning) per coordinamento di entità mobili autonome, in particolare droni. Nello specifico, il problema include: pianificazione (offline) multi-agente in ambienti incerti, ri-pianificazione (online) multi-agente per la gestione di situazioni impreviste in sede di pianificazione (dovute ad esempio all'incertezza), e gestione della strategia di coordinamento che può variare sulla base della capacità degli agenti di comunicare tra loro (capacità che possono cambiare nel tempo in funzione ai vincoli ambientali). Per lo studio di questi scenari, la letteratura sta esplorando lo sviluppo di tecniche di multi-agent reinforcement learning gerarchico, in cui i task vengono strutturati su vari livelli di gerarchia e tecniche di machine learning basate su rinforzo vengono utilizzate. Tali tecniche permettono di ottenere dei piani di azione che possono generalizzare rispetto a molteplici scenari così da gestire anche situazioni incerte. Questo si traduce nel dare in input all'algoritmo di apprendimento dati provenienti da diversi scenari così da imparare ad affrontare situazioni diverse.</p> <p>Impresa, presso cui si svolgerà l'attività esterna</p> <p>MBDA</p> <p>Lo studente di dottorato lavorerà a stretto contatto con l'azienda per imparare l'uso degli strumenti di simulazione dei velivoli. Questi strumenti sono necessari per generare i dati che verranno forniti agli algoritmi di apprendimento per rinforzo per la costruzione dei piani di azione. Sarà inoltre necessario intervenire sui simulatori stessi per integrare le capacità di comunicazione dei velivoli e per progettare alcuni scenari di riferimento su cui fare benchmarking e testbedding degli</p>



algoritmi prodotti. Un'ultima attività condotta in collaborazione con l'azienda riguarda la validazione e la valutazione dei risultati ottenuti dagli algoritmi sviluppati dal candidato al fine di capire i vantaggi e gli svantaggi e analizzare la fattibilità del sistema proposto.

Ente, università, azienda, centro di ricerca presso cui si svolgerà il periodo di studio e ricerca all'estero

King's College

varie attività di ricerca condivisa con periodi di scambio per teaching e di studenti. Le collaborazioni hanno portato alla scrittura di alcuni articoli scientifici.

All information regarding educational activities, personal funding, regulations and obligations of Ph.D. candidates are available on the web site <https://dottoratoit.deib.polimi.it/>