



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

Research Area n. 4 - Telecommunications

**PNRR\_352 Research Field: LEARNING METHODS FOR FUTURE WIRELESS AND WIRED COMMUNICATIONS**

**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**

In the recent past years, learning techniques have been successfully applied in the upper layers of telecommunication systems, in particular for the purpose of quality-of-service estimation and resource allocation in networks.

A new research trend is to apply learning methods for designing the physical layer of communication systems. Although some classical channels, like the additive white Gaussian noise channel model, are information theoretically well understood, the performance of other less understood communication models may benefit from the application of learning methods.

For example, for channel models and practical wireless and wired systems that show imperfections and nonlinearities, it is intractable to find the optimal signal set by resorting to an information-theoretic analysis. Also, information theory typically provides useful design tools in the large code blocklength regime, while it is not mature enough to find optimal signal schemes in the finite blocklength regime. In such cases, we expect that applying learning techniques can give new insights into the signal set design.

From a hardware implementation standpoint, algorithms that are designed from learning techniques are expected to be very energy efficient, thanks to specialized hardware



	architectures for neural network inference.
<b>Methods and techniques that will be developed and used to carry out the research</b>	<p>The starting point for the analysis of the physical layer of communication systems through learning techniques is the autoencoder neural network (NN). While training this kind of NN is quite straightforward for additive noise point-to-point channels, less obvious is how to train the NN in the presence of other types of interference or malicious users.</p> <p>In the first phase of the doctoral studies, we aim at investigating and developing new NN training techniques for those scenarios.</p> <p>In the second phase of the doctoral studies, we expect to set up an experimental demonstration of the new NN algorithms through field-programmable gate array (FPGA) boards and/or microcontrollers.</p>
<b>Educational objectives</b>	<p>The goal of this PhD is to let the student improve his/her hard and soft skills in the context of academic and industrial research.</p> <p>On one hand, the student will learn mathematical methods borrowed from both information theory and learning theory, and how to interpret the results of the research with a critical eye.</p> <p>On the other hand, the student will acquire soft skills like technical writing and scientific dissemination through participation to international conferences and doctoral courses. Especially during the visit period in the company, the student will have the opportunity to work in team.</p> <p>Finally, the student will learn to act as a bridge between academia and industry.</p>
<b>Job opportunities</b>	<p>Learning techniques find broad application in many fields of engineering. Specifically, companies in the field of electronics and telecommunications are investigating machine learning based solutions for the design of their products.</p> <p>We are aware of several companies in the Milan area that are working and investigating on this subject.</p> <p>Moreover, we expect that learning methods will play a fundamental role in the design of the sixth generation of mobile technology.</p>



<b>Composition of the research group</b>	0 Full Professors 2 Associated Professors 2 Assistant Professors 7 PhD Students
<b>Name of the research directors</b>	Luca Barletta

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

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

<b>National Operational Program for Research and Innovation</b>	
<b>Company where the candidate will attend the stage (name and brief description)</b>	STMicroelectronics - settore attività: Semiconductors - st.com
<b>By number of months at the company</b>	6
<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	Università: New Jersey Institute of Technology (NJIT) <a href="https://www.njit.edu/">https://www.njit.edu/</a>
<b>By number of months abroad</b>	6

<b>Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information</b>
<p><b>Attinenza alla tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352, art.6</b></p> <p>Il progetto di ricerca per il presente Dottorato ben si colloca all'interno del PNRR. La proposta ha infatti connotazione industriale e, fondandosi su due ambiti di forte innovazione per le imprese (l'intelligenza artificiale e la connettività), risponde agli obiettivi di crescita della produttività e occupazione dei giovani, protagonisti di questo rinnovamento. Le due tematiche oggetto della proposta rappresentano a tutti gli effetti dei game changer per le imprese. Infatti, possono</p> <ol style="list-style-type: none"> <li>1) velocizzare il time-to-market dei prodotti, mediante la realizzazione più rapida e versatile di soluzioni interconnesse ed intelligenti,</li> <li>2) stimolare la capacità di aprire nuovi mercati prima preclusi,</li> <li>3) favorire e consolidare l'integrazione tra ricerca accademica e sistema produttivo, il tutto con un accrescimento e consolidamento della competitività economica, duratura nel tempo.</li> </ol>



Le missioni e le componenti alle quali il presente progetto di ricerca risponde, come elencate nel Bando, sono le seguenti:

- M1C2 (missione: "Digitalizzazione, innovazione, competitività, cultura e turismo", componente: "Digitalizzazione, innovazione e competitività nel sistema produttivo"), con piena attinenza all'azione: "incentivi per la transizione digitale e per l'adozione di tecnologie innovative e le competenze digitali da parte del settore privato"
- M4C2 (missione: "Istruzione e ricerca", componente: "Dalla ricerca all'impresa"), con evidente affinità alla finalità: "Si sviluppa l'istruzione professionalizzante e si rafforza la filiera della ricerca e del trasferimento tecnologico."

**Impresa, presso cui si svolgerà l'attività esterna**

nome impresa: STMicroelectronics

settore attività: Semiconductors

descrizione sintetica attività: l'attività prevede il test degli algoritmi sviluppati nella prima fase del dottorato e l'implementazione in FPGA o microcontrollore.

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

Università: New Jersey Institute of Technology (NJIT)

descrizione sintetica attività: l'attività svolta dallo studente nell'università estera sarà principalmente, se non esclusivamente, di carattere teorico. In questa università stanno già affrontando tematiche di learning dal punto di vista information-theoretic, e quindi sarebbe una ottima opportunità per lo studente per prendere dimestichezza con questo tipo di analisi teorica.

**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/>**