POLITECNICO DI MILANO

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

Research Area n. 1 - Computer Science and Engineering

PNRR_352 Research Field: PARTITIONING AND MANAGING ARTIFICIAL INTELLIGENCE IN COMPUTING CONTINUA FOR SMART EYEWEAR

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	Here is a short description of motivations and objectives of the research: 1- Conceive the smart eyewear of the near future, capable not only of correcting vision defects and providing an object of style and protection for eye health, but also of offering new XR (extended reality), which includes the entire spectrum from "completely real" to "completely virtual" in the concept of reality-virtuality continuum, for a new way of perceiving (sensing) the surrounding world, using Artificial Intelligence (AI). 2- Develop hardware, firmware, algorithms (eye-tracking, object detection, spatial recognition, health monitoring, detection of visual defects / suffering, holographic image synthesis) and "App" (maps navigation, internet / cloud browsing, cognitive monitoring, AR / VR experience, electrochromic correction, etc.). 3- Optimize the application execution across the full computing continuum (including the smart eyewear, servers supporting the applications execution at the edge layer, possibly in 5G networks, and the cloud back-end) while guaranteeing application execution time taking into account the eyewear battery level, current application load, and the network latency.

Methods and techniques that will be developed and used to carry out the research	The methods and techniques that will be developed and used to carry out the research are listed below. 1) Development of mechanisms to support application components partitioning and their dynamic reconfiguration - The applications run by the smart eyewear will result in the combination of AI and cloud computing. This poses new challenges from the resource management perspective since, on one side the smart eyewear could be limited by its computing load and/or battery level, while cloud resources are usually far from the mobile devices and this long distance might be the cause of long latency. To solve this issue, edge computing establishes a new promising computing paradigm that moves AI and machine learning close to where the data generation and computation actually take place. Indeed, the edge paradigm allows faster computing and it can enhance the performance of AI-enabled applications and keep the operating costs low. Partitioning the DNN of AI application components and running partially on local device and assigning the other partitions to the existing resources on edge or cloud is a common approach to use optimally the resources on computing continua while satisfying quality of service constraints. The research will develop solutions to identify the candidate DNN partitioning points and a toolchain that will support final applications development, deployment, and dynamic reconfiguration. 2) Development of advanced algorithms for the dynamic reconfiguration of the application logic - The limited capacity of mobile devices to execute the inference tasks with heavy process on one hand and the cost of running the application on edge or cloud on the other hand makes the resource allocation problem across the computing continuum very difficult. The research will develop novel algorithms to support the smart eyewear applications execution taking into account: i) on the field the memory and computing capacity and energy available at the smart eyewear, and ii) on the edge/cloud the costs to guarantee a given latency threshold and the competition to access the resources at the edge platform site (e.g., a set of small datacenters located inside the 5G Radio Access Network), and in the remote cloud. 3) Quantitative evaluation and user acceptance

	assessment - During the development and integration of the above algorithms, quantitative measurements will be made by considering the execution of the applications developed within OR3. These validations will be integrated by subjective evaluations aimed at quantifying the subjective perception of user experience while running the target applications and by assessing the energy consumption at the smart eyewear, the edge servers and the cost incurred to use on demand resources at the cloud back-end
Educational objectives	The educational objectives are the study, investigation and identification of the basic enabling technologies for the development of intelligent eyewear, together with data analysis algorithms, to carry out a study of feasibility and have the basics to be able to design a first device prototype and start defining a test protocol and use cases. The PhD student will work and collaborate with other researchers and PhD students on all the areas required to develop the "smart glasses", namely: ELECTRONICS - identified sensors and cameras to be integrated into the mount; electronic designed on board for signal preprocessing; defined eyewear / edge / cloud partitioning of algorithm processing; defined architecture of battery management electronics, interfaces, communications. ALGORITHMS - development of preliminary eye-tracking and positioning algorithms using the selected sensors; experimented with the partitioning of the processing of some algorithms between edge and cloud; defined AI structure of action and object recognition algorithms. RESOURCE MANAGEMENT - implementation of the application development tool chain and resource management solutions using the selected sensors and the target applications in lab and cloud environments. VALIDATION - definition of the structures and architectures of the environments to be created, to validate the pre-prototypes; identification of the preliminary tests to be performed to characterize the subcomponents and the algorithms; preliminary preparation of the various laboratories and scenarios that emulate real environments in which to carry out the

	subsequent validation.
Job opportunities	This research opens the doors to a career in the engineering of complex edge and cloud systems supporting several applications domains ranging from, e.g., web service based applications, data-intensive and artificial intelligence applications with performance concerns. In addition to an academic career, the applicant will develop expertise to support Small and Medium Enterprises or Public Administrations to: i) migrate their applications to the cloud, ii) identify the most suitable cloud provider/technology, and iii) optimise the application architecture to use at best the underlying computing continuum resources.
Composition of the research group	0 Full Professors 2 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Danilo Ardagna

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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)	LUXOTTICA s.r.l. (https://www.luxottica.com/it)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Università Politecnica di Valencia, Prof. Germán Moltó, Grid and High Performance Computing Group (GRyCAP), Institute of Instrumentation for Molecular Imaging (I3M), Valencia Polytechnic City of Innovation (CPI) https://www.grycap.upv.es https://www.grycap.upv.es/gmolto/index.php
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Attinenza alla tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352, art.6

Il progetto proposto mira a sviluppare l'Intelligenza Artificiale per gli occhiali intelligenti (smart eyewear) e definire il corretto partizionamento tra edge e cloud computing, per potenziare l'esperienza sensoriale tra Persona e Mondo circostante. I nuovi occhiali intelligenti saranno ideati per interagire con la realtà reale e con quella estesa (XR, eXtended Reality) che i servizi sviluppati andranno a rendere disponibili. Queste aree disciplinari e tematiche sono coerenti con i fabbisogni del Paese, in termini di figure ad alta qualificazione e orientate a soddisfare i fabbisogni di innovazione delle imprese di cui al PNRR. In particolare, le Missioni del PNRR che trarranno maggior beneficio da questo progetto sono:
Digitalizzazione, innovazione, competitività, cultura e turismo in partic. nel sistema produttivo e Turismo e Cultura 4.0;
Inclusione e Coesione, in partic. Infrastrutture sociali, famiglie, comunità e terzo settore;
Salute, in particolare Reti di prossimità, strutture e telemedicina per l'assistenza sanitaria nazionale.
Relativamente alla missione Digitalizzazione, Innovazione e Competitività nel sistema produttivo la ricerca svilupperà algoritmi intelligenti in grado di partizionare la logica applicativa tra gli occhiali intelligenti e il cloud in modo da ottimizzare le prestazioni dell'applicazione in base alle prestazioni della rete e lo stato della batteria degli occhiali e favorirà lo sviluppo di applicazioni innovative da parte delle PMI italiane basando le proprie applicazioni anche su sistemi di Software as a Service.

Impresa attività esterna: LUXOTTICA s.r.l. La ricerca svilupperà algoritmi intelligenti in grado di partizionare la logica applicativa tra gli occhiali intelligenti e il cloud in modo da ottimizzare le prestazioni dell'applicazione in base alle prestazioni della rete e lo stato della batteria degli occhiali e favorirà lo sviluppo di applicazioni innovative e di ottimizzare l'hardware sottostante

Ente, università, azienda, centro di ricerca estero

Università Politecnica di Valencia,
Prof. Germán Moltó, Institute of Instrumentation for Molecular Imaging (I3M), Valencia Polytechnic City of Innovation (CPI)
Il dottorando svilupperà e validerà presso UPV il sistema di partizionamento della logica applicativa che verrà integrato con gli orchestratori di risorse (Kubernetes, K3S, etc.) che verranno adottati. Inoltre verranno sviluppati e testati i meccanismi di adattamento dell'infrastruttura e di migrazione dei componenti software/partizioni delle componenti neurali

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/