POLITECNICO DI MILANO

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

Research Area n. 2 - Electronics

PNRR_352 Research Field: ELECTRONIC PROCESSING AND POWER MANAGEMENT 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	The objectives of the research 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. More in detail, the goals are: development of hardware (microelectronics, sensors, photonics), firmware (programs for microcontrollers and Field-Programmable Gate-Arrays and Digital Signal Processors), software and algorithms (eye-tracking, object detection, spatial recognition, health monitoring) for the smart eyewear. Furthermore, validation of the new smart eyewear in real application scenarios, devising test and benchmark equipment that will become the next standard to evaluate the quality and acceptability of smart eyewear and to evaluate their impact in the everyday experience and better guide the development of new algorithms and apps, aimed at meeting the new needs of users and the provision of new services. The motivation arises from the growing interest to merge reality with augmented and virtual information domains to improve the safety and quality of life of users and the pivotal role of smart eyewear to act as "hub" for this technological fusion and breakthrough.

Methods and techniques that will be developed and used to carry out the research	The PhD student will survey an overview of different miniaturized sensor technologies that can be integrated in the eyewear and will study how to pre-process the signals from the sensors placed inside the glasses using multiple solutions spanning from digital devices to the definition of architectures of custom ASICs dedicated and designed specifically for the "smart eyewear" application, potentially leveraging analog processing of signals. The project will begin to design, build and test electronic circuitry for both the eyewear frame and for edge computing, initially based on commercial components and processing boards for demonstration purposes. The R&D phase on such "wearable" and on-edge electronics will allow to achieve various benefits, including compactness, reduction of execution times and energy for the tested App, reduced lead times latency (response that can drop from a few seconds to a few hundred milliseconds) and a significant reduction in the energy consumption of the servers. Main activities 1. Development of electronics for the acquisition and processing of sensor data 2. Partitioning of processing between electronics in the frame, on edge and on cloud 3. Development of electronics for battery management, interfaces, interconnectivity During all these activities of component selection, electronics schematic design, circuit assembly, and interconnection of the various sub-blocks, the related testing and performance measurement activities of the various sensors and functional blocks will be carried out in parallel, in order to be able to characterize the performance of each sensor, device and schematic, in order to carry out the actions necessary for any refinement of the design or for the resolution of any problems, taking into consideration the future integration of the developed technologies in the glasses
Educational objectives	The learning objectives of this PhD program are the development of a "vertical" deep knowledge in electronics design, with particular focus on low-power, miniaturization and integration of sensors and electronics for processing. A second goal concerns the training to "horizontal" interactions and collaborations of electronic engineering

	with several technological (physics, mechanical and material science, thermal, artificial intelligence) and non-technical (ergonomy and design, marketing, production, product vision) areas of competence. More specifically, the PhD students 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. PHOTONICS - identification of the photonic technologies necessary to produce a near-eye display; development of synthesis algorithms for digital holograms; implementation of digital color holograms on phase modulators (SLM) and their projection by laser light; characterization of holograms with video cameras. 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. INTEGRATION - preliminary integration of the sensors and cameras inside the frame of the glasses; evaluation of overall dimensions and partitioning of the electronics to be integrated in the mount and in the edge; sensor performance characterization tests and their comparison. 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 PhD project is characterized by three key aspects: (1) high risk and innovation, (2) high multi-disciplinarily, (3) industry-oriented, which all make it an excellent avenue to open multiple types of carriers. The first is of

	course the job of hardware designer in industries of both electronic and microelectronic circuits (both analog and digital ones) and sensors micro-systems. Relevant application areas connected to this project are wearable devices, Internet-of-Things networks and systems, low-power design and energy harvesting, embedded processing. Several other opportunities include: international researcher in Academia or Industry in the, project manager in multi-disciplinary teams including engineers, material scientists, data scientists, as well as roles in product development, technical marketing and management.
Composition of the research group	1 Full Professors 1 Associated Professors 0 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Marco Carminati

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)	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)	École Polytechnique Fédérale de Lausanne (EPFL), Svizzera (https://www.epfl.ch/labs/iclab/index-html/bci-group/)
By number of months abroad	6

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

Attinenza PNRR La borsa di Dottorato di Ricerca verterà su aree disciplinari e tematiche coerenti con i fabbisogni del Paese, creando figure ad alta qualificazione, orientate a soddisfare l'innovazione delle imprese, tramite l'acquisizione di tecnologie di punta in diversi settori aziendali, 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. sistema produttivo e Turismo e Cultura 4.0

Inclusione e Coesione in partic. Infrastrutture sociali, famiglie, comunità e terzo settore;

Salute e in particolare Reti di prossimità, strutture e telemedicina per l'assistenza sanitaria nazionale, nonché potenzialmente la medicina personalizzata e la prevenzione di patologie tramite il monitoraggio e lo stimolo positivo ad attività salutari.

il progetto mira a sviluppare nuove capacità di progetto elettronico e validazione sperimentale per occhiali intelligenti (smart eyewear) e potenziare l'esperienza sensoriale interattiva tra Persona e Mondo circostante, elevando il ruolo dell'occhiale da dispositivo medico o accessorio di moda ad elemento tecnologico fondamentale nel Metaverso. Gli smart eyewear potenzieranno l'interazione delle Persone tramite l'eXtended Reality (XR) oltre a correggere i difetti di visione e a proteggere l'occhio, diventando il nuovo paradigma di "occhio" e "cervello" elettronico indossabile.

Impresa attività esterna LUXOTTICA s.r.l.

Studio dell'integrabilità nella montatura dell'occhiale smart dei sistemi elettronici di acquisizione ed elaborazione dei segnali da micro-sensori. In particolare, durante questa attività esterna saranno affrontati i temi della prospettiva di miniaturizzazione e del packaging di elettronica e sensori, dell'ntegrazione elettronico-meccanica, delle problematiche termiche e di alimentazione

Ente, università, azienda, centro di ricerca estero École Polytechnique Fédérale de Lausanne (EPFL), Svizzera

Ricerca sui sensori di parametri fisiologici miniaturizzati (quali ad esempio biomarcatori presenti nel sudore), in particolare di tipo elettrochimico adattabili all'inserimento negli smart glasses.
Studio dei materiali per gli elettrodi, indagine sui parametri misurabili quali indicatori su salute e benessere della persona (e per differenti tipologie di persone, dagli sportivi agli anziani). Studio di tecniche di sensor fusion di differenti parametri biomedici per l'estrazione locale di informazioni di rilevanza sanitaria e feedback all'utente/paziente

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/