POLITECNICO DI MILANO

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

Research Area n. 2 - Electronics

PNRR_352 Research Field: ELECTRONICS AND MICROSENSORS 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 PhD research. 1- Develop hardware (microelectronics, sensors, cameras), firmware (programs for microcontrollers, Field-Programmable Gate-Arrays, Digital Signal Processors) and software (Bluetooth/5G communication, power management, signal processing, user interfaces, etc.) for allowing other PhD students to add 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 / adaptive dioptric). 2- Optimize and miniaturize the smart eyewear prototypes (frames, lenses, microelectronics, photonics, sensors, processing, battery charging, etc.) to minimize consumption and waste, maximize comfort and recyclability and develop new methods of mixed integration (not just frames and lenses) that optimize costs and ensure sustainability and circular economy, without however affecting the quality of the design. 3- Validate the sensors and electronics of the smart glasses in real application scenarios, devising tests and benchmarks to evaluate the quality and acceptability of smart eyewear and to evaluate the impact of XR in the

	everyday experience and better guide the development of new algorithms and apps.
Methods and techniques that will be developed and used to carry out the research	The PhD student will study, select and test components, sensors and electronic processors to be embedded into smart glasses. The electronics will pre-process signals from sensors placed inside the glasses' frame, using ARM -CORTEX microprocessors, FPGA programmable logic, commercial DSPs, and/or system-on-chip (SoC, for example Zynq) to exploit in "smart eyewear" applications. 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. Main activities are summarized in the followings. 1. Identification of cameras and sensors - The activity will be focused on identifying the most appropriate camera and sensor technologies (e.g., RGB + thermal / NIR-SWIR or event-based or other solutions) to meet technical performance and consumption requirements for being integrated into the frame. 2. Development of electronics for the acquisition and processing of sensor data - The activity will aim to define and develop the electronics that will have to interface with the sensors, to acquire their signals, condition them, filter them and pre-process them, before transmitting them for further processing. 3. Partitioning of processing between electronics in the frame, on edge and on cloud - The activity will analyze and define the correct partition to optimize the energy consumption, guaranteeing speed and computing power, low latency and usability of interactions, bandwidth requirements and transmission speed. 4. Development of electronics for battery management, interfaces, interconnectivity - The activity will identify all the sub-blocks necessary to complete the smart eyewear electronics, from battery management to user interfaces (touch controls, touch, etc.) and connectivity to the edge (Bluetooth, WiFi, 5G, etc.).
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. 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 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	The PhD student will acquire many skills for different job opportunities. More specifically, she/he will be able to design and develop electronic sensors and circuitry for

	embedded electronic processors into smart equipments. The student will become able to develop electronics for pre-processing sensor signals, using microprocessors, FPGAs, DSPs, SoC. The PhD students will acquire skills on team work and will collaborate with other researchers and PhD students on all the areas required to develop any "smart" embedded system.
Composition of the research group	2 Full Professors 5 Associated Professors 4 Assistant Professors 6 PhD Students
Name of the research directors	Prof. Franco Zappa

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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)	STMicroelectronics, Crolles/Grenoble (Francia) (https://www.st.com/en/mems-and-sensors.html)
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 svilupperà nuove capacità di ideazione, progetto e prototipazione dell'elettronica da integrare all'interno degli occhiali intelligenti, per offrire nuove esperienze sensoriale interattive tra Persona e Mondo. I nuovi occhiali intelligenti dovranno essere il frutto dell'unione di elettronica

intelligente ed eXtended Reality (XR), in modo da offrire un'esperienza personalizzata all'utente finale, non limitandosi a sole applicazioni specifiche. Queste 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. sistema produttivo e Turismo e Cultura 4.0;
Inclusione e Coesione, in partic. Infrastrutture sociali, famiglie, comunità e terzo settore;
Salute, in partic. Reti di prossimità, strutture e telemedicina per l'assistenza sanitaria nazionale.

Impresa presso cui si svolgerà l'attività esterna
LUXOTTICA s.r.l.
Studio dell'elettronica e della sensoristica da integrare nella montatura dell'occhiale intelligente, per l'acquisizione e la pre-elaborazione dei segnali da microsensori. Durante questa attività esterna saranno affrontati i temi della miniaturizzazione, del packaging, del collaudo e dell'affidabilità dell'elettronica e dei sensori, con le problematiche termiche e di consumo energetico e di alimentazione.

Azienda presso cui si svolgerà il periodo di studio e ricerca all'estero
STMicroelectronics
STMicroelectronics dispone di uno dei portafogli di microsensori MEMS (Micro-Electro-Mechanical Systems) e picoproiettori più estesi del settore, inclusi accelerometri, giroscopi, bussole digitali, moduli inerziali, microfoni MEMS e sensori ambientali (come quelli di pressione, temperatura e umidità). La collaborazione permetterà di ottimizzare la scelta dei sensori e dei componenti elettronici da integrare nell'occhiale intelligente, per poter sviluppare soluzioni completamente integrate, anche nell'ottica di una futura capacità di produzione industriale ad alto volume. Durante la ricerca, il dottorando progetterà l'integrazione dei sensori negli occhiali (sia per sensor fusion che per embedded electronics) al fine di consentire nuove applicazioni emergenti e altamente esigenti, come navigazione indoor e servizi basati sulla posizione

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/