POLITECNICO DI MILANO

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

Research Area n. 1 - Computer Science and Engineering

PNRR_352 Research Field: ALGORITHMS FOR EXTENDED PERCEPTION, SPATIAL RECOGNITION, AND OBJECT DETECTION 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 overall project objective is to 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 AR (augmented reality) experiences, MR (mixed reality) and VR (virtual reality) and their XR (extended reality) superset that 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, to interact with it (human interface), to monitor one's state of health, using Artificial Intelligence (AI). In particular, the PhD student will study and develop algorithms for object detection, spatial recognition, and people action recognition which will enhance her own perception of the surrounding. This will be possible thanks to the integration of artificial vision with different sensing modalities such as sound, smell, and vision beyond the visible spectrum. Artificial intelligence algorithms will be developed to fuse and making sense of such different sensing modalities in a unique, coherent, and extended perception of the surroundings. This fusion will become an extended new sensorial experience for the smart eyewear user which will live the extended reality experience beyond the common visual sense via the enhanced ones.

	Among the PhD objectives, we expect also to design new applications and services for this extended perception and validate the effectiveness of these algorithms in real applications. We expect thus the definition of new benchmarks and procedures for user acceptance that will become the next standard to evaluate the quality and acceptability of smart eyewear. Some simple application examples range from memory support and perception by projecting information not known (e.g., description of works of art or information on places and people), or not perceived (e.g., olfactory sensations, invisible to the human eye, out of the audible range) in response to simple speech stimuli or eye pointing (gaze).
Methods and techniques that will be developed and used to carry out the research	Methods and techniques that will be developed and used to carry out the research include algorithms for advanced 3D perception (e.g., 3D reconstruction, semantic scene parsing, object recognition, human activity recognition), algorithms for multimodal sensor processing and sensor fusion (e.g., video signals, audio signals, accelerometers, imaging beyond the visible spectrum, etc.), and artificial intelligence (e.g., deep neural networks, differentiable rendering, semantic processing, etc.). Some of the algorithms to be developed will therefore be oriented to: i) Eye tracking, position tracking, egocentric action recognition: in order to understand which parts of the scene a person is observing, how she is moving within it and how she is interacting, and thus anticipate the commands of the same, recognize possible particular contexts, recognizing objects, faithfully integrating augmented perception into the physical world observed both indoors and out; ii) Object detection and extended spatial cognition: in order to recognize the objects and environments surrounding the observer, identify their use, correlate their characteristics with knowledge bases in the cloud, report information to the observer, thus extending his perceptive and cognitive capabilities; All these functions will then be validated in simulated environments in the laboratory and "in the wild" through existing viewers and eye-trackers, thus identifying the

	gaps in the market that the smart eyewear project will fill. Equipment for the acquisition of the position and the surrounding world will provide valid tools to obtain a quantitative validation of the goodness of the developed algorithms. Algorithms that will then be validated in real application contexts.
Educational objectives	PhD candidate will have the highest level of formation, leading to strong interdisciplinary expertise, along with continuous research activity in the latest AI and Computer Vision topics explored by both the scientific and industrial communities. In details, the educational objectives are focused on the study, investigation and identification of the basic enabling technologies for the development of intelligent eyewear, embedded AI, together with artificial intelligence and data analysis algorithms. 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. - 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. By the continuous interaction with colleagues having different skills and competences the PhD student will develop a unique background easily applicable in different field of research and innovation.
Job opportunities	PhDs will have excellent qualifications for both academia and industry where their need is widely acknowledged. The company involved in funding this research scholarship is highly interested in acquiring new highly skilled resources, but it is not the only one; the skills acquired during this PhD project will be highly appreciated by other companies in computer vision, artificial intelligence and intelligent systems.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Matteo Matteucci

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)	Alexandre Bernardino (http://www.isr.tecnico.ulisboa.pt/~alex)

By number of months abroad	6

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

Attinenza PNRR Il progetto mira a ideare e prototipare occhiali e servizi intelligenti (smart eyewear) per potenziare l'esperienza sensoriale interattiva Persona/Mondo. Gli occhiali intelligenti uniranno potenzialità di extended Reality (XR) alle funzionalità primarie di correttori dei difetti di visione / protezione dell'occhio. Queste aree sono coerenti con i fabbisogni del Paese, in termini di figure ad alta qualificazione e orientate a soddisfare i fabbisogni di innovazione di cui al PNRR. Le Missioni del PNRR che trarranno maggior beneficio sono:
- M1 Digitalizzazione, innovazione, competitività, cultura e turismo, e in particolare sistema produttivo e Turismo e Cultura 4.0;
la diffusione di occhiali smart aprirebbe nuovi scenari di fruibilità della cultura e accessibilità turistica con la rimozione delle barriere fisiche e cognitive al patrimonio.
- M4 Istruzione e ricerca e in particolare Dalla ricerca all'impresa in quanto il progetto proposto si configura in una più ampia attività di collaborazione con Luxottica volta a rafforzare la ricerca e la diffusione di modelli innovativi per la ricerca di base relativa a componentistica per l'elettronica, l'ottica e la fotonica e applicata ai nuovi prodotti e servizi relativi allo smarteyewear.
- M5 Inclusione e Coesione e Infrastrutture sociali, famiglie, comunità e terzo settore;
- M6 Salute e in particolare Reti di prossimità, strutture e telemedicina per l'assistenza sanitaria nazionale. Il progetto smart eyewear prevede, tra gli altri, un case study nell'ambito delle tecnologie assistive per ipovedenti che potranno beneficiare del supporto fornito da algoritmi di intelligenza artificiale e sensoristica avanzata

Impresa attività esterna LUXOTTICA s.r.l. il dottorando collaborerà a stretto contatto con Luxottica al fine di sviluppare e validare algoritmi di intelligenza artificiale su dispositivi innovativi come gli smart eyewear che verranno sviluppati presso Luxottica. L'attività avrà due momenti; in una prima fase si avrà l'iniziale analisi e formalizzazione dei requisiti, che poi verranno raffinati e approfonditi durante il periodo di ricerca. In un secondo momento il dottorando sarà affiancato da Luxottica nell'attività di raccolta dati e validazione sperimentale.

Università estera Inst. for Systems and Robotics, Univ. de Lisboa (prof. A. Bernardino)
Lo studente approfondirà le tematiche relative a computer vision, l'object recognition e il tracking visuale andando a complementare le competenze in intelligenza artificiale del laboratorio di intelligenza artificiale e robotica del Politecnico di Milano.

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/