POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 41st cycle

Research Area n. 2 - Electronics

THEMATIC Research Field: LOW-POWER EYE TRACKING: ULTIMATE LIMITS OF LENS-INTEGRATED IR SENSING

Monthly net income of PhDscholarship (max 36 months)
1500.0 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	Preliminary research works have shown that coupling a standard lens of traditional eyewear with IR photodetectors, can add smart functionalities to glasses, in particular in the area of eye tracking. In particular, optical coupling to the edges of the lens enable gaze tracking across 9 quadrants in the visual field. The goal of this research plan is to assess the ultimate performance of this approach, especially to further reduce the power dissipation or increase the angular resolution in gaze estimation. Three cross-disciplinary directions in the optoelectronics sensing domain will be explored: (i) enhancement of the signal intensity and spatial sensitivity by coupling the edge PDs with properly-designed meta-surfaces deposited on the lens surfaces, (ii) possibility to directly deposit non-silicon photodetectors along the edges (iii) feasibility to introduce transparent light diffusing structures or particles in the plastic lens. These studies will include an assessment of the optical properties and anatomical realism of model eyes, that would allow to adopt robotic platforms to automatically create large datasets for training machine learning algorithms more easily than on human subjects, pivotal to push the limits of the gaze reconstruction capabilities. Moreover, the impact of glasses slippage on the tracking performance will be studied, possibly comparing different sensing approaches

	to reliably estimate the mutual orientation between head and glasses and thus correct the slippage-induced error.The second target of this PhD will be focused on the driving and sensing electronics. First of all, a universal hardware platform for photodetector-based gaze estimation will be developed, starting from the experience gathered by past designs and leveraging a novel generation of low-power microcontrollers with embedded accelerators for machine learning such as Gap-9. Moreover, the work will target a feasibility analysis of realizing an Application Specific Integrated Circuit (ASIC) for IR-based ultra-low-power eye tracking to replace discrete components. A Silicon CMOS solution would grant ultimate miniaturization and power reduction, being tailored on the application.
Methods and techniques that will be developed and used to carry out the research	The methods adopted in the work will combine numerical simulations and electronics design with experimental analysis and validation of the approaches. The first year will be devoted to the assessment of the limits and potential of enhancing lens edge readout along the 3 directions listed above, leading to the realization of an improved low-power prototype. The second year will be devoted to the validation of a such a prototype and, in parallel, to the development of a novel hardware platform based on a new generation of microcontrollers for TinyML and to investigation of the model eyes for training robust gaze estimation algorithms to be run in the improved prototype. The third year will focus on the consolidation of results and on the feasibility analysis of the ASIC approach for the prototype electronics, including both analog front-end and neuromorphic processing blocks. The activity of the first year will be highly multidisciplinary, with collaborations in the fields of optics and materials science, while the second and third year will mostly focus on electronics and microelectronics. This work lies at the convergence of sensors, electronics, optics and embedded machine learning, cooperating to achieve the best compromise between tracking performance and power dissipation.
Educational objectives	The educational objectives are multiple: (1) strengthening

	a vertical expertise on high-sensitivity low-power electronic design, (2) opening the candidate to cross-disciplinary research, including academic and industrial R&D perspectives, (3) learning to self-organize, lead a research project, interact with several other teams, disseminate technical results.
Job opportunities	PhD candidates with expertise in wearables, electronics, sensors and embedded processing are highly requested by companies developing electronic systems in multiple application areas spanning from industry, IoT, to the field of medical and extended reality devices.
Composition of the research group	1 Full Professors 2 Associated Professors 0 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Marco Carminati

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences). TEACHING ASSISTANTSHIP: availability of funding in recognition of supporting teaching activities by the PhD student There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

COMPUTER AVAILABILITY:
1st year: Yes
2nd year: Yes
3rd year: Yes

DESK AVAILABILITY:
1st year: Yes
2nd year: Yes
3rd year: Yes

The student will carry out the research activity within the Smart Eyewear Lab jointly established between Politecnico di Milano and EssilorLuxottica in a dynamic and stimulating environment composed of both academic and company researchers, several PhD students and Master students coming from different degrees (Electronics, Telecom, Computer Science, Biomedical, Physics…) and working in different topics, from electronics to machine learning.