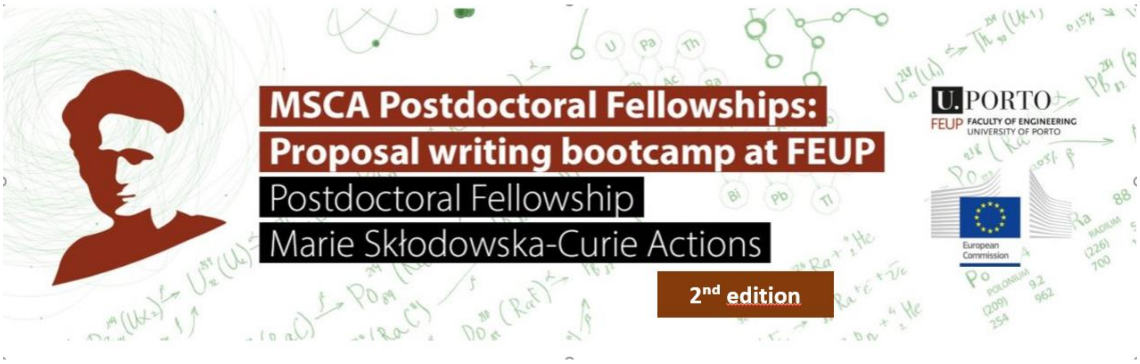


SUPERVISOR INFORMATION	
First and Last name	Henrique Salgado
URL of supervisor webpage	https://www.cienciavitae.pt/portal/pt/AA1C-F7A3-8E3D
Department	Electrical and Computer Engineering
Field(s) of research	Integrated optical sensing and communications
PROJECT PROPOSAL	
Title (optional)	**Design and Optimization of Optical Phased Arrays and Waveforms for Optical Integrated Sensing and Communication (O-ISAC)**
Brief project description	This research proposal focuses on the design and optimization of **Optical Phased Arrays (OPA)** and **waveforms** to enhance the performance of Optical Integrated Sensing and Communication (O-ISAC) systems. Over two years, the work will explore novel OPA architectures for improved beam steering, integrate advanced waveform designs such as pulse-based and multi-carrier waveforms, and evaluate the overall performance of the system. The outcomes will contribute to the realization of robust, high-rate, and precise optical sensing and communication systems.

Introduction and Motivation

The rapid evolution of autonomous systems, intelligent transportation, and next-generation wireless networks has intensified the demand for systems capable of simultaneous sensing and communication. Integrated Sensing and Communication (ISAC) is emerging as a transformative concept for applications such as autonomous vehicles, smart cities, and 6G wireless networks. While Radio Frequency (RF)-based ISAC has been extensively studied, its limitations in bandwidth and precision highlight the need for optical counterparts.

Optical Integrated Sensing and Communication (O-ISAC), leveraging Free-Space Optical Communication (FSOC) and optical sensing technologies, offers unparalleled advantages such as higher communication rates, enhanced sensing precision, and reduced multi-user interference. However, for O-ISAC to reach its full potential, two critical components require focused research:

1. **Optical Phased Arrays (OPA):** OPAs provide agile, solid-state beam steering capabilities, which are essential for efficient signal targeting in both sensing and

communication. Compared to traditional mechanical steering methods, OPAs offer faster response times, miniaturization opportunities, and greater robustness.

2. **Waveform Design:** The design of suitable waveforms is vital for achieving optimal performance in both sensing and communication. Optical waveforms must address challenges such as real and non-negative signal requirements while ensuring energy efficiency and high resolution.

By addressing these challenges, the proposed research will contribute to the development of compact, efficient, and high-performance O-ISAC systems, enabling a new generation of communication and sensing platforms.

Objectives

The primary objectives of this research are:

- Design and optimize Optical Phased Arrays (OPA): Develop scalable, low-power, and high-resolution OPAs for agile beam steering in O-ISAC systems.
- Develop optical waveform designs: Focus on real, non-negative waveforms tailored for simultaneous communication and sensing.
- Evaluate OPA and waveform performance: Integrate OPAs with waveform designs and evaluate performance under realistic conditions for O-ISAC.
- Propose joint optimization strategies: Investigate the interplay between OPA architecture and waveform design for achieving global optimization of O-ISAC systems.

Tasks

Task 1: Literature Review and System Modeling

The research will begin with an in-depth literature review and system modeling. This phase will involve studying existing OPA designs, beam steering mechanisms, and waveform techniques for ISAC. The base approach would be the use of phase shifters and wavelength tuning to achieve beam steering. A generalized model for O-ISAC will be developed, incorporating OPA beam steering and waveform integration to establish a foundation for subsequent work.

Task 2: Design of Optical Phased Arrays (OPA)

The next phase will focus on the design of Optical Phased Arrays (OPA). A Si-SiN OPA will be developed with an emphasis on improving phase control and reducing power consumption. Analyze phase tuning range and SOI (Silicon-on-Isulating) grating structures using 3D electromagnetic simulations to optimize beam performance. Key parameters such as beam steering speed, field-of-view (FOV), and sidelobe suppression will be optimized. Additionally, miniaturized architectures will be explored to address challenges related to scalability and integration.

Task 3: Waveform Design and Optimization

Following the OPA design, the research will proceed with waveform design and optimization. Waveform designs suitable for optical systems will be developed and analyzed. Pulsed waveforms will integrate pulse-position modulation (PPM) for communication and time-of-flight (ToF) sensing. Multi-carrier waveforms, specifically DC-biased optical OFDM (DCO-OFDM), will be implemented and optimized for simultaneous communication and sensing. Optimization strategies will be formulated for key waveform parameters, including chirp rate, modulation index, and power allocation.

Task 4: Integration and Simulation

The integration and simulation phase will combine the designed OPAs with the optimized waveforms into a simulated O-ISAC system. System performance metrics, such as communication rate (bit error rate and bandwidth efficiency), sensing precision (distance resolution and angle resolution), and beam steering speed and accuracy, will be evaluated. Monte Carlo simulations will be conducted to validate the system's robustness under realistic conditions.

Task 5: Joint Optimization of OPA and Waveform Performance

The final technical phase will address the joint optimization of OPA and waveform performance. The mutual dependence between OPA characteristics, such as sidelobe suppression and steering speed, and waveform parameters will be investigated. A joint optimization framework will be proposed to achieve global trade-offs between performance metrics for communication and sensing.

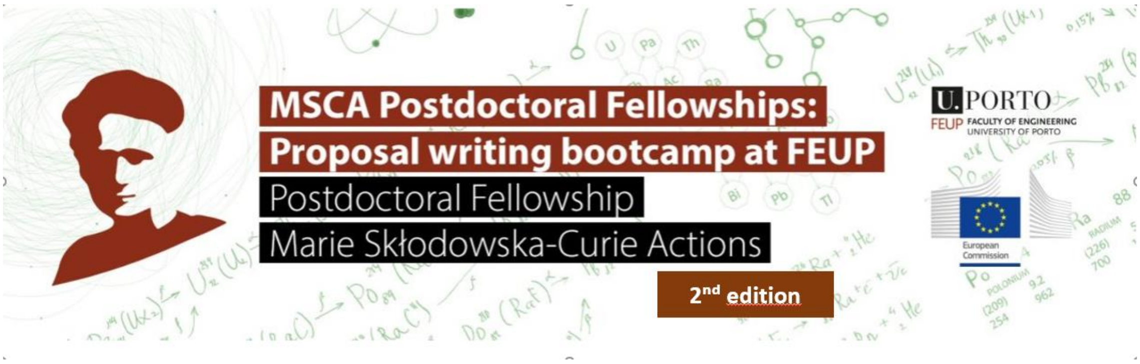
Task 6: Reporting and Dissemination

Finally, the research outcomes will be documented and disseminated. This will include the preparation of technical reports, research articles for high-impact journals and conferences, and the final thesis, which will comprehensively document the research methodologies, findings, and contributions.

Research Outcomes

The anticipated outcomes of this research include:

- A Si-SiN OPA design: Demonstrating faster beam steering, reduced power consumption, and high-resolution capabilities.



- Optimized waveform designs: Tailored optical waveforms for energy-efficient, high-precision communication and sensing.
- Integrated OPA and waveform framework: A unified system that balances communication rate, sensing precision, and beam control speed.
- Performance evaluation: A comprehensive evaluation of the proposed O-ISAC system under realistic conditions.
- Publications and dissemination: Peer-reviewed publications in high-impact journals and conference presentations.

Conclusion

This research will address critical challenges in the design and optimization of Optical Phased Arrays and waveforms for Optical Integrated Sensing and Communication (O-ISAC) systems. By developing novel OPA architectures and advanced waveform techniques, this work will contribute to the realization of high-performance, compact, and efficient O-ISAC systems. The outcomes will pave the way for practical deployment of O-ISAC in applications such as autonomous vehicles, intelligent transportation systems, and 6G wireless communication networks.