

Optical fibre sensing of critical infrastructures

Introduction

Optical fibre networks constitute the backbone of modern information society, enabling high-speed and high-capacity data transmission that underlies contemporary economies, communication infrastructures, and public services. Yet, beyond their primary role for data communication, optical fibres have their potential to become highly sensitive sensors, capable of detecting environmental and structural changes along their length. Simultaneous transmission of data and sensing is a way how we monitor and protect critical infrastructure while fibre are still used for their main purpose – data transmission.

By exploiting the intrinsic sensitivity of optical fibres to strain, temperature, vibration, and acoustic signals, optical fibre sensing (OFS) technologies can provide distributed, real-time monitoring over long distances. When integrated into existing telecommunication infrastructure, these systems enable early detection of anomalies such as structural degradation, mechanical stress, or external disturbances. This convergence of communication and sensing transforms optical networks into powerful tools for infrastructure integrity, safety, and resilience.

Motivation and Scope

The protection and stable operation of critical infrastructures like energy distribution, transportation, water supply, or communication networks are fundamental to societal and economic stability. Ageing of infrastructure, environmental threats, as well as increased interconnectivity, pose new reliability and protection issues. Traditional monitoring approaches often rely on evaluating parameters at various layers of the ISO/OSI model, which can provide general information of network condition but offer only a little or no information about degradation, security threats, or physical tampering.

Fiber-optic sensing offers completely new possibilities in the field of protecting critical infrastructures and thus ensuring their resilience. Using technologies such as Distributed Acoustic Sensing (DAS), Distributed Temperature Sensing (DTS), and Fiber Bragg Gratings (FBGs), State of Polarization (SoP) monitoring provides continuous, high-resolution event detection along existing fibre paths. This capability allows real-time detection of ground movement near pipelines, vibrations on railway tracks, or temperature variations in power cables without interrupting data transmission. As a result, OFS enhances the resilience and operational awareness of critical infrastructure.

Integrating sensing into communication fibres also offers a cost-effective path to large-scale deployment. By utilizing the existing fibre infrastructure, network operators can enhance monitoring coverage with minimal additional investment, thereby improving both sustainability and economic efficiency. The integration of optical communication and sensing enables predictive maintenance, incident prevention, and rapid response, thereby enhancing safety while reducing operational costs while minimizing environmental impact. However, sharing the same transmission medium for multiple applications introduces additional challenges, particularly related to potential mutual interference, which must be properly addressed.

Key topics for the meeting include (but are not limited to):

- Distributed sensing for structural health monitoring of bridges, tunnels, pipelines, power grids, etc.
- Real-time environmental monitoring for early detection of seismic activity, landslides, or flooding
- Security and intrusion detection along critical assets such as data cables, borders, and transportation corridors
- Integration of fibre sensing with digital twins for predictive maintenance and situational awareness
- Energy-efficient and sustainable sensing architectures leveraging shared communication–sensing networks

- Standardization and interoperability to ensure scalable deployment across heterogeneous infrastructures
- Novel concepts, systems, and methods for optical fibre infrastructure protection
- Modelling, simulation, and digital twin development of distributed optical fibre sensing (DOFS) systems

Mentorship, Networking, & Outreach

Alongside in-depth discussions on optical fibre sensing of critical infrastructures, the event will emphasize mentorship and professional networking. A key aim is to bridge the gap between academia and industry by bringing together researchers, engineers, and entrepreneurs focused on the fusion of optical communications and sensing.

We are especially committed to empowering early-career professionals and supporting women in science and engineering. Dedicated sessions will encourage their active participation in shaping the future of intelligent optical networks. The event will offer young researchers valuable opportunities to connect with experts in photonics, AI, and network engineering, gaining insights on research directions, career development, and entrepreneurship.

We also plan an on-site demonstration session, allowing attendees to interact directly with cutting-edge optical transmission and sensing technologies. This hands-on experience will offer practical understanding of the real-world implementation of joint data and sensing systems.

Planned sessions include (but are not limited to):

- **Empowering Early-Career Researchers and Women in Photonics and ICT:** A dedicated session focused on diversity, inclusion, and mentorship
- **Boosting Resilience with Real-Time Monitoring:** The session explores how fibre networks can monitor their surroundings to detect issues early and stay resilient during environmental or structural changes.
- **Smart Control for Energy-Efficient Networks:** How intent-based control and efficient data handling can help reduce energy use, making optical networks more sustainable and cost-effective.
- **Interactive Demo Session and Networking Event:** Live demonstrations followed by informal discussions to foster collaboration and exchange

Interested to contribute or participate?

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