Sustainable Water Management Doctoral Programme (Water4All)

Title of the PhD Project	Water level and temperature measurements based on fiber Bragg grating sensors
Acronym	ELE-3
Research Fields of the Project	Fiber optical sensor systems for sustainable water management
Keywords	Fiber optics, fiber Bragg gratings, temperature sensor, water level sensor, advanced signal processing, machine learning algorithms, groundwater management, well monitoring
Host Institution, Department and Campus Location	İzmir Institute of Technology, Electrical-Electronics Engineering Department, Urla, İzmir
PhD Awarding Institution and Graduate Programme	Izmir Institute of Technology, Graduate School, PhD in Electronics Engineering
Name and Affiliation of Main Supervisor	Kıvılcım YÜKSEL ALDOĞAN, Associate professor (IZTECH)
Name and Affiliation of Co-Supervisors	Abdurrahman Gümüş, Assistant professor (IZTECH) Yalın Bastanlar, Professsor (IZTECH)
Research Environment and Infrastructure	The Izmir Institute of Technology (IZTECH) has been distinguished as *one of the Top 5 Research Universities* out of 200+ higher education institutions in Türkiye, ranking first in terms of the number of peer-reviewed articles per faculty member. One of the strategic goals of IZTECH is to advance its position to a leading academic institution in water research in European Research Area. IZTECH Campus is in Urla,

	İzmir and has an area of 232.30 hectares of land (the third largest campus area in Türkiye). Being an English medium university, IZTECH currently has Engineering, Science, and Architecture faculties with 19 departments (engineering 10, science 5 and architecture 5), with 18 undergraduate, 29 master's (9 interdisciplinary) and 15 doctorate (4 interdisciplinary) programs in 19 majors. IZTECH has 354 laboratories, 80% of which are for R&D purposes and 20% of which are for educational purposes. All laboratories contain the appropriate technology for education, teaching and research in various fields. Importantly, the Integrated Research Center (IRC) of IZTECH is one of the most-equipped and competent research centers in Türkiye, located on 6,250 m2 area. IRC incorporates eight different Application and Research Centers (ARCs) including Environmental Development ARC, Geothermal Energy ARC, Biotechnology and Bioengineering ARC, National Mass Spectrometry ARC, Wind Energy Meteorology ARC and Continuing Education Center. The equipment and analysis portfolio are accessible through a website that was designed considering online-shopping perspective. Furthermore, the academic supervisors of ELE-3 have their own laboratories, namely FiSENSLAB, MIRALAB and CVRG that will be involved in the project. The Fiber Optic Metrology and Sensor Applications Laboratory (FiSENSLAB, https://eee.iyte.edu.tr/en/fiber-optic-sensors-lab/) was established in 2012 as a complementary part of the ongoing research at the Electrical and Electronics Engineering Department of IZTECH on the photonics domain. Specific research areas focused on at FiSENS-LAB include design and implementation of optical fiber reflectometry techniques, Distributed Optical Fiber Sensors (DOFS), Fiber Bragg Grating sensors (FBG), Passive Optical Networks (PON), and sensor data analysis using machine learning algorithms. The Machine Intelligence Research and Applications Laboratory (MIRALAB) at Izmir Institute of Technology, Türkiye, is dedicated to exploring the frontiers of artificial intelligence, with a particular focus on sequential data analysis and computer vision. MIRALAB is engaged in developing advanced AI methodologies, including transformers, diffusion-based models, and multimodal systems, by focusing on the application areas of optical sensors, biosensors, medical image understanding, facial expression analysis, wearable devices and digital health. The Computer Vision Research Group (CVRG, cvrg.iyte.edu.tr) at Izmir Institute of Technology targets to conduct research on the cutting-edge topics of applying AI and machine learning techniques for visual data such as: Visual object

	detection/classification, visual localization, vision for autonomous driving and ADAS, 3D reconstruction from images, object tracking, vision for robotics.
Scientific Context of the Project	Overuse of the groundwater potential in water-stressed areas is of ever-increasing importance. This problem directly leads to decrease in groundwater table level. Measuring water levels in water wells helps in the efficient management of water resources by preventing them from over-pumping, assessing aquifer recharge, evaluating the performance of individual wells, providing early detection of depletion and contamination, planning the water supply for long-term. Water level data from wells are valuable for hydrogeological studies and research. Researchers use this information to model groundwater flow, assess aquifer characteristics, and gain insights into the overall hydrological systems. Temperature monitoring of cold and hot water resources provides valuable information in many aspects such as water quality assessment, environmental monitoring, and hydrological studies. Additionally, seismic movements occurring during earthquakes damage the earth's crust and the structures above, affecting cold and hot underground water resources. Especially with field observations and scientific studies conducted in recent years, many researchers have tried to reveal the relationship between earthquakes and groundwater in different situations. In this context, optical fiber sensors, notably Fiber Bragg Gratings (FBGs) have been shown as great candidate for the water level and temperature monitoring due to the many advantages of these mass-producible intrinsic sensing devices. The advantages include their inherent wavelength-encoded demodulation feature, resistance to electromagnetic interference, great configurability with multiplexing capability, remote operation, passive and lightning/corrosion-resistive nature, as well as their small size. These sensor systems, when amalgamated with Deep Learning technologies, are adept at addressing unique challenges in their respective domains (e.g. downscaling the measured data with better resolution, agricultural yield estimation). Our proposed thesis (ELE-3) will focus on developing an innovative measurement and analysis platform for both water level and temperature monitoring that can be adapted for various implementation scenario.

Brief Workplan	**0 – 2 years:** PhD candidate will take classes from partner universities Analysis of the state of the art Requirement analysis Simulation of the sensor interrogation system Fiber optic lab trainings **0.5 – 2.5 years:** Data collection capability improvement with fiber optic sensors. Noise modelling and analysis. **1.0 – 4 years:** Implementing the fiber optic sensors and tools specific for the corresponding Ph.D. project. Comparison between simulated and experimental data. Secondments visits. Intersectoral mobility (outside plant trials). Congress and article publishing. **1.0 – 4 years:** Developing and implementing artificial intelligence algorithms for the analysis of fiber optic sensors specific for the corresponding Ph.D. project **3.0 – 4 years**: Thesis report, dissemination activities.

Innovative Aspects of the Project	Water level and temperature monitoring of active groundwater wells, distribution canals, and the strategic points in the irrigation system have seen significant innovations in recent years, driven by advancements in sensor technologies, data analytics, and communication systems. The proposed solution, in this project, will enable groundwater researchers and decision makers; to have quick access to the measurement data with a deep insight to assess the gap between potential and actual irrigation performances. The platform can be incorporated with real-time sensing capability, automated alert systems, and early warning protocol.
Training Opportunities of the Project	Doctoral schools and courses from the leading academic institutions in Türkiye, namely, Izmir Institute of Technology (IZTECH-beneficiary) in İzmir, İstanbul Technical University (ITU) in İstanbul, Gebze Technical University (GTU) in Kocaeli, and Middle East Technical University (METU) in Ankara. ○ Research Laboratories of the co-advisors (FiSENS, MIRALAB, CVRG) ○ 1 sectoral partnership (SAMM Teknoloji). ○ 3 international academic secondments (UMONS, UPNA, XLIM).
Interdisciplinary Aspects	The main modules of the Water4All project are identified as Environment, Electronics, Planning, Material Science and Energy, and each has different angles of training on research and expected outcomes. In this respect, academic training of PhD student in Water4All is constructed in a modular approach that is interdisciplinary by nature. Water level and temperature monitoring of water resources is inherently interdisciplinary, drawing from principles of hydrology, geology, physics, engineering, computer science, and environmental science. Collaborative efforts among experts from these diverse fields are essential for effective water resource management and environmental conservation.
Intersectoral Mobility ☐ **Short Visit**	**SAMM technology, Kocaeli premises, Türkiye** SAMM Teknoloji has developed many fiber optic equipment and components for different application areas to date. In addition, in recent years, SAMM Teknoloji

☒ **Secondment**	has focused on fiber optic-based sensing technologies and aimed to produce value-added products in this regard. SAMM Teknoloji has developed a fiber optic-based sensing systems that can be implemented to water level and temperture monitoring appliation. SAMM Teknoloji will be involved in in the project training, research, and management activities by organizing short-term research activities and trainings both in the R&D center and production facilities of the company. The PhD students involved in the project will be provided by the necessary equipment and infrastructure to get acquainted with fiber sensing concepts.
Intersectoral Mobility ☐ **Short Visit** ☐ **Secondment**	NA
International Academic Secondment	Short-term missions, trainings and laboratory facilities will be offered at the following project secondments: ○ University of Mons, Electromagnetism & Telecommunication Unit, **Belgium** (Host Supervisor: Prof. Marc Wuilpart) ○ Public University of Navarre (UPNA), Optical Communications group, **Spain** (Host Supervisor: Prof. Manuel Lopez-Amo Sainz) ○ XLIM Research Institute, fiber photonics group, **France** (Host Supervisor: Prof. Georges Humbert)

Main Supervisor	
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	M.Sc. Electromagnetism and Telecommunications, University of Mons, Belgium 2006 M.Sc. Electronics Engineering, Ege University, Türkiye 2000 B.Sc. Electronics Engineering, Dokuz Eylül University, Türkiye 1995 **Professional Networks** Google Scholar: https://scholar.google.com/citations?user=rq9hCjsAAAAJ&hl=tr ResearchGate: https://www.researchgate.net/profile/Kivilcim-Yueksel Scopus: https://www.scopus.com/authid/detail.uri?authorId=24831988400 ORCID: https://orcid.org/0000-0003-1512-3022
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Brief CV	**Assist. Prof. Dr. Abdurrahman GÜMÜŞ** **E-mail:** abdurrahmangumus@iyte.edu.tr **Academic Degrees** Ph.D. Electrical and Computer Engineering, Cornell University, USA 2014 M.Sc. Electrical and Computer Engineering, Cornell University, USA 2010 B.Sc. Electrical and Electronics Engineering, Istanbul University, Türkiye 2005 **Professional Networks** Google Scholar: https://scholar.google.com.tr/citations?user=Hc7A4o0AAAAJ&hl=en Scopus: https://www.scopus.com/authid/detail.uri?authorId=35315599800 ORCID: https://orcid.org/0000-0003-2993-5769

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