

**Sustainable Water Management  
Doctoral Programme (Water4All)**



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<b>Title of the PhD Project</b>	Sensing solutions for water leak detection and smart irrigation systems in water-stressed areas
<b>Acronym</b>	ELE-4
<b>Research Fields of the Project</b>	Fiber optical sensor systems for sustainable water management
<b>Keywords</b>	Fiber optics, water leak detection, smart water, smart irrigation, advanced signal processing, machine learning algorithms, groundwater management, infrastructure monitoring
<b>Host Institution, Department and Campus Location</b>	Izmir Institute of Technology, Electrical-Electronics Engineering Department, Urla, İzmir
<b>PhD Awarding Institution and Graduate Programme</b>	Izmir Institute of Technology, Graduate School, PhD in Electronics Engineering
<b>Name and Affiliation of Main Supervisor</b>	Kıvılcım YÜKSEL ALDOĞAN, Associate professor (IZTECH)
<b>Name and Affiliation of Co-Supervisors</b>	Abdurrahman Gümüş, Assistant professor (IZTECH) Yalın Bastanlar, Professor (IZTECH)
<b>Research Environment and Infrastructure</b>	The Izmir Institute of Technology (IZTECH) has been distinguished as <i>one of the Top 5 Research Universities</i> 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,



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	<p>İzmir and has an area of 232.30 hectares of land (the third largest campus area in Türkiye).</p> <p>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&amp;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 m<sup>2</sup> 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.</p> <p>Furthermore, the academic supervisors of ELE-4 have their own laboratories, namely FiSENSLAB, MIRALAB and CVRG that will be involved in the project.</p> <p>The Fiber Optic Metrology and Sensor Applications Laboratory (FiSENSLAB, <a href="https://eee.iyte.edu.tr/en/fiber-optic-sensors-lab/">https://eee.iyte.edu.tr/en/fiber-optic-sensors-lab/</a>) 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.</p> <p>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.</p> <p>The Computer Vision Research Group (CVRG, <a href="http://cvrg.iyte.edu.tr">cvrg.iyte.edu.tr</a>) 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</p>
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	<p>detection/classification, visual localization, vision for autonomous driving and ADAS, 3D reconstruction from images, object tracking, vision for robotics.</p>
<p><b>Scientific Context of the Project</b></p>	<p>Leak detection in water distribution systems is of vital importance in the safe and effective transportation of drinking water. Leaks can be caused by poor pipeline quality or lack of maintenance. Therefore, early and accurate detection of leaks is essential to prevent resource waste and protect water quality.</p> <p>Inefficient water transport system in developing countries, water scarcity and low funds allocated for the installation of pipeline leak protection and detection systems cause excessive water loss. Various fiber-based sensor technologies will be investigated to detect leaks, from the reservoir down to individual zones.</p> <p>Overuse of the groundwater potential in water-stressed areas is another issue addressed by this project. This directly leads to decrease in groundwater table level. Therefore, water stressed Mediterranean areas especially and firstly need to protect groundwater potential quality as well as quantity. This firstly requires strengthened sustainable water management structure and making awareness of the reasons and results of the mismanagement which leads to higher gap between groundwater potential and actual use.</p> <p>Event detection and classification are enhanced using various sensor systems, including deep learning (DL) techniques, catering to a wide array of applications. These systems, combined with DL, effectively address specific challenges in their respective areas. The integration of DL with sensor systems highlights their versatility and effectiveness in dealing with various challenges in event detection and classification. For example, DL algorithms can enhance chemical sensors as early warning systems for hazardous releases, while seismic sensors in environmental monitoring effectively classify earthquakes. The fusion of DL and distributed acoustic sensing has brought new levels of precision and capability in monitoring and interpreting events along fiber-optic lines. Recent studies have utilized DL for enhancing long-distance fiber-optic vibration sensing and threat classification in complex environments, with impressive identification accuracies.</p> <p>Our proposal will focus on implementing an innovative monitoring and analysis platform for both water leak detection and for providing smart irrigation system. A case study from Türkiye will be used to illustrate how the separately discussed aspects come together in practice. Despite the activities of many irrigation</p>



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	<p>cooperatives in the country, the irrigation performance is in general lower than potential leaving a big room for significant improvements by the way of innovative trans-disciplinary management approach and technological support as proposed in this project.</p>
<p><b>Brief Workplan</b></p>	<p><b>0 – 2 years:</b> PhD candidate will take classes from partner universities</p> <p>Analysis of the state of the art</p> <p>Requirement analysis</p> <p>Simulation of the sensor interrogation system</p> <p>Fiber optic lab trainings</p> <p><b>0.5 – 2.5 years:</b> Data collection capability improvement with fiber optic sensors. Noise modelling and analysis.</p> <p><b>1.0 – 4 years:</b> Implementing the fiber optic sensors and tools specific for the corresponding Ph.D. project.</p> <p>Comparison between simulated and experimental data.</p> <p>Secondments visits.</p> <p>Intersectoral mobility (outside plant trials).</p> <p>Congress and article publishing.</p> <p><b>1.0 – 4 years:</b> Developing and implementing artificial intelligence algorithms for the analysis of fiber optic sensors specific for the corresponding Ph.D. project</p> <p><b>3.0 – 4 years:</b> Thesis report, dissemination activities.</p>

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<p><b>Innovative Aspects of the Project</b></p>	<p>Early Leak Detection by using various fiber-based sensor technologies, notably by analyzing changes in the vibration patterns along the fiber optic cable is the main innovative aspect of the Project. Early detection of leaks and pipeline issues can lead to significant cost savings. Repairing a small leak promptly is generally more cost-effective than dealing with the consequences of a major pipeline failure. Innovative sensor-based monitoring system will facilitate permanent supervision (replacing inspection-based supervision) help protecting the environment.</p>
<p><b>Training Opportunities of the Project</b></p>	<p>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.</p> <ul style="list-style-type: none"> <li>○ Research Laboratories of the co-advisors (FiSENS, MIRALAB, CVRG)</li> <li>○ 1 sectoral partnership (SAMM Teknoloji).</li> <li>○ 3 international academic secondments (UMONS, UPNA, XLIM).</li> </ul>
<p><b>Interdisciplinary Aspects</b></p>	<p>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.</p> <p>Water leak detection is inherently interdisciplinary, drawing from principles of physics, engineering, computer science, and environmental science. ELE-4 project will be at the intersection of sensors and data analysis, for efficient planning and sustainable environment. Collaborative efforts among experts from these diverse fields are essential for effective water resource management and environmental conservation.</p>
<p><b>Intersectoral Mobility</b></p> <p><input type="checkbox"/> Short Visit</p> <p><input checked="" type="checkbox"/> Secondment</p>	<p><b>SAMM technology, Kocaeli premises, Türkiye</b></p> <p>SAMM Teknoloji has developed many fiber optic equipment and components for different application areas to date. In addition, in recent years, SAMM Teknoloji has focused on fiber optic-based sensing technologies and aimed to produce value-added products in this regard.</p>

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	<p>SAMM Teknoloji has developed a fiber optic-based sensing system that has been implemented various distributed acoustic sensing infrastructure monitoring applications.</p> <p>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&amp;D center and production facilities of the company.</p> <p>The PhD students involved in the project will be provided by the necessary equipment and infrastructure to get acquainted with fiber sensing concepts.</p>
<b>Intersectoral Mobility</b>  <input type="checkbox"/> Short Visit  <input type="checkbox"/> Secondment	NA
<b>International Academic Secondment</b>	<p>Short-term missions, trainings and laboratory facilities will be offered at the following project secondments:</p> <ul style="list-style-type: none"><li>○ University of Mons, Electromagnetism &amp; Telecommunication Unit, <b>Belgium</b> (Host Supervisor: Prof. Marc Wuilpart )</li><li>○ Public University of Navarre (UPNA), Optical Communications group, <b>Spain</b> (Host Supervisor: Prof. Manuel Lopez-Amo Sainz)</li><li>○ XLIM Research Institute, fiber photonics group, <b>France</b> (Host Supervisor: Prof. Georges Humbert )</li></ul>
<b>Main Supervisor</b>	
<b>Brief CV</b>	<b>Assoc. Prof. Dr. Kivilcim YÜKSEL ALDOGAN</b>  E-mail: <a href="mailto:kivilcimyuksel@iyte.edu.tr">kivilcimyuksel@iyte.edu.tr</a>



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	<p><b>Academic Degrees</b></p> <p>Ph.D. Electromagnetism and Telecommunications, University of Mons, Belgium 2011</p> <p>M.Sc. Electromagnetism and Telecommunications, University of Mons, Belgium 2006</p> <p>M.Sc. Electronics Engineering, Ege University, Türkiye 2000</p> <p>B.Sc. Electronics Engineering, Dokuz Eylül University, Türkiye 1995</p> <p><b>Professional Networks</b></p> <p>Google Scholar: <a href="https://scholar.google.com/citations?user=rq9hCjsAAAAJ&amp;hl=tr">https://scholar.google.com/citations?user=rq9hCjsAAAAJ&amp;hl=tr</a></p> <p>ResearchGate: <a href="https://www.researchgate.net/profile/Kivilcim-YuekseI">https://www.researchgate.net/profile/Kivilcim-YuekseI</a></p> <p>Scopus: <a href="https://www.scopus.com/authid/detail.uri?authorId=24831988400">https://www.scopus.com/authid/detail.uri?authorId=24831988400</a></p> <p>ORCID: <a href="https://orcid.org/0000-0003-1512-3022">https://orcid.org/0000-0003-1512-3022</a></p>
<b>Co-supervisors</b>	

<b>Brief CV</b>	<p><b>Assist. Prof. Dr. Abdurrahman GÜMÜŞ</b></p> <p>E-mail: <a href="mailto:abdurrahmangumus@iyte.edu.tr">abdurrahmangumus@iyte.edu.tr</a></p> <p><b>Academic Degrees</b></p> <p>Ph.D. Electrical and Computer Engineering, Cornell University, USA 2014</p> <p>M.Sc. Electrical and Computer Engineering, Cornell University, USA 2010</p> <p>B.Sc. Electrical and Electronics Engineering, Istanbul University, Türkiye 2005</p> <p><b>Professional Networks</b></p> <p>Google Scholar: <a href="https://scholar.google.com.tr/citations?user=Hc7A4o0AAAAJ&amp;hl=en">https://scholar.google.com.tr/citations?user=Hc7A4o0AAAAJ&amp;hl=en</a></p> <p>Scopus: <a href="https://www.scopus.com/authid/detail.uri?authorId=35315599800">https://www.scopus.com/authid/detail.uri?authorId=35315599800</a></p> <p>ORCID: <a href="https://orcid.org/0000-0003-2993-5769">https://orcid.org/0000-0003-2993-5769</a></p>
<b>Brief CV</b>	<p><b>Prof. Dr. Yalın BAŞTANLAR</b></p> <p>E-mail: <a href="mailto:yalinbaskanlar@iyte.edu.tr">yalinbaskanlar@iyte.edu.tr</a></p> <p><b>Academic Degrees</b></p> <p>Ph.D. Informatics Institute, Middle East Technical University, Türkiye 2009</p> <p>M.Sc. Informatics Institute, Middle East Technical University, Türkiye 2005</p> <p>B.Sc. Civil Engineering, Middle East Technical University, Türkiye 2001</p> <p><b>Professional Networks</b></p> <p>Google Scholar: <a href="https://scholar.google.com.tr/citations?user=3WTNhHYAAAAJ&amp;hl=tr&amp;oi=ao">https://scholar.google.com.tr/citations?user=3WTNhHYAAAAJ&amp;hl=tr&amp;oi=ao</a></p> <p>ResearchGate: <a href="https://www.researchgate.net/profile/Yalin-Baskanlar">https://www.researchgate.net/profile/Yalin-Baskanlar</a></p> <p>ORCID: <a href="https://orcid.org/0000-0002-3774-6872">https://orcid.org/0000-0002-3774-6872</a></p>