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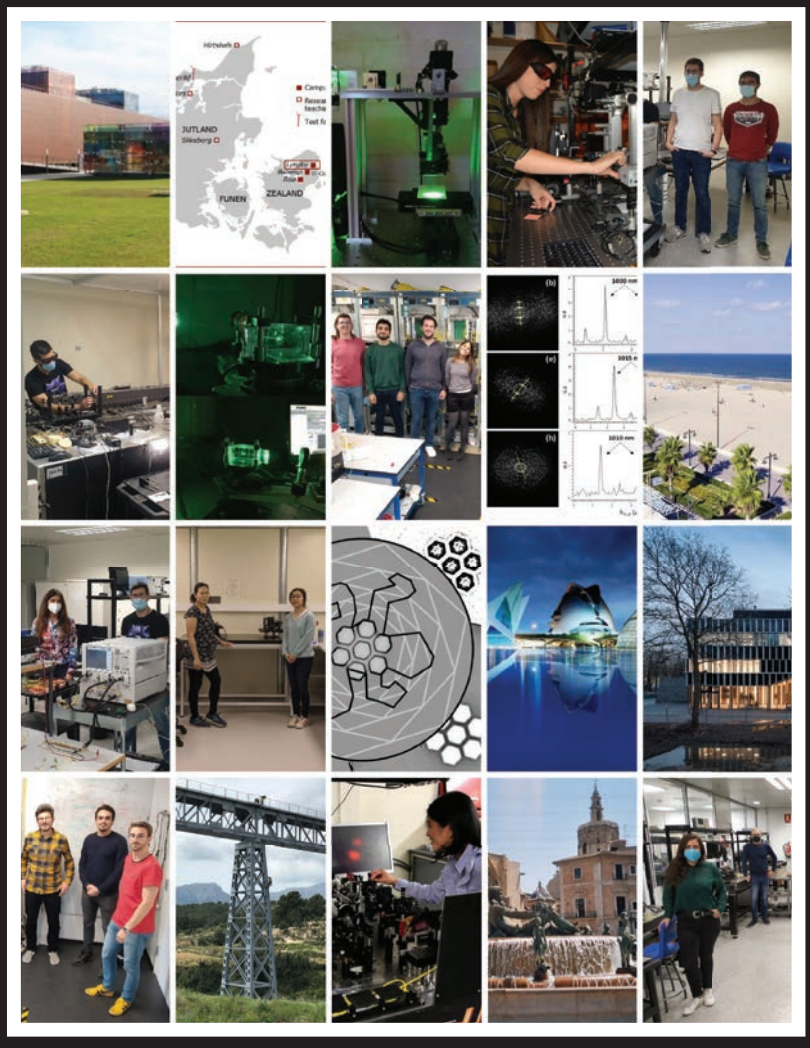
Research From Around the World



Also Inside:

- 2021 John Tyndall Award Recipient
- Senior Member Elevations

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Unleashing Machine Learning in the Service of Photonics from the Technical University of Denmark

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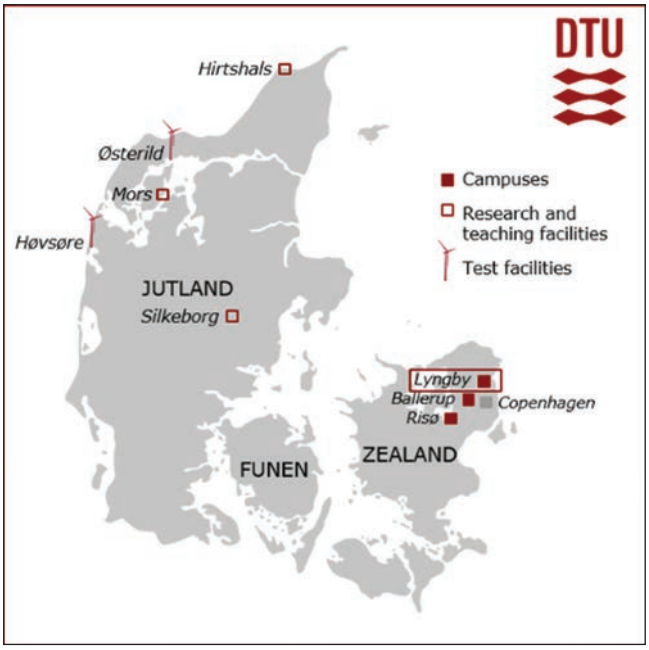
In 1829, the Danish physicist H.C. Ørsted, one of the forefathers of electromagnetism, founded the Den Polytekniske Læreanstalt ('College of Advanced Technology'). Just 9 years earlier (in 1820, 200 years ago!) Ørsted had carried out his first experiment proving a connection between electricity and magnetism. In 1994, the college became the Technical University of Denmark (DTU) with its main university campus located in Lyngby, just outside Copenhagen, and a few additional research facilities spread throughout Denmark.

The university covers nearly all fields related to engineering, from bio- and chemical engineering, to civil, and mechanical. Acknowledging DTU's founder, a strong focus is, of course, dedicated to electrical and optical engineering.

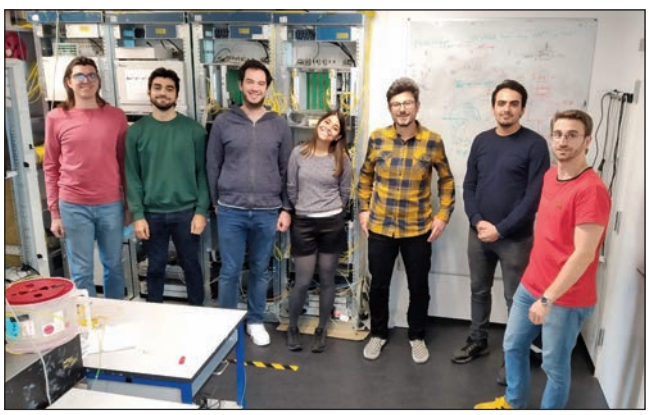
The Department of Photonics Engineering (DTU Fotonik) was funded in 1998, initially called Researcher Center COM, by merging researchers involved in photonics and prior part of two separate centers: the center for microelectronic and the center for broadband telecommunication. The department aims at covering all topics related to optics and photonics, from photovoltaic to ultrafast optics, from optical communication and coding to device fabrication and quantum optics. Currently, DTU Fotonik includes approx. 220 researchers, including 90 Ph.D. students, and educates approx. 40 students enrolled in the M.Sc. programs of Telecommunication Engineering and Photonics Engineering.



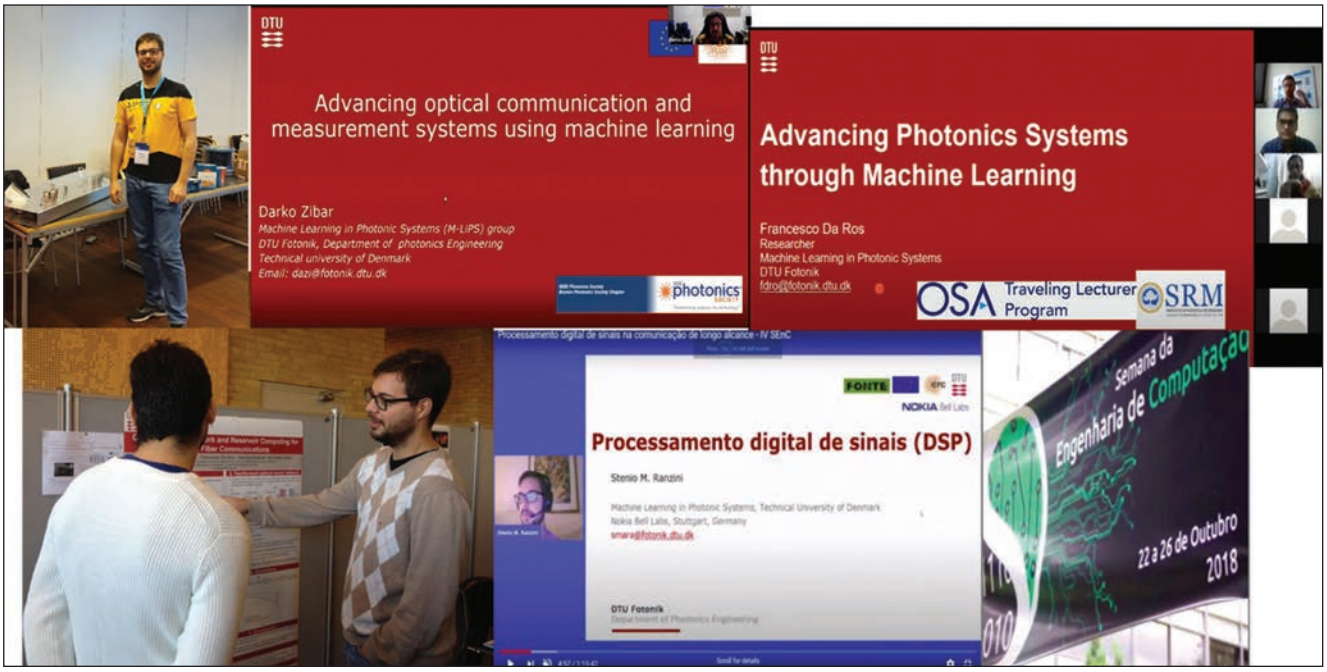
DTU campuses and off-site research and test facilities in Denmark.

Within DTU Fotonik, we are part of the Machine Learning in Photonic System (MLiPS) group, where we focus on the development and application of digital signal processing and machine learning techniques to advance photonic systems. Our targets are classical and quantum measurements and characterization techniques, optical communication, and sensing systems. As our society is heavily dependent on information sharing, the current communication infrastructure needs to constantly evolve to meet future demands. Machine learning (ML) provides extremely powerful tools to enable improving current transmission system, by designing new signaling systems for the nonlinear optical channel, e.g. through the application of autoencoders and neural-network receivers, by enhancing the characterization of devices, such as lasers and frequency combs, by improving optical subsystems, e.g. amplifiers and transponders, and by providing intelligence within network controllers, e.g. through improved quality-of-service estimation. One of our favorite research directions is applying ML techniques to improve optical amplifiers, especially amplifiers able to open new frequency bands for communication. We focus on applying inverse system design which is a powerful approach to design more efficient and fastly reconfigurable amplifiers. Together with our collaborators at Politecnico di Torino and Aston University, we recently demonstrated a multi-band programmable-gain Raman amplifier covering beyond 17-THz of frequency bandwidth. Other than leading an exciting experiment, the joint work allowed us to visit the labs at Aston University and enjoy spending a few weeks in Birmingham.

One of the buildings of DTU Fotonik, designed with a special focus on light. Copyright: Adam Mørk.



Most of the MLiPS group in the lab in front of our in-line optical transmission racks.



Outreach activities of the MLiPS group, recently forced to migrate onto virtual platforms but still allowing to connect with students and colleagues all over the world.

More recently, we started looking into how photonics can help ML, instead of the other way around i.e. applying ML to address photonics problems. We are then looking into developing a photonic hardware platform to solve ML tasks, e.g. through optical neural networks and photonic reservoir computing. That allows us to explore how to use the tools of linear and nonlinear optics to implement effective computations.

Finally, one of the key strengths that characterize our group is being a diverse and highly international environment. Whereas we are only 10 group members, we represent over 7 different nationalities, spread over three continents. We strongly believe in diversity and outreach is thus one of our passions. Lately, outreach activities have been forced to move onto more virtual platforms, but the powerful optical communication backbone still allows us to reach students and colleagues from all over the world. We are always looking for new exciting collaborations on topics bringing together ML and photonics. If the dark Danish winters or the bright Danish summers do not scare you, we are regularly hosting students and researchers on external research stays. You are welcome to reach out if you want to try combining ML and photonics with the Danish 'hygge' environment.