REAL-time monitoring and mitigation of nonlinear effects in optical **NET**works (REAL-NET)

Deliverable 5.4 – Open-to-all Workshop II (OTAW II) (details on courses provided and ESR attendance record)

Project details

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ACRONYMS

ESR(s): Early Stage Researcher(s)

OTAW: Open-to-all Workshop

REAL-NET: REAL-time monitoring and mitigation of nonlinear effects in optical NETworks

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1 EXECUTIVE SUMMARY

This present document is a deliverable based on the first Open-to-all Workshop (OTAW2) organised by REAL-NET, held on 15-19th March 2021, online remotely due to the COVID-19 pandemic.

The OTAW2 on "SINO methods and applications" has been organised concurrently the Lake Como School on "Machine Learning Photonics".

This intensive 5 days event was delivered both by high-profile members of the REAL-NET consortium and their research group, and from external speakers, comprising: David Saad (Aston University, UK), Nathan Kutz (University of Washington), Darko ZIbar (DTU, Denmark) and Demetri Psaltis (EPFL, Switzerland).

The event addressed ESRs from the REAL-NET and other ITNS FONTE, MOCCA, WON, POST DIGITAL and MULTIPLY, with **105 participants** included the speakers.

All the 6 REAL-NET ESRs attended the workshop.

2 The event

The entire event was held online and remotely due to the coronavirus outbreak, instead of at the lovely Villa Grumello, Lake Como Italy.

Figure 3 Villa Grumello, Lake Como, Italy

This first OTAW, organised by REAL-NET (OTAW2), has been a 5 days event focused on comprehensive review talks from major figures in complementary areas of photonics, machine learning and SINO methods and applications. The event took place on 15-19th March 2021 and it was organized by REAL-NET together with other ITNs: FONTE (EID), MOCCA (EID), WON (ETN), POST DIGITAL (ETN) and MULTIPLY (COFUND).

OTAW2 and Lake Como School, brings together experts in emerging photonic technologies, machine learning techniques, and fundamental physics who will share with young researchers their knowledge and interdisciplinary approaches for understanding and designing complex photonic systems and their practical applications.

The areas covered included, but were not limited to: machine learning methods and complexity of optical communication systems, including topics such as the nonlinear Fourier transform and transmission over multimode fibres; complexity in quantum systems emulated in photonics (including optical computing); complexity of emerging novel materials, device and components such as micro-resonators and plasmonic nanostructures. Importantly, the complexity in bio-medical photonic applications will be also considered as a high priority topic.

School Directors

- **Claudio Conti**, Institute for Complex Systems, CNR, and Sapienza University, Rome, Italy
- **Roberto Morandotti**, INRS, Montreal, Canada
- **Sergey Turitsyn**, Aston University, Birmingham, UK
- **Stefan Wabnitz**, Sapienza University of Rome, Rome, Italy

The OTAW2 was widely advertised through REAL-NET website, personal contacts, mailing lists, LinkedIn and social media, such as Twitter, where the information was extensively re-tweeted within all the projects and people involved, reaching the final number of 105 participants, including the speakers.

All the 6 ESRs of REAL-NET participated in the event.

2.1 Agenda

The complete agenda of the event is available on the Lake Como School Website: https://mlph.lakecomoschool.org/preliminary-program/ and also in annex 1.

2.2 Main Speakers

- **Nathan Kutz**, University of Washington, USA: Machine Learning for Physics Discovery and Control in Optical Systems
- **Demetri Psaltis**, EPFL, Switzerland: Machine learning in imaging in complex optical media
- **Serge Massar**, ULB Bruxelles, Belgium: Towards high-performance spatially parallel optical reservoir computing
- **Goery Genty**, Tampere University, Finland: Machine learning analysis of extreme events in optical modulational instability
- **Darko Zibar**, DTU, Denmark: Machine learning techniques for optical communications
- **Shuangyi Yan**, University of Bristol, UK: Machine-learning applications in future optical networks
- **Stéphane Barland**, Institut Non Linéaire de Nice, France: Resonator neuron and triggering multipulse excitability in laser with injected signal
- **Diederik Wiersma**, LENS Lab, Italy, Nanophotonics-based micro robotics
- **Lorenzo Pavesi**, Università di Trento, Italy: Relationship between brain connectivity and function by integrated photonics
- **Ingo Fisher**, CSIC-UIB, Spain: Ultrafast photonic reservoir computing: from fundamental properties to real-world applications
- **P.T. Lau**, The Hong Kong Poly University, Hong Kong: Machine learning applications in optical Communications and Networks
- **Benjamin Wetzel**, XLIM France: Nonlinear guided optics & applications: from ultrashort pulse processing to multidimensional control
- **Claudio Conti**, CNR-ISC, Italy: Neuromorphic computing and Ising machines by wave
- **Daniel Brunner**, Institut Femto, France: How to do reservoir computing with photonic systems; 3D photonic integration for scalable photonic neural networks
- **Mathieu Chagnon**, Nokia Bell Labs, Germany: Reinventing Communication Methods with Machine Learning: From Bits-in to Bits-out
- **Kathy Lüdge**, TU Berlin, Germany: Reservoir computing with laser networks: Performance, Memory capacity and optimization via Eigenvalue analysis
- **David Saad**, Aston University, UK: Machine learning beyond the hype – principled methods for photonics
- **Aurelio Uncini**, Sapienza University of Rome: Deep Neural Networks: New Trends and Perspective for Big-Data Applications

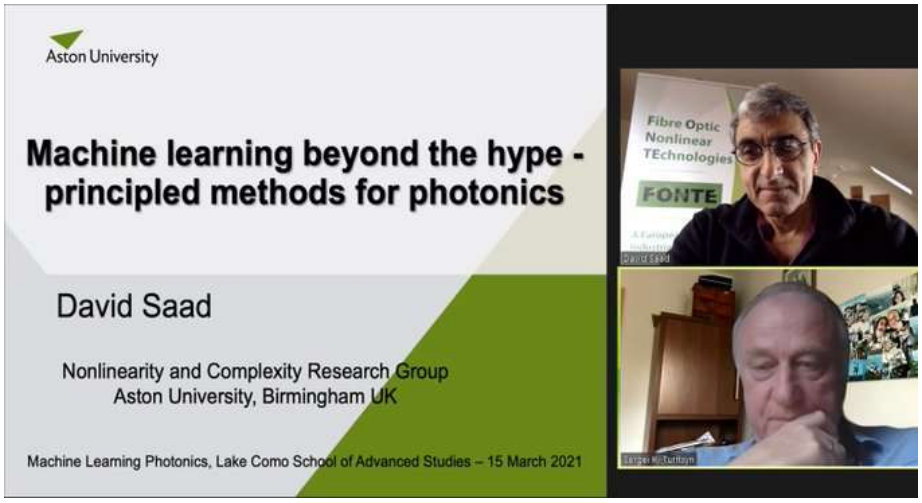

Figure 2 Prof. David Saad one of the speakers of the OTAW2 event (on the top right) and Prof. Sergei K. Turitsyn, REAL-NET coordinator and School director (bottom right)

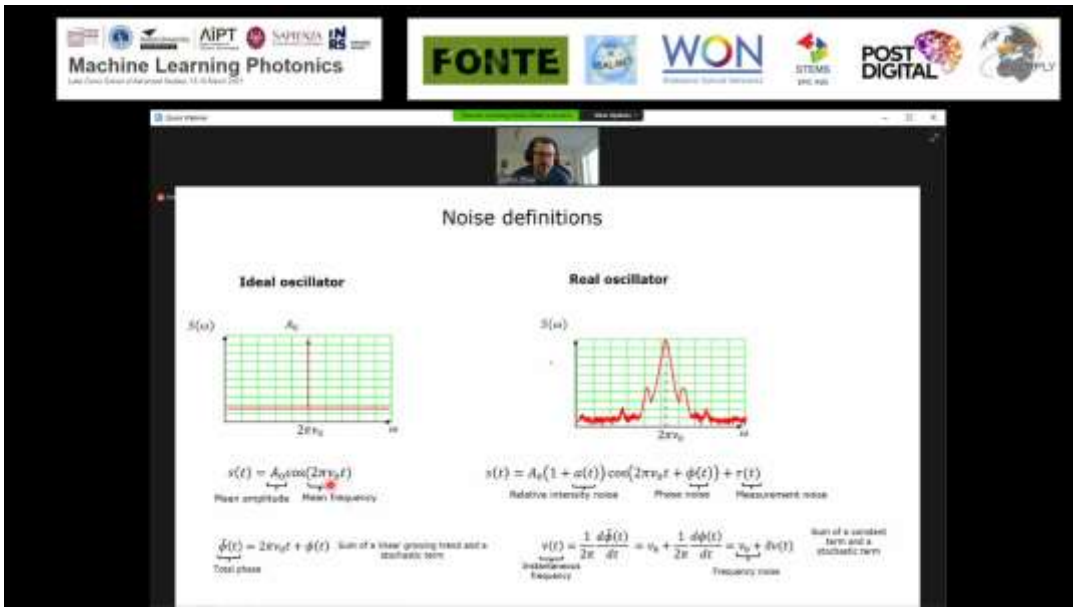

Figure 4 Prof. Darko Zibar´s lecture on Machine Learning during the Lake Como School/OTAW 2 event

3 Post event organization

Most of the lectures are going to be available to all the participants who attend the event.

We expect a substantial impact of the overall event in terms of cross-fertilization between different topics, and knowledge sharing between invited speakers and participants.

ANNEX I:

Final Program (all times are in Central European Time)

Monday, March 15

Morning session, Moderators: **Claudio Conti** (9:00-11:15) and **Sergei Turitsyn** (11:15-12:45)

9:00-9:15 Welcome by **Claudio Conti**, **Roberto Morandotti**, **Sergey Turitsyn** and **Stefan Wabnitz**

9:15-10:15 **Aurelio Uncini**, Sapienza Università di Roma, Italy, "Deep neural networks: new trends and perspective for big-data applications I"

10:15-11:15 **Claudio Conti,** Sapienza and CNR-ISC, Italy**:** "Ising Machine by waves"

11:15-11:45 Virtual coffee break

11:45-12:45 **David Saad**, Aston University, UK: "Machine learning beyond the hype – principled methods for photonics"

12:45-14:00 Virtual lunch

Afternoon session, Moderators: **Claudio Conti** (14:00-15:00) and **Stefan Wabnitz** (15:00-16:00)

14:00-15:00 **Aurelio Uncini**, Sapienza Università di Roma, Italy: "Deep Neural Networks: New trends and perspective for big-data applications II"

15:00-16:00 **Nathan Kutz,** University of Washington, USA**:** "Machine learning for physics discovery and control in optical systems I"

Tuesday, March 16

Morning session, Moderator: **Stefan Wabnitz**

9:00-10:10 **P.T. Lau,** The Hong Kong Poly University, Hong Kong**:** "Machine learning applications in optical Communications and Networks"

10:00-11:00 **Miguel C. Soriano**, IFISC (CSIC-UIB), Spain: "Ultrafast photonic reservoir computing: From fundamental properties to real-world applications"

11:00-11:30 Virtual coffee break

11:30-12:30 **Benjamin Wetzel**, XLIM France: "Nonlinear guided optics & applications: from ultrashort pulse processing to multidimensional control"

12:30-14:00 Virtual lunch

Afternoon session, Moderator: **Benjamin Wetzel**

14:00-15:00 **Demetri Psaltis**, EPFL, Switzerland: "Machine learning for imaging in complex optical media"

14:00-15:00 **Darko Zibar**, DTU, Denmark: "Advancing classical and quantum photonic system design using machine learning I"

16:00-16:30 Virtual coffee break

16:30-17:30 **Shuangyi Yan**, University of Bristol, UK "Machine-learning applications in future optical networks"

17:30-18:15 **Nathan Kutz,** University of Washington, USA**:** "Machine learning for physics discovery and control in optical systems II"

Wednesday, March 17

Morning session, Moderator: **Stefan Wabnitz**

9:00-10:00 **Lorenzo Pavesi**, Università di Trento, Italy, "Is it possible to make living neurons and optical microresonators compute together? I"

10:00-11:00 **Demetri Psaltis**, EPFL, Switzerland: "Optical machine learning using nonlinear propagation in multi-mode fibers"

11:00-11:30 Virtual coffee break

11:30-12:30 **Stephane Barland**, Institut Non-Linéaire de Nice, France: "Effective low-dimensional dynamics of a mean-field coupled network of slow-fast spiking lasers"

12:30-14:00 Virtual lunch

Afternoon session, Moderator: **Roberto Morandotti**

14:00-15:00 **Goery Genty**, Tampere University, Finland, "Machine learning analysis of instabilities and coherent nonlinear dynamics in fibre-optic systems"

15:00-16:00 **Darko Zibar**, DTU, Denmark: “Advancing classical and quantum photonic system design using machine learning II”

16:00-16:30 Virtual coffee break

16:30-18:00 **Kathy Lüdge**, TU Berlin, Germany: “Reservoir computing with laser networks: Performance, Memory capacity and optimization via Eigenvalue analysis”

Thursday, March 18

Morning session, Moderator: **Sergei Turitsyn**

9:00-10:00 **Claudio Conti,** Sapienza and CNR-ISC, Italy**,** “Extreme Learning Machine by waves”

10:00-11:00 **Daniel Brunner,** Institut Femto, France: “How to do reservoir computing with photonic systems”

11:00-11:30 Virtual coffee break

11:30-12:30 **Mathieu Chagnon**, Nokia Bell Labs, Germany: “Reinventing communication methods with machine learning: from bits-in to bits-out”

12:30-14:00 Virtual lunch

Afternoon session, Moderator: **Claudio Conti**

14:00-15:00 **Serge Massar,** ULB Bruxelles, Belgium: “The mathematical basis for reservoir computing”

15:00-16:00 **Lorenzo Pavesi**, Università di Trento, Italy, “Is it possible to make living neurons and optical microresonators compute together? II”

Friday, March 19

Morning session, Moderator: **Claudio Conti**

9:00-10:00 **Diederik Wiersma**, LENS Lab, Italy, “Photonic microrobotics and responsive materials for AI”

10:00-11:00 **Daniel Brunner**, Institut Femto, France: “3D photonic integration for scalable photonic neural networks”

11:00-11:30 Virtual coffee break

11:30-12:30 **Stephane Barland**, Institut Non-Linéaire de Nice, France:“ Convolutional neural networks for self-mixing interferometry”

12:30-12:45 **Claudio Conti**, **Roberto Morandotti**, **Sergei Turitsyn**, and **Stefan Wabnitz**: Summary and conclusions

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