Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Dates: April 2021 - September 2022

Laboratory: Wavefront Engineering Lab, Department of Applied Physics
Institution: Universitat de Barcelona
City, Country: Diagonal Sud Campus, Barcelona

Title of the master thesis: Neural-network based approach to the Non-Line of Sight Imaging problem.

Name of the master thesis supervisor and co-supervisor:
(for external proposals a co-supervisor from the Master program in needed)

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Keywords: Non-line-of-sight Imaging, computational imaging, neural networks

Summary of the subject (maximum 1 page):

The ability to see through walls has always been an impossible ambition. Recently, several research groups have proposed solutions that circumvent the problem. Instead of looking through the obstacle, which gives no information, they analyze the light that is scattered when reflected in a lateral obstacle. This approach is called Non-Line-of-Sight (NLOS) imaging and the first publication in this field is relatively recent (see ref. [1]). After this seminal work, various solutions that improve the performance of the original method have been published (see, for instance, [2] and references therein). Interestingly, the November issue of Optics & Photonics News features a must-read article highlighting recent research in NLOS [2]. In general, NLOS endeavors focus on reducing the calculation effort, so the retrieved image could be (ideally) obtained in real-time.

The analysis of the scattered light is not enough to reconstruct the object behind the wall. This information is complemented with the flight time of every considered ray. This data is obtained using a pulsed laser and appropriate sensor. Correlating these two measurements is by no means trivial and produces an exponential grow of the dimensionality of the problem. Nevertheless, since light is propagated according to wave diffraction theory, Liu and collaborators have recently proposed a smart solution based on Fourier optics methods [3].

The present master thesis project focuses on the implementation of a NLOS system based on neural networks. A large dataset can be synthetically produced using propagation algorithms and a proper calibration of the lateral surface, whereas the time of flight measurements will be estimated using Lidar. Finally, this information will be used to train a Deep Neural Network with the aim to speed up the reconstruction process.

References

1. A. Velten, T. Willwacher, O. Gupta, A. Veeraraghavan, M. G. Bawendi and R. Raskar, "Recovering three-dimensional shape around a corner using ultrafast time-of-flight imaging", Nat. Commun. **3,** 745 (2012).
2. X. Feng and L. Gao, "Toward Non-Line-of-Sight Videography", Optics and Photonics News, November (2021)
3. X. Liu, I. Guillén, M. La Manna, J. H. Nam, S. A. Reza, T.-H. Le, A. Jarabo, D. Gutierrez and A. Velten, "Non-line-of-sight imaging using phasor-field virtual wave optics, Nature **572**, 620–623 (2019)

Additional information (if needed):
Prospective students are encouraged to contact the advisors before registration.

Required skills:

- Outstanding programming skills in Python.
- Beam propagation (Fourier optics)
- Image processing techniques
- Machine learning and neural networks