Kavan Ahmadi

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PROFILE:

- Self-motivated Ph.D. candidate with interdisciplinary research expertise in photonics techniques for device authentication and encryption
- Rich experience in experimental optical methods such as interferometry, polarimetry, Fourier optics, digital holography, and imaging system
- Experience in computer simulation using Python and familiar with OSLO and Flex PDE
- Rich experience in data acquisition and controlling electro-optical devices using LabVIEW
- Rich experience in analyzing and classifying images using machine learning algorithms such as k-NN, SVM, and CNN. Implementing Neural Network using Tensorflow and Keras
- Experience in 3D printing
- Computer Skills: Linux and Windows
- Language Skills: Persian (Native), Kurdish (Mother's tongue), English (B2/C1), Spanish (A2), Catalan (A2)

EDUCATION:

- University of Barcelona, Barcelona, Spain
  Ph.D. Physics, October 2017- December 2022 (Expected)
  Award: Predoctoral Research Fellowship (APIF), July 2019- June 2022
  Thesis title: *Classifying synthesized optical codes using polarimetric information and machine learning algorisms for optical security applications*

- Malek Ashtar University of Technology, Shahinshahr, Isfahan, Iran
  M.S. Electro-Optical Engineering-Laser, 2011-2013
  Thesis title: *Thermal analysis of Nd:YAG Laser active material based on slab geometry*
  GPA: 3.7/4

- Razi University, Kermanshah, Iran
  B.S. Physics, 2005-2009
  GPA: 2.7/4

RESEARCH INTERESTS:

- Optical encoding
- Wavefront engineering
- Highly focused fields
- Beam modulation
- Fourier optics
- Digital holography
- Machine learning
- Pattern classification
- Polarization optics

RESEARCH EXPERIENCE:

University of Barcelona, Barcelona
Ph.D. Candidate, 2017-present

a. Optical authentication
Document signature is a powerful technique used to determine whether a message is fake or valid. Three-dimensional (3D) printing can be understood as any group of processes by which some materials are joined or solidified through a computer-controlled system in order to create a three-dimensional object. 3D printers can be used to print different types of structures using a relatively large number of materials and with different types of filling patterns. We demonstrated that the combined use of optical techniques and machine learning algorithms might be able to distinguish among different classes of samples. We produced

nanoparticle encoded optical codes with predetermined designs synthesized with a 3D printer. Each sample was characterized by analyzing the polarization state of the emerging light. Using the one class-support vector machine algorithm, we found high accuracy figures in recognition of the true class codes.

b. Optical visual encryption

Secret sharing and exclusive-OR visual encryption are related security techniques that have also been ported to the optical domain. In this regard, we proposed a system able to transmit text using the visual encryption paradigm. The characters of a string are sequentially processed, one at a time. The binary representation of every character of the string is split in two using the usual XOR approach, and then the two resulting characters are independently manipulated. Each character is holographically encoded and used as the input of an optical setup able to produce focused fields with tunable spiral polarization. On the other side, the characters are recovered by interrogating a convolutional neural network that is trained in a previous stage.

c. Beam modulation

Twisted nematic liquid crystal spatial light modulators (TNLC-SLMs) are kind of relatively low-cost electro-optics devices widely used in many branches of optical information processing. We applied an efficient and fast approach to generate light beams with arbitrary intensity profiles and phase distributions. The process includes a fast method to characterize LCD based on a modified Mach-Zehnder interferometer configuration and fringe analysis in the Fourier domain, double-pixel hologram (DPH) Arrizon's approach for encoding arbitrary complex modulation, and finally, fast mapping of DPHs using the k-Nearest Neighbor Classifier.

Wavefront Engineering Group, Department of Applied Physics, University of Barcelona
Researcher, 2019-present. https://www.ub.edu/waveng/
Funding, Agencia Española de Investigación, R&D project # PID2019-104268GB-C2

d. Highly focused electromagnetic field

The detection of the longitudinal component of a highly focused electromagnetic beam is not a simple task. Although several methods have been reported in the literature in recent years, this measure is still not routinely performed. We proposed a method that allows us to estimate and visualize the longitudinal component of the field in a relatively simple way. First, we measured the transverse components of the focused field in several planes normal to the optical axis. Then, we determined the complex amplitude of the two transverse field components: the phase was obtained using a phase recovery algorithm, while the phase difference between the two components was determined from the Stokes parameters. Finally, the longitudinal component was estimated using Gauss's theorem. Experimental results demonstrated an excellent agreement with theoretical predictions. I participated in this team-working task in designing and implementing the experiment.

e. Wavefront sensing

We presented a method to estimate the aberrated wavefront at the focal plane of a vectorial diffraction system. In contrast to the phase, the polarization state of optical fields is simply measurable. In this regard, we introduced an alternative approach for determining the aberration of the wavefront using polarimetric information. The method is based on training a convolutional neural network using a large set of polarimetric mapping images obtained by simulating the propagation of aberrated wavefronts through a high-NA microscope objective; then, the coefficients of the Zernike polynomials could be recovered after interrogating the trained network.

TEACHING EXPERIENCE:

University of Barcelona, Department of Applied Physics and Optics, Barcelona
Teaching Assistant
Fundamental Optics Laboratory, September 2019- present

CHAPTER BOOKS:

1. **K. Ahmadi**, "Beam implementation with a translucent twisted-nematic liquid crystal display," in P. J. Rosen (Ed.), "Holography- Recent Advances and Applications," IntechOpen, Rijeka, 2022, Ch. 25. DOI: 10.5772/intechopen.105671.

JOURNAL PAPERS:

2. **K. Ahmadi** and A. Carnicer, "Optical visual encryption using focused beams and convolutional neural networks" Opt. Lasers Eng, 161, 107321(2023)
3. D. Maluenda*, M. Aviñoá*, **K. Ahmadi***, R. Martínez-Herrero, and A. Carnicer, "Experimental estimation of the longitudinal component of a highly focused electromagnetic field," Sci Rep 11, 17992 (2021) [* Equally contributed authors]
4. **K. Ahmadi**, P. Latorre-Carmona, B. Javidi, and A. Carnicer, "Polarimetric Identification of 3D-Printed Nano Particle Encoded Optical Codes," IEEE Photonics, 12(3), 1-10 (2020)

CONFERENCE PAPERS:

5. **K. Ahmadi,** A. Carnicer, "*Estimation of Zernike polynomials for a highly focused electromagnetic field using polarimetric mapping images and neural networks,*" J. Phys.: Conf. Ser. **2407** 012002, 2022 (oral presentation in V International Conference on Applications of Optics and Photonics)
6. **K. Ahmadi**, D. Maluenda, and A. Carnicer, "*Fast mapping of Double-Pixel Holograms using K-nearest Neighbors*," OSA Imaging and Applied Optics Congress, DW5E.7, 2021 (oral presentation)
7. **K. Ahmadi**, I. Juvells, A. Carnicer, "*On how thick diffusers can contribute to the design of optical security systems*," Proc. SPIE 11207, Fourth International Conference on Applications of Optics and Photonics, 112071H, 2019 (poster presentation)

OTHER CONTRIBUTIONS:

8. **K. Ahmadi**, "*Encoding ASCII codes into an optical beam*," IONS Ireland 2021 (oral presentation)
9. M. Aviñoá, D. Maluenda, **K. Ahmadi**, R. Martínez-Herrero, and A. Carnicer, "GUI-Based Phase Retrieval Algorithm for the Reconstruction of the Longitudinal Component of Electromagnetic Beams," in V International Conference on Applications of Optics and Photonics-AOP2022 (poster presentation).
10. D. Maluenda, M. Aviñoá, **K. Ahmadi**, A. Carnicer, and R. Martínez-Herrero, "On the total estimation of the electromagnetic field in the focal area with no interaction with the media," in V International Conference on Applications of Optics and Photonics-AOP2022 (keynote).

ACTIVITIES:

- Optica, student member, 2021-present
- IEEE Access, volunteer reviewer, 2020-present

WORK STYLE:

- Willing to perform basic tasks to solve complex problems
- Able to learn new knowledge required for a new field of research
- Strong independent work style and excellent teamwork skills
- Well-organized and passionate