



ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME



Scientific Report

First name / Family name

Esdras Anzuola

Nationality

Spain

Fraunhofer Institute of Optronics,
System Technologies and Image
Exploitation IOSB

Name of the *Host Organisation*

Szymon Gładysz

First Name / family name
of the *Scientific Coordinator*
Period of the fellowship

Adaptive Optics Group Leader

01/07/2015 to 28/02/2017

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The main focus of our research has been the development of mathematical models and optimization techniques in the context of adaptive optics and free space optical communications.

During this fellowship we have first evaluated and proposed blind search algorithms based on model-free stochastic optimization techniques and we have evaluated their convergence rates and correction capabilities. Optimization of Genetic Algorithms (GA), Stochastic Parallel Gradient Descent (SPGD), Simulated Annealing (SA) or Algorithms of Pattern Extraction (Alopex) based on new modal decomposition of the input parameters related to the characteristics of the turbulent atmosphere has been proposed, implemented and published.

We have also focused our research on developing mathematical models for describing some of the effects that dynamic atmosphere has on optical systems. First we published a method for emulating dynamic atmosphere using computational techniques and we

demonstrated that the method is able to produce dynamic wavefronts that follow the behaviour predicted by the theory while introducing key advantages in terms of storage in computer memory. Second, we proposed a statistical model for describing the turbulence-induced fading on optical systems. This model was compared with numerical simulations for different scenarios, where uncompensated and compensated techniques were applied.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Anzuola, Esdras, and Szymon Gladysz. "Modeling dynamic atmospheric turbulence using wave-front temporal spectra and Karhunen-Loève decomposition" accepted in *Optical Engineering*, 2017

Anzuola, Esdras, and Szymon Gladysz. "Statistical model for free-space optical coherent communications using adaptive optics." *SPIE Security+ Defence*. International Society for Optics and Photonics, 2016.

Anzuola, Esdras, et al. "Performance of wavefront-sensorless adaptive optics using modal and zonal correction." *SPIE Remote Sensing*. International Society for Optics and Photonics, 2016.

Karin Stein, Szymon Gładysz , Andreas Zepp, Esdras Anzuola, Max Segel. "Novel wavefront strategies for strong atmospheric turbulence". *Optronics in Defense and Security*, January 2-4, 2016, Paris, France

Anzuola, Esdras, and Aniceto Belmonte. "Experimental analysis of adaptive optics compensation in free-space coherent laser communications." *SPIE Optical Engineering+ Applications*. International Society for Optics and Photonics, 2016.

Anzuola, Esdras, et al. "Holographic wavefront sensor based on Karhunen-Loève decomposition." *SPIE Optical Engineering+ Applications*. International Society for Optics and Photonics, 2016.

Segel, Max, et al. "Modal vs. zonal wavefront-sensorless adaptive optics for free-space laser communications." *Adaptive Optics: Analysis, Methods & Systems*. Optical Society of America, 2016.

Anzuola, Esdras, et al. "Holographic Wavefront Sensing for Atmospheric Turbulence using Karhunen-Loève Decomposition." *Adaptive Optics: Analysis, Methods & Systems*. Optical Society of America, 2016

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Adaptive Optics: Analysis, Methods & Systems (AO)

Heidelberg, Germany, 25 - 28 July 2016

SPIE Optics + Photonics

San Diego, California, United States, 6 - 10 August 2016

SPIE Security + Defense

Edinburgh, Scotland, 25 – 29 September 2016

SPIE Remote Sensing

Edinburgh, Scotland, 25 – 29 September 2016

IV – RESEARCH EXCHANGE PROGRAMME (REP)

REP Organisation: Fraunhofer Heinrich-Hertz Institute

Country: Germany

Department or project: Free space optical communications

Local scientific coordinator: Nicolas Perlot

Dates: 27/06 to 1/07 2016

The REP programme was useful in terms of exchanging information and contacts with other Institute that is focused on similar fields of research. It was an interesting time for me as I could see in detail how other laboratories are organized and in which kind of applications or projects we could be involved together.