Super-resolution wavefront reconstruction

Sylvain Oberti*[1], Pierre Guiraud[2], Thierry Fusco[3,4], Benoit Neichel[3], Guido Agapito[5], and Carlos Correia[6,7]

[1]ESO – Germany
[2]Centro de Investigacion y Modelamiento de Fenomenos Aleatorios Valparaiso, Universidad de Valparaiso (CIMFAV) – Valpariaso, Chile
[3]Aix Marseille Université, CNRS, LAM – CNRS : UMR7326 – France
[4]Département d'Optique Théorique et Appliquée (DOTA) – ONERA – BP 52 29 avenue de la Division Leclerc 92320 Châtillon Cedex, France
[5]INAF - Osservatorio di Arcetri (INAF-Arcetri) – Italy
[6]MPIA – Germany
[7]SpaceODT – Portugal

Abstract

Super-resolution is a technique that seeks to upscale the resolution of a set of measured signals. Super-resolution retrieves higher-frequency signal content by combining multiple lower resolution sampled datasets. This method is well known both in the temporal and spatial domains, and widely used in imaging to reduce aliasing and enhance the resolution of coarsely sampled images. This talk describes the novel application of the super-resolution technique to the bi-dimensional wavefront reconstruction. In particular, we show how super-resolution is intrinsically suited for tomographic multi WaveFront Sensor (WFS) AO systems revealing many of its advantages with minimal design effort.
Starting from an intuitive mono-dimensional case, this talk provides a mathematical formalism for analyzing super-resolution configurations, followed by a numerical analysis of simulated SR systems for representative multi-WFS SH AO systems. Our results show that combining several WFS samples in a SR framework grants access to a larger number of modes than the native one offered by a single WFS. We also show that the associated noise propagation is not degraded under super-resolution. Then, the application of the super-resolution concept to future AO system design is illustrated for the cases of MORFEO, HARMONI-LTAO and MAVIS. Finally, we present some first results of on sky validation with GALACSI NFM and explore the extension of the method to Pyramid WFSs.
In summary, Super-resolution applied to Wavefront sensing and its reconstruction offers a new parameter space to explore as it decouples the size of the subaperture from the desired wavefront sampling resolution. By cutting short with old assumptions, new, more flexible and better performing AO designs become now possible.

*Speaker