Adaptive optics assisted imager co-design for space observation from the ground

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Adaptive optics is used to mitigate the effects of atmospheric turbulence on imaging systems, but the correction is only partial and deconvolution is often required to improve the resolution. This results in entire optical/digital systems which are traditionally designed sequentially, *i.e.* the adaptive optics system is optimised first regarding PSF-based criteria, and the restoration algorithms are designed in a second step. However, this sequential approach is sub-optimal since, by doing so, the optimisation of the optical system design doesn't take into account the deconvolution process. Besides, PSF-based criteria are somewhat arbitrary as it reflects the focal plane images quality while the quantity of interest is the restored images quality.
Studies on optical/digital systems suggest that jointly optimising the whole system regarding the restored images quality is a better alternative. This approach is referred to as "joint optical/digital design" or "optical/digital co-design" in the literature. We propose to extend the co-design strategy proposed by Stork & Robinson [1] to the design of an adaptive optics assisted imaging system. We derive a simple criterion that takes into account the source properties and the entire optical/digital system performance. To illustrate the interest of using this approach, we use it to optimise the flux distribution between the wavefront sensor and the imaging camera. Later, any parameter of the optical/digital system, if not the entire system itself, could be optimised this way.

References

[1] D. G. Stork and M. D. Robinson, "Theoretical foundations for joint digital-optical analysis of electro-optical imaging systems," *Appl. Opt., AO*, vol. 47, no. 10, pp. B64–B75, Apr. 2008, doi: [10.1364/AO.47.000B64](https://doi.org/10.1364/AO.47.000B64).