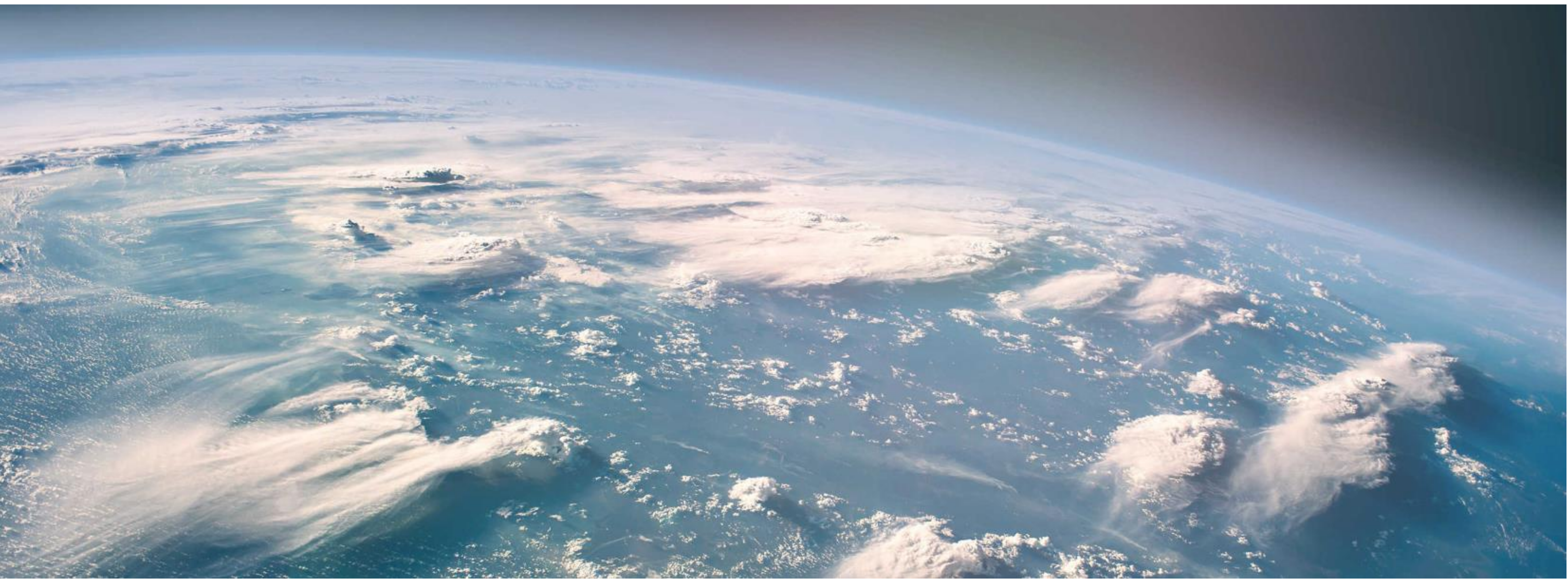
SURPRISE

SUPER-RESOLVED COMPRESSIVE INSTRUMENT IN THE VISIBLE AND MEDIUM INFRARED FOR EARTH OBSERVATION APPLICATIONS



Detailed Design Report

[D4.3]

CNR – IFAC

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Compressive Sensing (CS) is an innovative signal acquisition technique that benefits from the feature of many natural signals being highly correlated. The main idea of CS is that, with prior knowledge about the signal's sparsity, the signal can be reconstructed using fewer samples. In a standard signal compression strategy, data are first sampled and then compressed to reduce final data volume. CS, on the other hand, aims to reduce the volume of acquired signal samples.

CS techniques rely on the acquisition of a set of spatially integrated measurements of the scene of interest, modulated by a suitable spatial pattern. In practice, this is obtained by using an SLM that physically performs the scalar product between a random pattern and the incoming light, followed by an optical assembly that concentrates signal on a single element detector that acquires it.

Although CS has mainly been used for merging data acquisition and compression into a single step, it can be also used to acquire images whose resolution after reconstruction is increased up to that of the coding pattern applied. This concept is referred to as the super-resolution approach. A super-resolution imaging system is an imaging system that acquires images with a number of pixels enhanced with respect to the nominal one. In order to ensure that the highest spatial frequency present in the image to be acquired will be captured, the dimensions of the single modulating elements of the SLM must be equal to or smaller in size than the diffraction-limited spot blur formed by the fore-optics at the image plane.

Concerning the instrument's architecture, the idea behind the concept is the single-pixel camera: the image produced by the collection optics is modulated at the image plane by an SLM - acting as a coding mask - and the signal transmitted through the SLM is focused by an optical condenser on a single pixel detector. Finally, a set of measurements – each corresponding to a different modulation pattern applied to the image – is used to reconstruct the original image by using suitable CS reconstruction algorithms.

The aim of the SURPRISE's demonstrator is to show how the use of Spatial Light Modulation (SLM) technology and Compressive Sensing (CS) approach can be exploited to yield a significant improvement of the performance of EO super-spectral payloads in the visible (VIS), near- (NIR) and medium-wave infrared (MIR), in terms of their spatial resolution, on-board data processing and data encryption capabilities.

Deliverable 4.3 deals with the design of the SURPRISE demonstrator. The instrument's working principle is based on the use of an SLM to increase the number of pixels of the image observed by the instrument's fore-optics. The architecture of the SURPRISE demonstrator consists of three functional main blocks: optical section, target scanning system and master unit.

The design of the optical section of the demonstrator started with the in-depth study of SLM performances in order to select the most suitable model amongst those commercially available. Starting from the selected SLM model, the optical CAD yielded the definition of all the major optical parameters needed for the implementation of the demonstrator in the laboratory. The results also allowed to identify all the optical subsystems (SLM, MWIR detectors, VIS-NIR dispersion and detection system, HI-RES camera) and optical components with relevant mounts. Most of them are COTS.

The design of the target scanning system ensures maximum flexibility and it includes: the identification of a set of targets in the VIS-NIR and MWIR spectral regions, the selection of suitable movement stages and the definition of the SW architecture and relevant protocols to interface the master unit.

The Master Unit for the synchronisation and data storage and management is designed to control a heterogeneous set of sensors and actuators. The SW architecture and files format is also defined.

In this deliverable, we also outline a general procedure for the optical alignment of the demonstrator and for the alignment of the target with respect to the optical system. Additional calibration and alignment procedures to take into account additional factors for the alignment of the target scanning system are also described.

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