Master thesis and internship[BR]- Master's thesis : Improvement of the optical setup of a compressive sensing imager[BR]- Internship

Auteur : Ruwet, Emile
Promoteur(s) : Georges, Marc
Faculté : Faculté des Sciences appliquées
Diplôme : Master en ingénieur civil en aérospatiale, à finalité spécialisée en "aerospace engineering"
Année académique : 2023-2024
URI/URL : http://hdl.handle.net/2268.2/20509

Improvement of the optical setup of a compressive sensing imager

Author:
Emile RUWET

Academic supervisor:
Marc GEORGES

Committee members:
Lionel CLERMONT
Serge HABRAKEN
Laurent JACQUES

Master's thesis completed in order to obtain the degree of Master of Science in Aerospace Engineering by Emile RUWET

University of Liège - Faculty of Applied Sciences
Academic year 2023-2024

Abstract

Compressed sensing is an emerging field that allows for the recovery of a sparse signal from fewer measurements than permitted by the Nyquist theorem. This new paradigm can be used to create new imager architectures that are simpler, more compact, and cheaper than traditional imagers, acquiring images in a compressed manner and thereby reducing the amount of data to handle. These characteristics are appealing for potential implementation in Earth observation satellites, where size and weight are critical factors, and where the amount of collected data is substantial, with limited storage capacity and transfer rates to the ground.

This master's thesis focuses on the implementation of the optical part of a compressive sensing imager in the laboratory, with the objective of performing a particular compressive sensing reconstruction method, known as inpainting. A comprehensive review of the state of the art in compressive sensing and various imager architectures is first provided. Afterwards, the design of the instrument and the selection of all its components are extensively detailed. A digital micromirror device is used for producing incomplete, damaged images of a scene, and a camera detector records the resulting image. Subsequently, a calibration procedure for the damaged images was established to prepare them for reconstruction through inpainting. This calibration includes dark and flat frame corrections, as well as post-reconstruction image perspective correction. The instrument's point spread function is also measured, and a dithering method is implemented to improve its resolution. Furthermore, the pattern mask used for the reconstruction is studied and calibrated using morphological erosion.

Keywords — compressive sensing, inpainting, optical imaging device, digital micromirror device, Scheimpflug principle, pattern mask, point spread function, dithering

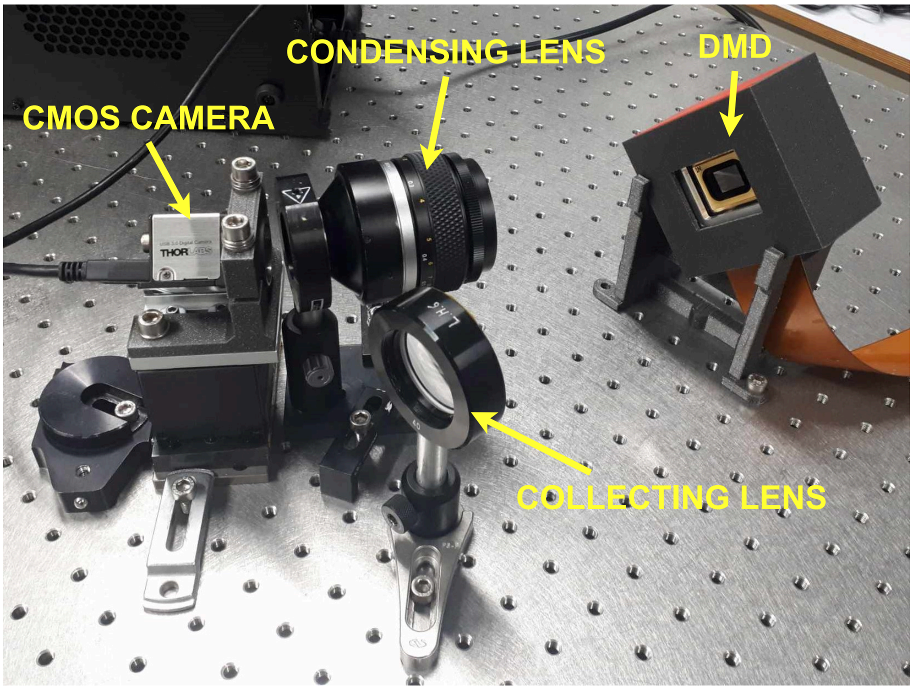


Figure 1: Picture of the assembled imager in the laboratory. The scene is located outside the picture toward the left of the optical setup. The different optical components are highlighted.

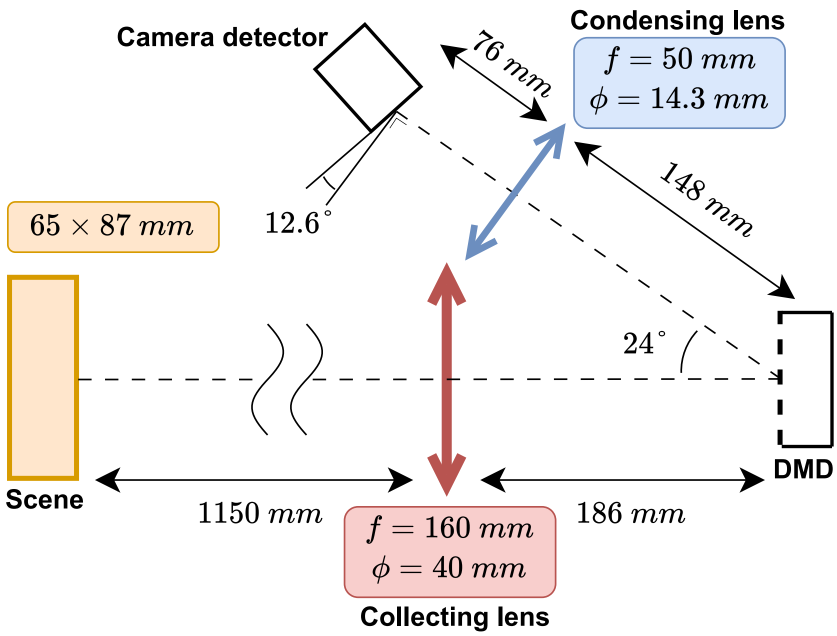


Figure 2: Top view scheme of the imager with its main dimensions.

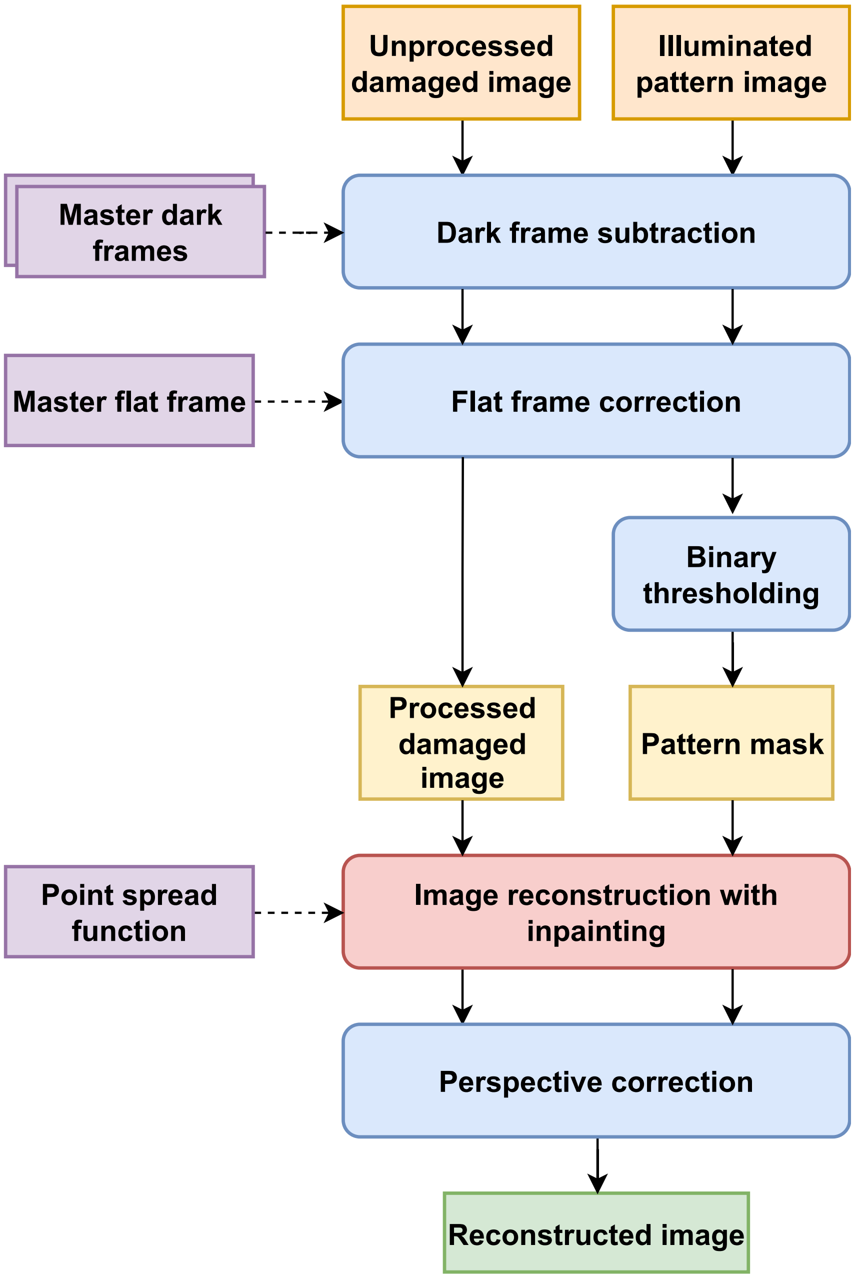
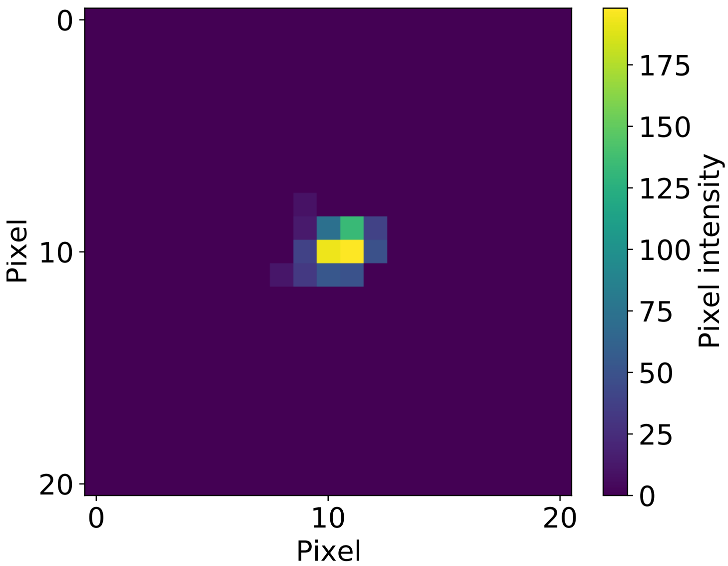
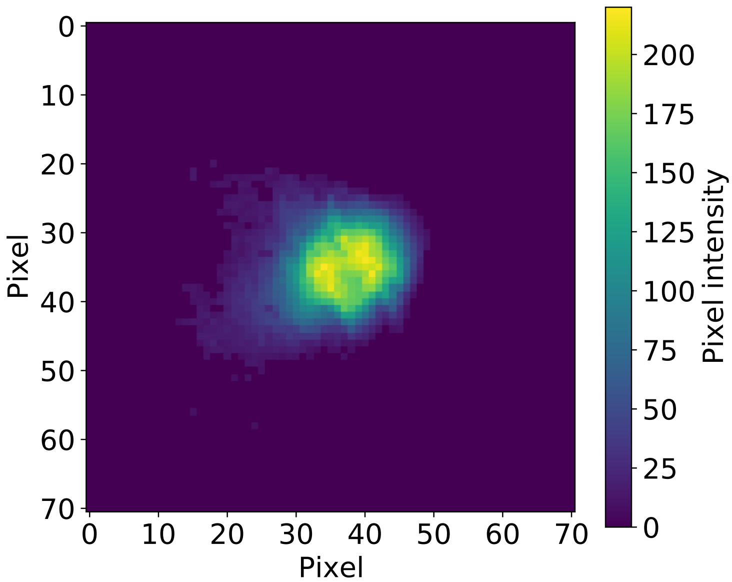


Figure 3: General flowchart of the calibration and post-processing of an image.



(a) Without dithering



(b) With dithering

Figure 4: Comparison between the central PSF of the imager obtained without and with dithering.