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PANCAM Panoramic Camera for planetary and small bodies’s exploration

Paolo Martini[1], Claudio Pernechele[1], Emanuele Simioni[1], Francesca Esposito[1], Fabio D'Amico[1], Ugo Cortesi[2], Marco Gai[2], Andrea Argan[1], Luigi Lessio[1], Immacolata Donnarumma[3], Alessandro Turchi[3], Giovanni Costa[1], Diego Scaccabarozzi[4], Davide Greggio[1], Matteo Massironi[5], and Riccardo Pozzobon[5]
[1]INAF, Osservatorio Astronomico di Padova, Italy (paolo.martini@inaf.it)
[2]IFAC CNR Firenze
[3]ASI Roma
[4]Politecnico di Milano
[5]Università di Padova

I. INTRODUCTION

In the framework of NRRP Earth-Moon-Mars (EMM) initiative PANCAM will deliver a bifocal panoramic camera system with an extremely large field of view (360°x100°). A central image with a higher resolution 20° field of view is also provided. The PANCAM design, prototyping and testing presents numerous technological challenges related to the peculiarity of the optics and the need to ensure scientific validity of the acquired images. Intended for a multi-purpose infrastructure supporting future Lunar and Martian exploration the project, thanks to the presence of a panoramic field of view and a higher resolution channels, allows for different applications such as monitoring of lunar infrastructure, small bodies exploration [3]. PANCAM project involve, also, the development of a software platform able to manage framing and providing correct images for environment analysis . Special effort was , therefore, devoted to ensure a precise frame calibration algorithm to support future metrology applications.

I. PANCAM architecture A. Overall architecture

As a part of EMM project framework PANCAM design requirements for the camera as well as the entire image acquisition system can be summarized in the following table.

Tab 1 - PANCAM list of design parameters

Req. Num.	Table Column Head
EMM-PANCAM Main design parameter	Description
0060	FOV 360x100
0080	Resolution 0.1°/pixel
0050	20° round FOV

0070	RES = 0.03°/px
0020	TID tolerance

PANCAM innovative opto-mechanical design is described [1], overall architecture is outlined in Fig. 1

Thermo-elastic analysis and vibrational tests were carried out to reach a Technology Readiness Level (TRL) of 6 as required by NRRP-EMM project A 3D model was developed to carry out analyses.

To realize the acquisition system requirements as well as providing a flexible platform for future develompment a modular software architecture (see Fig. 2) was designed ensuring high performances on different hardware platforms (CPU-GPU-FPGA architecture). First development in MATLAB tests on the field was carried out. Following main software building blocks was outlined.

Fig. 3 PANCAM Software architecture building blocks

To allow the reconstruction of the scenario, a series of laboratory tests were conducted to correctly calibrate the camera and define a representation model. The tests were carried out at Osservatorio Astronomico di Padova, using specially designed targets.

The following figure (fig. 4) outline PANCAM optical layout.

The PANCAM optical design meets the project requirements as outlined by Optical Performances diagram (fig. 5)

B. Image sensor

An Imperex C2410 sensor with Sony IMX264 COTS RADHARD chip up to 70 krad TID and 3.5 micrometers pixel size was used. The sensor is equipped with a large application library that allows integration into the software platform. Tests was carried out to ensure matching with optics and mechanical framework..

C. On Board Computer

To ensure full elaborative power as well as EMM requirements a Nvidia Jetson computer was selected. The computer will provide a novel GPU architecture able to carry out intensive image acquisition and analysis. This computer architecture provide also space qualification heritage. Further analyses are being carried out to ensure full compatibility of the onboard computer with space standards

D. Image acquisition software

In accordance with the identified software architecture, a series of software modules have been developed with particular reference to acquisition and "image restoration". In particular, the software developments related to the autoexposure algorithm and image dewarping are described.

Autoexposure algorithm

Due to the extremely large field of view, a panoramic lens will necessarily work within a high-contrast scene. This implies that it is presumable to have both under and over exposed regions along the chipset, aside of a well-conditioned counts level. We developed a simple autoexposure algorithm that, based on a set of exposures, chooses for each single pixel the value prior to saturation, thus creating a homogeneously exposed image. The references of the original frame of each single pixel are, however, preserved in order to reconstruct the exposure operated for each single pixel. The trial carried out uses a monochromatic 8-bit-depth sensor, however the actual sensor may support 12 bit/px.

Dewarping algorithm

Due to PANCAM extreme field of view, geometric calibration poses significant configuration challenges. Various methods have been developed to simplify the geometric calibration of cameras in short-range fields in controlled environments, such as clean rooms, and the use of simple calibration checkerboards Considering the PANCAM is intended to be a planetary payload future mission with photogrammetric objectives, the current state-of-the-art for this type of lens has been reviewed and extended to improve the descriptive model for the hyper-hemispherical field of view projection [2]. While the resulting dewarping is essential for photogrammetric applications, it became necessary to define an approximate model to represent a single capture as a composite of multiple pinhole models. Each of these models can be individually leveraged as a data source for scientific analyses relying on this specific geometric framework.

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