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The PanCam Calibration Target (PCT) and multispectral image processing for the ExoMars 2018 mission

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Abstract

The Panoramic Camera (PanCam) instrument for the ESA/NASA 2018 ExoMars mission is designed to be the 'eyes' of the Mars rover and is equipped with two wide angle multispectral cameras (WACs) from MSSL, and a focusable High Resolution Camera (HRC) from DLR. To achieve its science role within the ExoMars mission, the PanCam will generate terrain reflectance spectra to help identify the mineralogy of the Martian surface, and generate true-colour images of the Martian environment. The PanCam Calibration Target (PCT) is an essential component for the science operations of the PanCam instrument. Its purpose is to allow radiometric calibration and to support geometric calibration check-out of the PanCam instrument during the mission. Unlike other camera calibration targets flown to Mars, the PCT target regions are being made from stained glass. The paper describes the work undertaken during the early build and testing of the PCT, together with results from the baseline algorithms that have been designed and implemented to process the multispectral PanCam images.

1. Introduction

The current PCT design is $50\,\mathrm{mm} \times 50\,\mathrm{mm}$, and $16\,\mathrm{mm}$ in height. Fig. 1 shows the current CAD model for the PCT which is composed of mounting pads, a base plate, a layer of calibration targets, a top retaining plate and three shadow posts.

To ensure that the radiometric properties of the PCT don't change during the mission due to the high UV irradiation whilst on the Martian surface, we have decided to use annealed stained glass for our greyscale and colour targets. The base and retaining plates are made from (anodised) Titanium which has a coefficient of thermal expansion close to that of glass. The glass targets are soda-lime-silica based to which small quantities of Cerium are added to radiation harden the glass. The addition of appropriate metals or metal oxides to the glass mix prior to heating produces the variety of greyscale (90%, 70%, 50% and 30% reflectance) and colour glasses (red, green, blue and yellow). We use a core drill to remove a cylinder of stained glass from the quenched glass mix, and the core is then sectioned into stained glass wafers. Each wafer is given a reflective Aluminium back coating to increase the amount of reflected light. The 'white' glass wafer is slightly greyed and the black wafer is made from anodised Aluminium. The top surface of the black wafer has three raised 'bars' each with a polished top surface to provide a high contrast against the black background. These bars act as calibration targets for the HRC focus mechanism during surface operations.

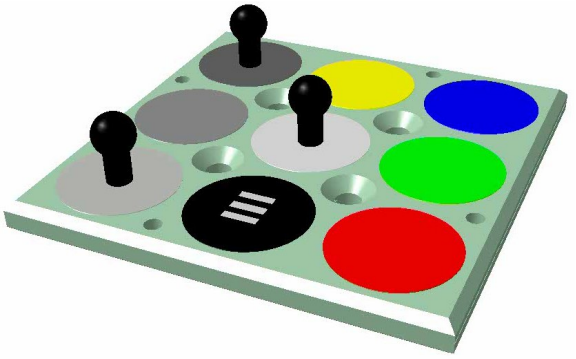

Figure 1: CAD model of the PanCam Calibration Target (PCT).

2. Radiometric and Colourimetric Processing Pipeline

To test our PCT required us to design and implement a software-based radiometric and colourimetric image processing pipe-line. Given the previous multi-

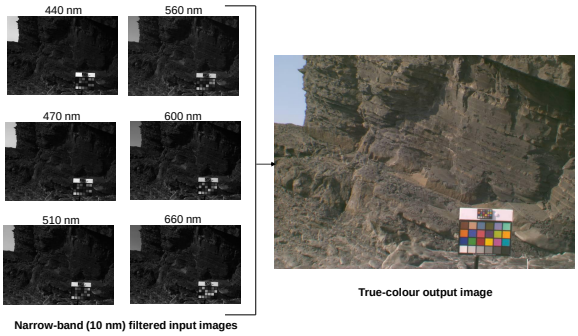

Figure 2: Example colour correction result from the Clarach Bay field trials using six of the narrowband (10 nm) filters.

spectral cameras flown to Mars, a good deal of research has been conducted in the area of processing multispectral image data to generate terrain Region of Interest (ROI) reflectance spectra, and colour corrected products. This work includes for example, the Viking Lander Mission [2], Mars Pathfinder [4], MER [1], and Phoenix [3]. We have developed our own algorithms based upon this previous work, and implemented a radiometric and colourimetric image processing pipeline. This baseline software has allowed us to conduct performance evaluation experiments with our current PCT design. The eventual image processing pipeline for the ExoMars 2018 mission will be a complete and enhanced version based upon this early processing pipeline work.

3. PCT Field Trials

To test our PCT design we have captured images of a prototype PCT during field trials at Clarach Bay beach, Ceredigion, UK. PanCam colleagues from DLR, UCL, and Joanneum Research have also undertaken trials as part of the Artic Mars Analog Svalbard Expedition (AMASE). The AU (multispectral) PanCam Emulator (AUPE) has been used for the field trials. The AUPE uses COTS monochromatic cameras with optics and filters that approximate to the PanCam instrument design. Each AUPE 'WAC' has a motorised filter wheel with 9 filters. Currently we use broadband (100 nm) filters to generate a quick look colour image, and use the narrowband (10 nm) filters when capturing images to be processed by our radiometric and colourimetric pipeline software, see Fig. 2. The baseline algorithms have been implemented in Mathcad and ported to both Java and LabVIEW.

4. Summary and Conclusions

The paper has reported on our current work for the ExoMars 2018 PanCam Calibration Target (PCT). We have a baseline radiometric and colourimetric image processing pipeline that has been designed for the purpose of testing our PCT. Our algorithms have been implemented in software and we have conducted a number of field trials where multispectral images of a PCT prototype have been captured. The generated reflectance spectra and colour corrected image results are encouraging. Future complete and enhanced versions of our radiometric and colourimetric image processing pipeline will be used during the ExoMars 2018 mission.

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