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SUB-PIXEL IMAGE REGISTRATION ON AN EMBEDDED SATELLITE PLATFORM

Abstract

CubeSats are limited in their physical size, which limits the physical size of Earth Observation payloads they can carry, resulting in reduced image quality. Algorithms exist that combine separate image frames with overlapping regions to produce better output image quality. These algorithms may either improve the signal to noise ratio via image averaging, increase resolution via super-resolution or merely remove redundant information with mosaicing. Such algorithms typically only function properly if the geometric transformations between the consecutive images are known with high accuracy. These algorithms can either be applied terrestrially or on-board a satellite. Downloading large raw image data sets for terrestrial processing is impractical for a CubeSat mission, and therefore an on-board solution is desirable.

Our paper discusses how to accurately determine the transformation between consecutive images on-board, laying the foundation for efficient on-board de-noising and super-resolution. Two common methods used to determine translation – normalised cross-correlation (NCC) and phase-correlation – are investigated. From simulated results, NCC is shown to be the better candidate for our application. NCC's results can be determined to sub-pixel accuracy by making use of curve fitting techniques. Important image properties that affect the NCC accuracy include translation and rotation between subsequent image frames, spatial frequencies, and noise. NCC is well suited for implementation on a satellite platform where images are captured in quick succession, resulting in partially overlapping images with little rotation between frames.

We implemented our proposed solution in a suitable hardware description language on a field programmable gate array (FPGA) test platform. The effect of tuning NCC's parameters – specifically sub-image versus window size – are investigated with regards to hardware utilisation and accuracy. Software simulation and firmware-implemented results, using generated data, are compared and discussed. Finally, future applications, which can substantially improve small satellite image quality using this technology, are explored.