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APPLICATION OF SUB-PIXEL MAPPING IN SPACE-BASED SATELLITE IDENTIFICATION FOR SPACE SITUATIONAL AWARENESS

Abstract

The increasing the number of satellites launches per year had made space situational awareness a pressing issue for the world. The main challenge of accurate SSA research is obtaining accurate visual data of satellites of interest, which requires powerful optical sensors. In this study we propose a two-step sub-pixel mapping method improving the performance of optical sensors to enable downsizing of space-based sensors with little performance trade-offs. The method seeks to enhance image resolution and optimising for either human visual or machine vision algorithms for the scientific purpose of the original images.

This study was carried out using simulated images of spacecrafts with accurate lighting from the Sun, and sensor parameters from that of NEOSSat. Two sub-pixel mapping techniques are applied in this study: Soft Then Harden (STH) and Neural-Network assisted Frame Combining (NNFC). The STH method improves resolution of a single frame of image by softening original coarse pixels, redistribute colours and intensities according to a spatial-attraction model, which considers sensor assembly parameters and classifications of surrounding coarse pixels. The softened sub-pixels would then be re-hardened to form clearer borders between objects. NNFC further improves results of STH by combining multiple frames within an imaging sequence from similar vantage points. This combination action allows sub-pixel features that have been caught in-between multiple pixels on one frame to be revealed by swapping out sections of the frame with sections of another frame where said object significantly occupies a pixel.

The combination of two above techniques increases fidelity seen in post-processed images when compared to either one technique being implemented alone, and significantly over the original image. When compared to simulated images rendered at a higher resolution for comparison, details previously difficult to identify in lower resolution images were revealed, with the level of detail comparable to that of a reference image at 20-40% higher resolution. Moreover, the increase in fidelity from STH method alone is close to 20%, suggesting that even with a single frame of usable image there can be tangible benefits in applying this method.

In SSA oriented space missions, this technology could be effectively utilised to increase sensor performance to save space, weight, and cost for the mission, or to break sensor performance bottlenecks that are difficult to circumvent. Moreover, this technique being a post-processing method means it can be applied retroactively to images from ongoing missions, extending mission lifetime while saving costs.