Aircraft detection using a digital camera aligned to the SLR laser at the SGF, Herstmonceux

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Introduction

The Space Geodesy Facility in Herstmonceux, UK ensures in-sky safety by interrupting the SLR laser fires when an aircraft enters an area of sky surrounding the direction of the beam. This is achieved using an active radar that tracks with the SLR telescope, an ADS-B receiver and an observer positioned beside the telescope.

This poster explores, for the first time at the SGF, the potential for additional in-sky safety from a digital camera system.

Camera

The uEye DCC3240M from IDS is a compact, sensitive, monochrome USB3.0 digital camera with a 1280x1024 pixel CMOS chip. It can run at up to 60 frames per second.

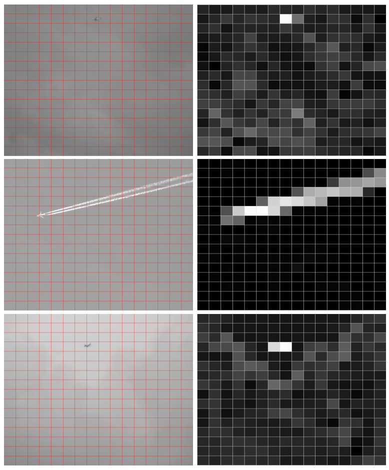
This camera was mounted on the underside of the SLR telescope and pointed to align with the SLR laser beam. A 100mm focal length C-mount lens was fitted, giving a field of view of approximately 5°. The camera connects to a Linux PC running the uEye camera daemon and is operated using an extensive library of commands available in C++. A display desktop application was built in Qt.

Identifying an aircraft

In a single frame an aircraft could be the brightest or darkest feature. The size in the image is not fixed and the shape depends on its orientation. Clouds appearing in the frame can obscure the aircraft or could trigger a false alarm.

In this study, an aircraft is considered to be an object that stands out in the frame.

Method for real-time aircraft detection



To identify an object that stands out from the rest of the frame, pixels were binned in to a NxN grid, each containing number of pixels $P=(height \times width)/N^2$. A standard deviation of the pixel values was calculated for each bin. Shown on the right are three example frames with the grids shown in red and beside them are the corresponding RMS grids. The largest RMS was identified and a mean and RMS of the RMS values were calculated for the whole grid. A threshold was required in order to decide if an aircraft is present. The criteria is:

*Maximum RMS > Mean RMS + Z * (RMS of grid RMS values)*

Two thresholds have been tested, the first was a hot threshold with a Z value of around 12, which immediately triggers a detection alarm. The second was a cold threshold at about Z=7, where a buffer is filled with each triggering frame before a detection alarm is triggered. A processing frame rate of > 10 Hz is achievable and so the buffer fills quickly.

Results, limitations and implementation

At a processing frame rate of >10Hz, this method is responsive and can identify aircraft quickly. The system was tested by switching the SLR laser off and setting the telescope to track aircraft from the ADS-B signals. To stop the laser fire, the program connects to the SGF 'listen2planes' server by TCP/IP to transmit a stop signal.

The edge of a cloud in a frame is likely to trigger this system, as is glare from the Sun. Optimising the threshold criteria will minimise these false alarms, but some will have to be tolerated.

This system has potential to spot smaller, low flying aircraft but these move quickly across the sky and so will require a fast reaction time.

Further development

- So far, this work has only been carried out during daylight hours. A similar approach could be extended in to dark night conditions by screening or filtering the laser light and detecting the bright red flashing lights carried by aircraft.
- It has also been restricted to monochrome images. Colour information may help to identify an aircraft on a blue sky or white cloud.
- The 5° field of view could be expanded to 10° or further, allowing earlier detection and an improved sample of the surrounding sky conditions.

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