A Modified Spectral Line Camera for Low Cost Anomaly Detection

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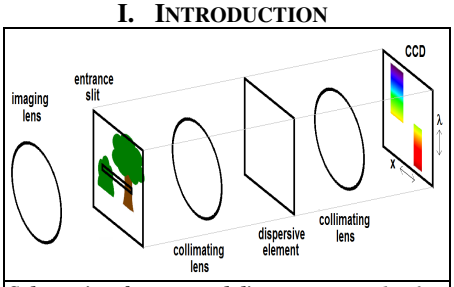
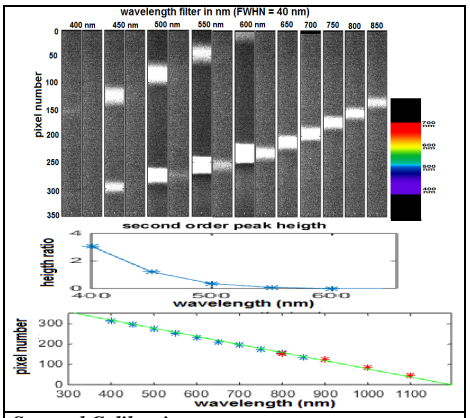
Spectral cameras are a valuable tool for anomaly detection because the spectral information provides more opportunities than a monochrome or color camera to distinguish targets from the background. We are currently working on the adaptation of a spectral line camera for outdoor use and for anomaly detection. This requires consideration of spectral calibration, lighting variation and adaptation of detection algorithms. When effective, this may provide a low coast alternative for full spectral detection.

I. Introduction



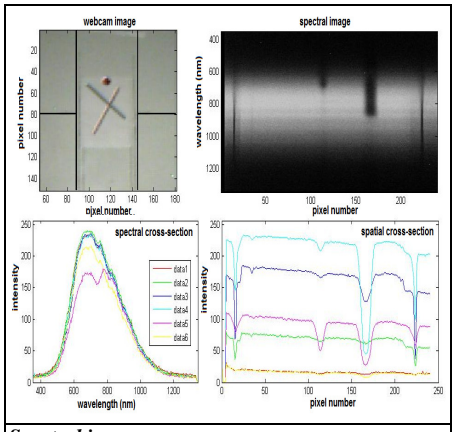
***Schematic of a spectral lime camera**. The first lens images the scenery onto the entrance slit which selects a line from the image. Collimating lenses and a dispersive element spectrally separate the line, the result of which is recorded by a CCD. For our project we use the SpectroCam V10 spectral imagers supplied by SpectraPartners (400-1000 nm) combined with the WATEX 902h2 supreme low light monochrome camera (sensitivity 400 nm (50%) – 1000 nm (5%)).*



***Spectral Calibration**.*

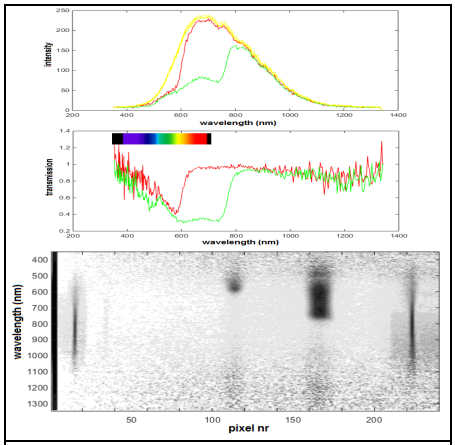
- *Top: Series of images taken through narrow band interference filters (40 nm FWHM). For 400-600 nm a second series was taken at higher intensity. Visible spectrum shown for comparison.*
- *Center: Second order peaks (λ'=2λ) are strong when they are near the center of the visible region. Peak height ratio can be used to remove second order distortion from spectra*
- *Bottom: pixel number vs wavelength (blue) or double wavelength (second order: red) shows a near-linear characteristic*

II. Indoor Test Images



Spectral image.

- *Top: webcam image (left) shows the target, an A4 sheet of paper at 4 m distance with a slanted green and red line. T-shaped makers are inserted in the image to indicate the area that is acquired. The spectral image (right) plotted in gray scale (white is high intensity) clearly shows the captured sections of the green and red line as well as gray lines at the side of the image.*
- *Bottom: cross-sections at various regions in the image (left) and at various wavelengths (right)*

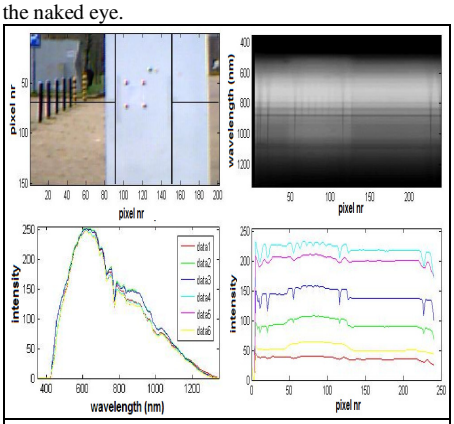


Spectral analysis

- *Top: spectra of the red and green band (columns: 112-116 and 162-173 respectively) and three (white) background bands and transmission (band / background intensity) of red and green band. The red band has lower intensity in the 500-600 nm region (blue-green). The green band has low intensity in all regions except the near infrared (> 800 nm) but mainly absorbs above 600 nm (red) which makes it indeed a dark green color.*
- *Bottom: transmission image obtained by dividing the spectral image by the background spectrum for each pixel. This provides more information than the original spectral image, especially in the low intensity regions (< 500 nm and > 1100 nm).*

III. Outdoor Resolution Tests

. Nevertheless it can still be distinguished even with the naked eye.



Outside resolution experiment. Resolution target (six green lines 0.1-0.8 mm in the center) placed outside at 10 m from the camera. Panels as above (webcam image, spectral image, spectral- and spatial cross-sections.

IV. Discussion

After calibration we considered acquisition of a target with colored lines. The background spectra are non-constant but drop off towards the blue and (infra)red end of the spectrum. We characterized spatial resolution that can be obtained so far and found that we could easily distinguish an 0.1 mm target line at a distance of 5 m (0.02 mrad resolution). As a final test we also performed a resolution test outside to evaluate performance at higher light conditions. While the camera still suffers from stray light which needs to be remedied it still was able to achieve the same high resolution.

At present our camera still requires technical development, to fully use its potential. A typical scene that we wish to explore is the detection of vessels near the horizon at sea or on flat land. However, with the required improvements the spectral line camera will become be suitable for the desired anomaly detection purpose and may provide an economic alternative for 2D spectral imagers.

V. References

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