Preliminary testing of acousto-optical hyperspectrometer for UAV

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Abstract. Basic results of the preliminary testing of acousto-optical hyperspectrometer for unmanned aerial vehicle are presented. The stability of sensing characteristics is studied. It is shown that warming-up of the photodetector as well as of the acousto-optic crystal results in variations of the output signal due to temperature drift. This study places additional requirements upon the system behaviour in changing environment. The development of calibration procedure and measuring algorithm for this purpose are considered.

Keywords: Hyperspectral imaging, Tunable filters, Remote sensing, Acousto-optics.

1. Introduction

Hyperspectral surveying is an effective technology for studying and monitoring the underlying Earth surface.

Hyperspectral devices, located on the unmanned aerial vehicle (UAV), open new opportunities for monitoring. In particular, they make it possible to realize the concept of monitoring by means of a personal device - on an individual assignment.

Hyperspectral devices based on tunable filters are best suited to this concept. They allow you to optimize the monitoring procedure for specific tasks and quickly change the algorithm depending on the information received. Also such systems permit to extract useful information directly on board in real time.

The authors designed and implemented such a device. The necessary stage of the work is the analysis of the quality of the images obtained. The quality of images can significantly influence the analysis and complicate it.

2. Description of the method

The following research was carried out in the work:

- data reproducibility, short-term and long-term stability;

- for time drift characteristics;
- the uniformity of the signal over the field of view.

The carried out researches have shown: the repeatability of the received data, the necessity of correcting temperature distortions, the need to refine the optical system, satisfactory for the tasks in view.

First, the uniformity of the brightness of the image was checked. For this purpose, the image was divided into classes and the false-colour picture (Fig. 1) clearly demonstrates the circular symmetry of the image that is caused by vignetting.

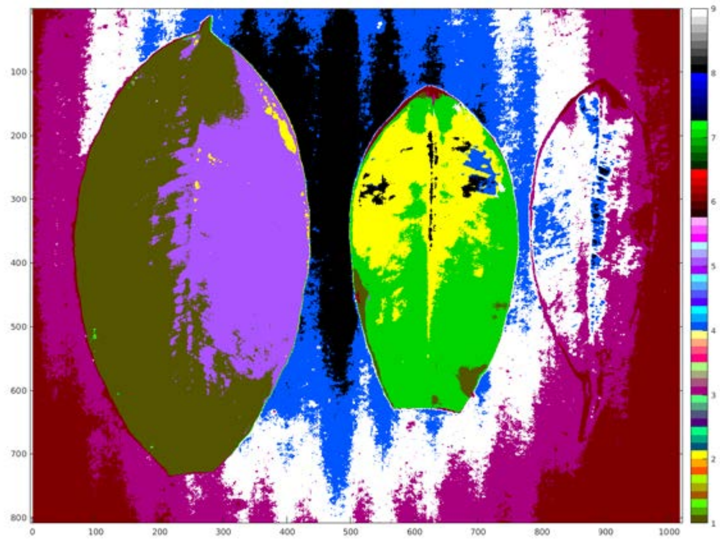


Figure1. The broken into classes image of three freshly cut geranium sheets.

After normalization, the image became more homogeneous (Fig. 2). Therefore the calibration is adequate.

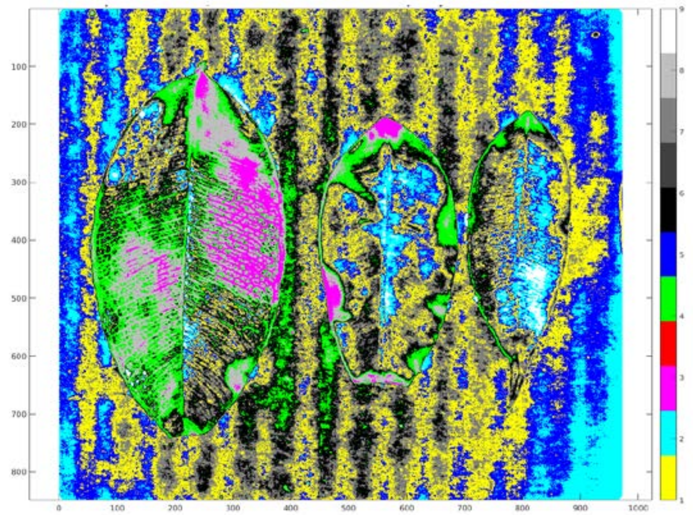


Figure 2. The image of the same leaves after the normalization.

The influence of the properties of the recording monochrome video camera was studied. Noise characteristics of photodetector are presented in Fig. 4. Also, noise amplitude distribution in the image shows (Figure 3, a) that the signal-to-noise ratio is inhomogeneous across the field with apparent vertical lines.

Moreover, another type of analysis indicates that the entire field of the photodetector is divided into 4 rectangular zones with different sensitivity characteristics (Figure 3, b).

Another factor affecting the recorded signal is the change in receiver characteristics with time.

As can be seen, from the analysis of various statistical characteristics (Fig. 4), the magnitude of the signal increases continuously. This is most likely due to the heating of the camera.

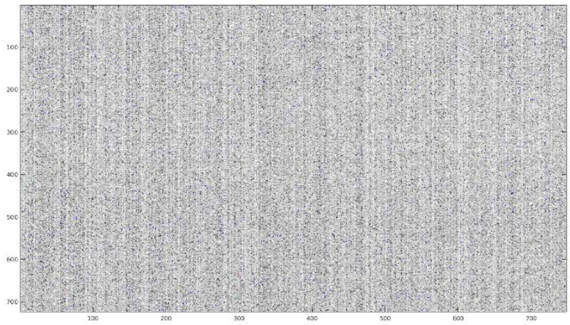


Figure 3a. Vertical bands on image.

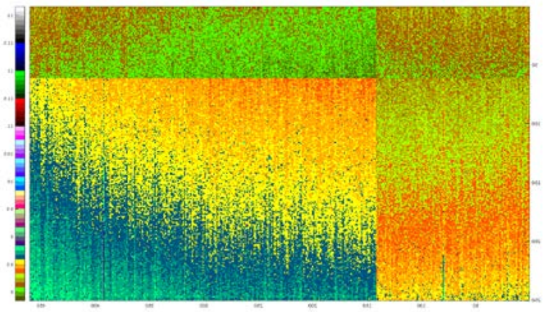


Figure 3b. Cross-sections on image.

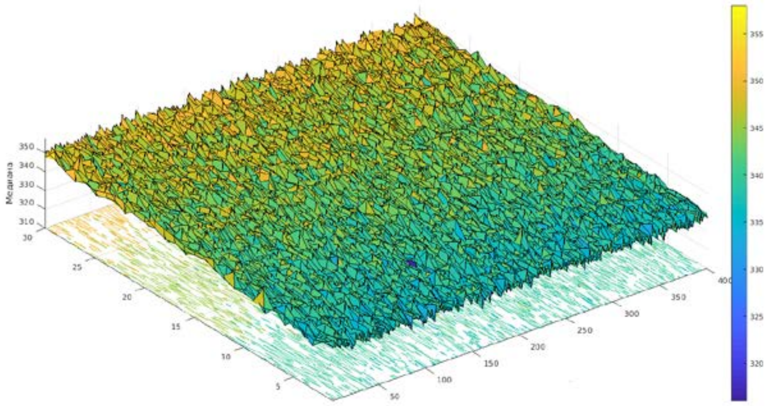


Figure 4. Drift of noise characteristics of the photodetector: median values.

The stability of the light source was checked as a part of the system. As it is seen from a series of spectra measured by a diffraction spectrometer (Figure. 5), the distribution is symmetrical and stable - just as it can be expected for a stabilized light source.

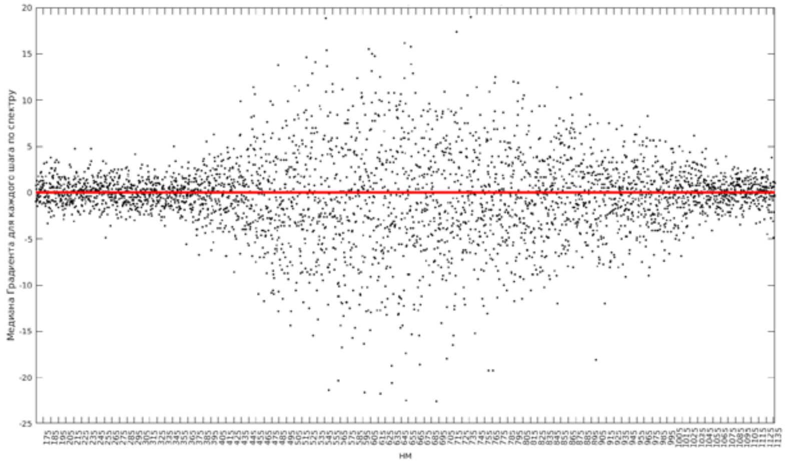
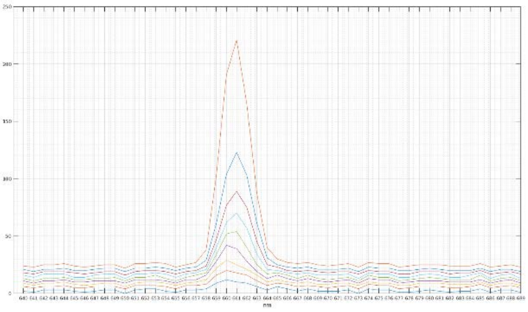


Figure 5. Measured spectral gradient of the light source.

To check the spectral characteristics of the hyperspectrometer, the spectrum of the laser source was measured. In both cases (Fig. 6 a, b), when the attenuated radiation was directly measured by the instrument, and when the radiation was reflected from a sheet of paper, the width of the transmission function corresponds to a passport value of 3 nm. It should be noted that the center of the maximum turned out to be shifted by 1 nm, which, although being within the bandwidth, but still requires more careful calibration and control of the tuning characteristic.

Artificial contrasting of the frames made it possible to detect permanently present defects (Figure 7), which are probably particles of dust adhering to the optical elements of the optical path.



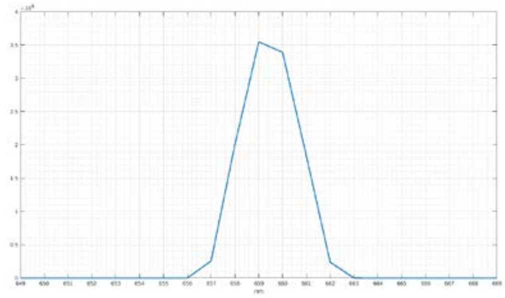


Figure 6a. Direct measured laser spectrum. **Figure 6b**. Reflected laser beam spectrum.

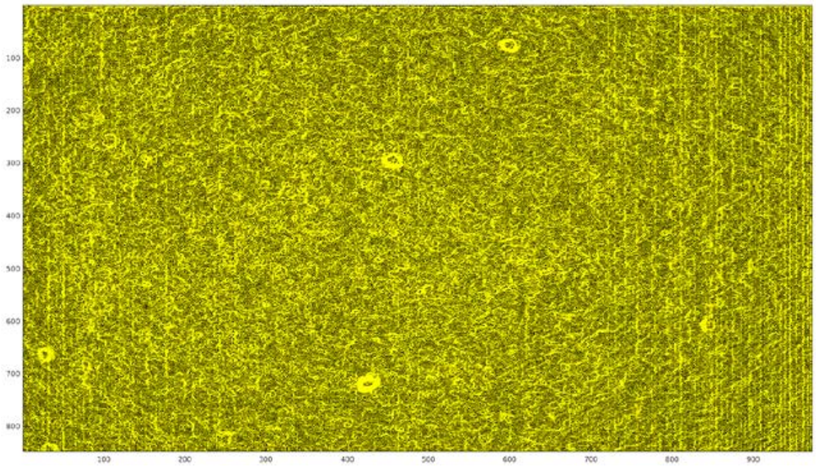


Figure 7. Processed image.

The conducted researches have shown that there are a number of factors that can negatively influence the analysis of hyperspectral information.

They are associated with the optical system (vignetting, pollution), the video camera (heterogeneity of the matrix), and the AOTF (spectral calibration).

Thus, to effectively use the hyperspectral system in monitoring tasks, it is necessary to eliminate these problems in hardware or to develop methods for correcting the effect of these factors.

3. Acknowledgments

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4. References

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