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EVALUATING SENSOR LINEARITY OF CHOSEN INFRARED SENSORS

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ABSTRACT:

A team of specialists from the Department of Remote Sensing and Photogrammetry from the Military University of Technology in Warsaw have been leading a project entitled “IRAMSWater - Innovative remote sensing system for the monitoring of pollutants in rivers, offshore waters and flooded areas” (PBS1/B9/8/2012) financed by the polish National Centre for Research and Development. The main aim of the project is to create a remote sensing system based on a wide range of sensors for evaluating, identifying and determining the distribution of biological, physical and chemical pollutants in water in real time. These analyses are being conducted based on spectral characteristics of a wide selection of pollutants, based on imagery acquired in narrow bands of the electromagnetic spectrum. To ensure that these spectral reflectance coefficients are determine precisely it was essential to establish a precise methodology for obtaining these data. In international literature, the most common approach is to acquire such imagery first ensuring that each scene contains at least one reference panel with a well know spectral characteristic, and then transforming the imagery and calculating the spectral response curves during post-processing. The research team from the Military University of Technology had proposed a method of extracting precise reflectance coefficients without the need for using a reference panel on the scene. This is done by precisely determining the camera exposure parameters in controlled conditions. This method however assumes that the sensor transfer function is linear.

An attempt was made to determine these methodologies for acquiring spectral reflectance coefficients from two Xenics frame sensors, which record imagery in the infrared range (900-1700nm): Xeva-4246, and XEVA XS-1.7.320. Both sensors have 320-256Px InGaAs arrays with 30µm pixels. The main difference between the sensors is the fact that the Xeva-4246 is thermo-electrically cooled (TE1) whilst the other is not. During these experiments both sensors were equipped with fixed 16mm focal length lenses with the f-stop also fixed to 16. Image acquisition was conducted in Xeneth software supplied by the manufacturer. The manufacturer also supplied calibration files for these sensors. These however were not used in this research as utilising these files greatly limits the exposure times which can be set in the software. In fact, in the case of the XEVA XS-1.7.320 sensor this parameter is not editable when calibration files are used. Such settings were unacceptable to us, seeing as our methodology was to be based solely on manipulating the exposure time depending on the illumination of the scene. When defining the sensor calibration process as the measurement of the output of a sensor in response to an accurately known input, then as a result of our measurements, we in fact get an equation which calibrates our images to obtain spectral reflectance characteristics.

Preliminary results obtained by the Xeva-4246 sensor showed that the proposed approach is correct and gives results within ±3% of actual spectral reflectance coefficients determined using a spectroradiometer. The results of these experiments had been described in more detail in "Using XEVA video sensors in acquiring spectral reflectance coefficients", Walczykowski *et al*, 2014. However, when conducting the same measurements using the second sensor, the XEVA XS-1.7.320, these accuracies were much lower during some, not all, conducted experiments. The results of single measuring sessions were sometimes over 10% different in comparison to reference data. There were however measurements during which accuracies around 2-3% were obtained. Having checked all other possibilities, it became evident that these inconsistencies occurred when certain specific integration times were set on the camera. This lead us to conduct a new experiment to check the transfer function of the sensor. A properly functioning sensor should have a linear (or close to linear) transfer function, meaning that an output is directly proportional to the input over its entire range so that the slope of a graph of output versus input describes a straight line. The image below represents a graph of the image digital value (output) versus the integration time at a constant scene illumination (input):

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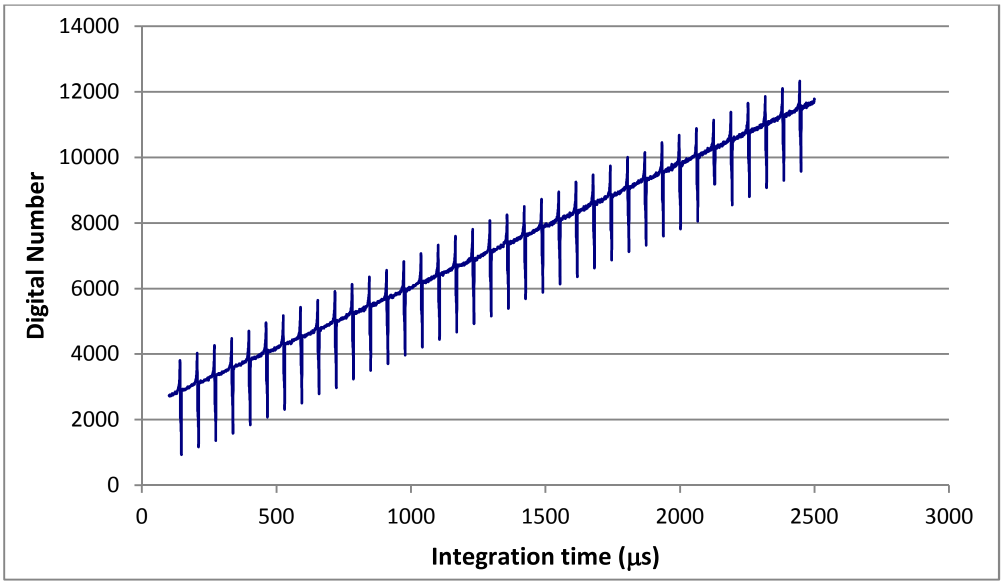

Fig. 1. Image digital value (output) versus the integration time at a constant scene illumination (input):

As is evident from the graph above, the sensor does not have a linear transfer function. There are certain integration times, occurring periodically, which give incorrect DN values.

This paper presents a detailed description of the way in which this evaluation of the sensor linearity was conducted. Additionally we conducted subsequent similar experiments to determine whether this pattern is recurrent and whether the visible errors in DN - ΔDN are constant or dependant on the light intensity and composition. The article will includes a proposed method of image processing used to eliminate the negative effects of this problem.