Determination of static characteristics of a low cost spectrometer for use in agriculture

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Abstract

Given the potential of low-cost sensors for agriculture, we evaluated a spectrometer developed with low cost components regarding its static characteristics in leaves of crisp lettuce and kale. Raw and processed measurements were compared to the ones obtained by a reference spectrometer. The analyses in raw and processed readings showed that measurements with low-cost sensors lead to very high errors. Correlation analysis, however, showed that these sensors may be useful when the phenomena of interest is variation in the reading, instead of the reading itself.

Key words: *Public Lab, Open hardware sensors, Sensor validation.*

Introduction

Even though low-cost sensors may be useful in agriculture, this is not the case when data quality is compromised by their components. This limitation, however, could be handled by data processing[1].

The goal of this work was to evaluate the performance of a low-cost sensor. We evaluated two Public Lab spectrometers (P and L). We also processed these readings in four different ways to evaluate if processing approaches could improve the results.

Results and Discussion

The low-cost spectrometers (Figure 1) were calibrated and used on the measurement of the spectral response of two vegetables: crisp lettuce (*Lactuca sativa* var. *crispa)* and kale (*Brassica oleracea*, group Acephala). The measurements were processed in four different ways and raw and processed readings were compared to the ones obtained by a reference spectrometer (FieldSpec 4 - FS). The sensors were evaluated regarding their precision, accuracy and reproducibility.

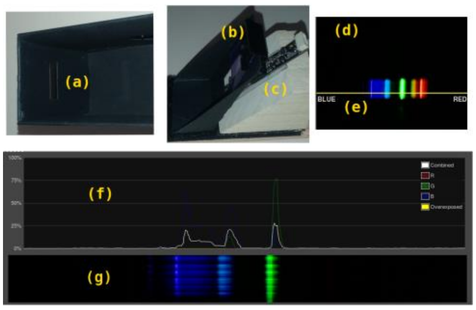

Figure 1. Details of the Public Lab sensor. (a) entrance, (b) DVD fragment, (c) webcam, (d) captured image, (e) selected line, (f) and (g) resulting spectra.

The precision of the low-cost sensors was at least two orders of magnitude worse than the precision of the reference sensor, regardless of the processing approach that was used (Table 1). As for reproducibility and accuracy (Table 2), the mean absolute percentage errors were twice the values obtained in the precision analysis.

We observed that the lowest errors were obtained in the readings referring to the wavelengths for which the channels were most sensitive (Figure 2). The correlations obtained by the sensor L were low (between 0.05 and 0.35), while the ones obtained by the sensor P could be considered high, i.e. above 0.7 for wavelengths over 510 nm.

Table 1. Coefficients of variation (CV) and average values of the mean absolute percentage error observed in the precision analysis for the Public Lab sensors (P e L) and the reference sensor (FS).

		FS	L	P
Average	Lettuce	0.00099	0.57230	0.58638
	Kale	0.00141	0.46507	0.36967
CV	Lettuce	0.01603	0.01612	0.00151
	Kale	0.01531	0.05641	0.00935

Table 2. Coefficients of variation (CV) and average values of the mean absolute percentage error observed in the accuracy and reproducibility analyses for the Public Lab sensors (P e L) and the reference sensor (FS).

	Accuracy		Reproducibility	
	Lettuce	Kale	Lettuce	Kale
Average	0.708	0.763	0.8519	0.7929
CV	0.170	0.106	0.0739	0.0644

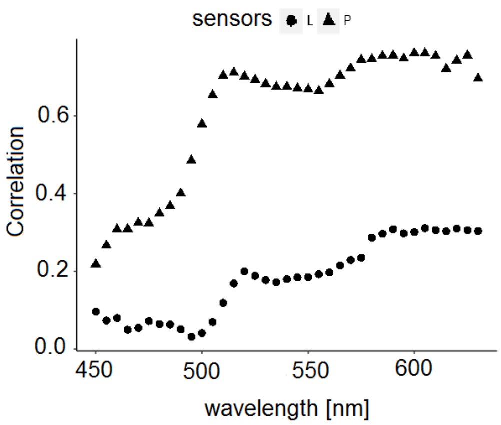

Figure 2. Correlation values of the sensors P and L with the FS, by wavelength, using the raw readings.

Conclusions

The analyses of reproducibility, accuracy and precision showed that the Public Lab sensors are not suited for direct measurements, regardless of the processing approaches used. However, they may be useful when the phenomena of interest is the variability in the measurement, due to the correlation observed.

Acknowledgement

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[1]SCHEELINE, A. Cell phone spectrometry: Science in your pocket? **TrAC Trends in Analytical Chemistry**, v. 85, p. 20–25, dez. 2016.