LabVIEW Based Real-time Color Measurement System

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ABSTRACT

Colorimetry is of paramount importance to the agricultural industry. Colorimetry refers to the processing of agricultural products for consumer needs from a marketing point of view, and therefore the agricultural industry spends a lot of money and time classifying each product. In the past, agricultural professionals had to use program codes that are difficult to learn, and even the most basic image analysis for agricultural product classification required mastering different program libraries. Today, the LabVIEW platform offers a flexible, fast, easy-to-learn, and complete image analysis infrastructure with various useful modules. For this reason, in this study, a method analysis for color perception with a simple USB webcam and software developed for real-time color analysis on the LabVIEW platform is presented and its success in the basic color analysis is tried to be revealed. The basic application developed for this purpose in LabVIEW v2019 using NI Vision Development Module v19 and NI IMAQ v19 modules. The basic fact that is the LabVIEW application is the idea that LabVIEW can only be analyzed with expensive IEEE 1394, but it should be known that these analyzes can be done with USB webcams. For this purpose, the application includes a USB webcam driver that can be stacked seamlessly. USB Webcam and colorimeter measurement-based results of ɣR factors for each of RGB color channels are 1.161232, 0.506287, 0.432229; ɣG factors for each of RGB color channels are 0.519619, 1.025383, 1.201444; at last ɣB factors for each of RGB color channels are 0.600362, 0.714016, 1.413406, respectively.

INTRODUCTION

Agricultural production areas have a lot of industrial applications. The application of technology to agricultural processes has resulted in significant revenues. In addition, the use of technology provides for precision and speed in tasks that individuals are unable to perform. This situation leads to changes in agricultural output and processing. Different processes in agriculture benefit from the use of technology, such as robotic weed control systems, automatic harvesting systems, sorting machine systems, packing systems, grading and identification of agricultural products, and so on.

For all of these types of cases, we employ color measurements. As a result, the use of color sensors in agriculture is extremely important. Professional spectrometers, on the other hand, are useless in agricultural applications from the low-cost product perspective. In general, they are beneficial for data collection in laboratories. As a result, low-cost color sensors with repeatable errors are required for field measurements. There is also a lot of application in the literature about colormeter measurements.

The color of the fruit on the outside is an important factor for consumers when purchasing agricultural products (Leon *et al.*, 2006). The aesthetic quality standards of the items have an impact on the prices of fruits and vegetables. As a result, distinguishing the color change of fruits from the original fruits is difficult (Xing *et al.*, 2006). For the quality analysis of agricultural products, computer vision technology has advanced significantly (Brosnan and Wen Sun, 2004). Computer vision units are also commonly employed in industrial applications to identify fruit damage based on external color.

For evaluating faults on vegetables and fruits, Mendoza *et al.* (2006) investigated image analysis units that assess standard sRGB color, HSV, and *L*, a*, b** color spaces. Ratule *et al.* (2006) studied the effects of cold storage on the chilling injury of the 'Berangan' banana (*Musa* cv. *berangan*).

Color measurement may be employed instead of chemical analysis, according to Fouda and Salah (2014). A link between the colored component and the chemical in the food may also exist. Color measurement is said to be easier and faster than chemical analysis.

Pawar and Dale (2016) used the Raspberry Pi 2 to detect flaws in 15 lemons and sort them into categories. They used the Python programming language with OpenCV to create algorithms for detecting and sorting lemons. They discovered that the faulty skin area may be recognized for one pixel up to 4.3677 x 10-6 cm². They further emphasize that their technology was discovered to be more cost-effective and clever.

Narendra and Hareesh (2010) discuss the current development and application of image analysis and computer vision systems in the agricultural and food industries for sorting and grading items. According to them, computer vision systems are rapidly being used in the business for inspection and evaluation. They also claim that the sorting and grading devices can deliver a quick, cost-effective, sanitary, uniform, and objective assessment. However, they point out that challenges remain, as seen by the comparatively delayed commercial adoption of computer vision technologies across all industries.

According to Mahendran *et al.* (2011), computer vision is a fast, consistent, and objective inspection tool that has spread across a wide range of industries. For completely automated

processes, the approaches' speed and precision meet ever-increasing production and quality criteria.

The following factors influence the quality of agricultural products: size, color, shape, and type of skin defects according to the international marketing standard. The color of the food surface for customers is the first quality parameter. This is crucial in gaining market acceptance for the product. The goal of the study was to use color analysis to assess color change at RGB color samples.

MATERIALS and METHODS

The X-Rite Ci60 model colorimeter was used to determine the color of the primer (Figure 1). A white reflecting plate was used to calibrate an X-Rite Ci60 colorimeter.

Figure 1. Calibration plate and X-Rite Ci60 portable spectrometer.

The Ci6x line of portable spectrometers (Ci60, Ci62, Ci64, and Ci64UV) provide a quick and accurate way to determine the color at any point of the manufacturing process. The Ci6x Series allows us to manage color in a simple, portable, and cost-effective manner. It allows for all sizes of color measures due to the different alternatives of product family software. Repeatable performances are also possible with this robust measurement technology. As a result, the Ci6x series is a solid choice for a variety of agricultural tasks. Table 1 displays the spectrometer's technical parameters.

Table 1. Technical specifications of X-Rite Ci60 spectrometer ([Anonymous, 2021](#)).

Properties	Explanations
Measurement Geometrics	d/8°, DRS spectral engine, choice of optical aperture: 4 mm measurement area/6.5 mm target window 8 mm measurement area/14 mm target window 14 mm measurement area/20 mm target window
Receiver	Blue-enhanced silicon photodiodes
Light Source	Gas-filled tungsten lamp
Illuminant Type	A, C, D50, D55, D65, F2, F7, F11, and F12
Standard Observer	2° and 10°
Spectral Range	400nm – 700nm
Spectral Interval	10nm – measured, 10nm – output
Measurement Range	0 to 200% reflectance
Measuring Time	Approx. 2 seconds
Inter-Instrument Agreement (Ci60)	CIE L*a*b*: Avg. 0.40 ΔE*ab, based on avg. of 12 BCRA series II tiles (specular component included) Max. 0.60 ΔE*ab on any tile (specular component included)
Short-Term Repeatability (Ci60)	10 ΔE*ab on white ceramic (standard deviation)

RGB color plate webcam video was measured firstly with LabVIEW color measurement software to compare them with colorimeter measurements to get calibration factors. Measurements were done in the room light condition and it was 250 lux. The webcam was placed 25 cm far from the color plates for the measurements (Figure 2).

Figure 2. Webcam.

For graphical programming, LabVIEW software comprises two parts: a front panel and a block diagram. The front panel is an interactive software component that contains an interface area with several components and allows the user to insert data into the software (Figure 3).
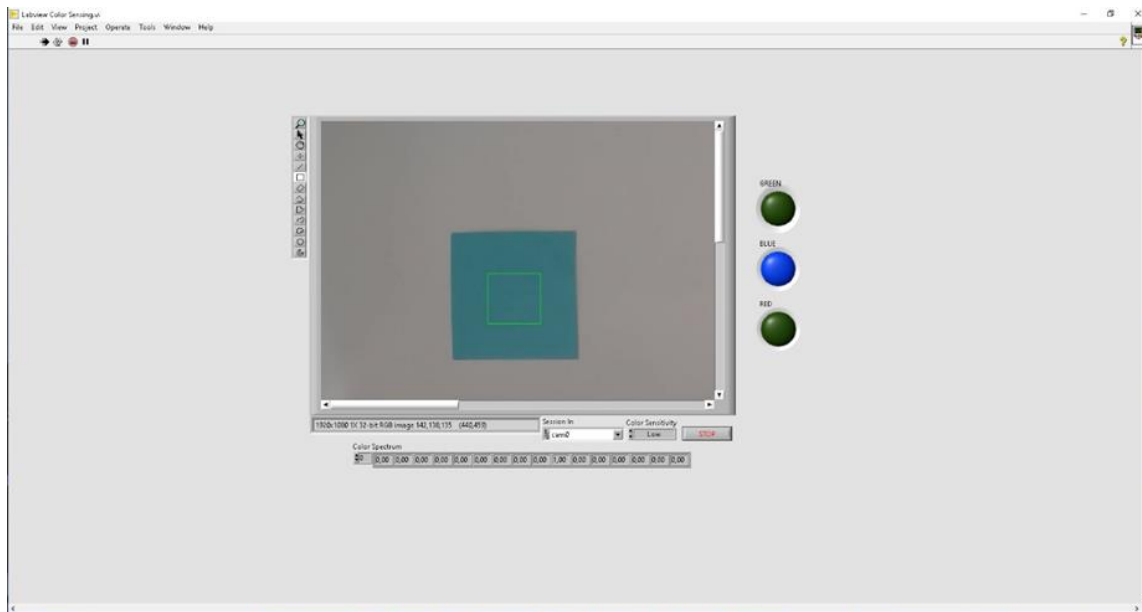
Figure 3. Color measurement application's front panel.

The actual programming procedure was carried out on the block diagram. The source codes run into this problem, which is caused by the use of virtual object linkages (Figure 4).
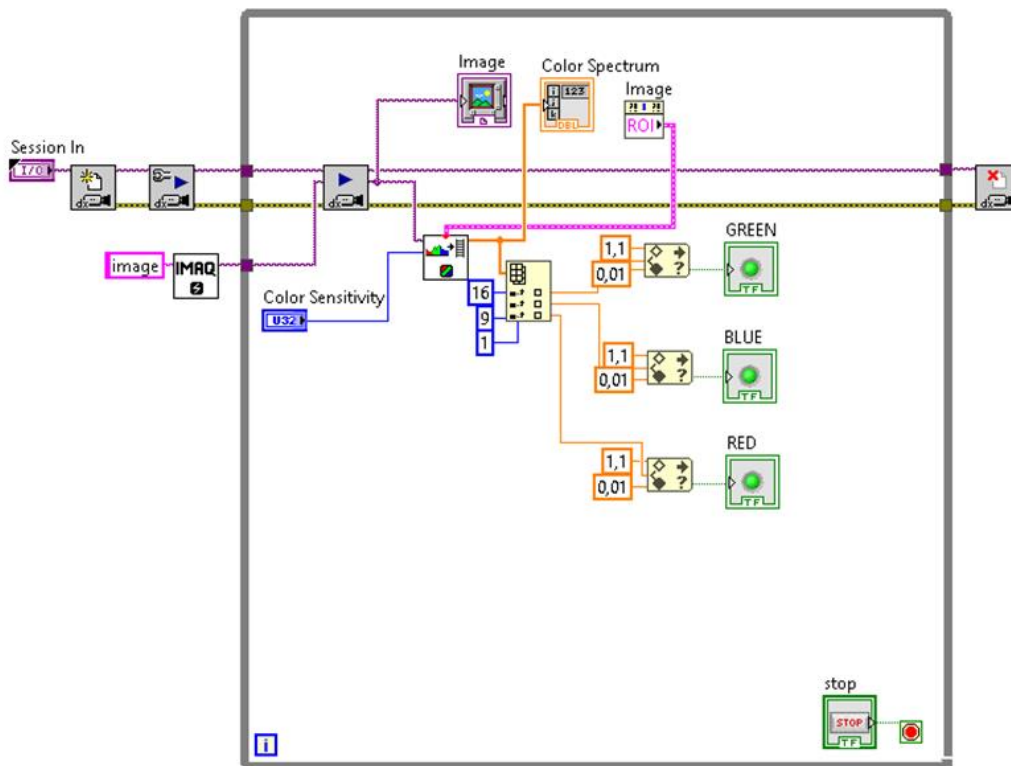

Figure 4. Application block diagram for color measurement.

In the block diagram of the color determination software, first, a session is opening with an image acquisition tool by this way video source is open for color sensitivity selection, after that color spectrum is determined by the software. In the end, colors are determined by the given ranges of the color spectrum.

RESULTS and DISCUSSION

According to test results, utilizing calibration factors, webcam-based LabVIEW software can deliver satisfactory accurate RGB data. As a result, a webcam can be used in agricultural and industrial applications. Table 2 displays the RGB color plate calibration factors. In the table, RRN, RGN, RBN values are red, green, blue values of red plate measured by using National Instruments LabVIEW software; RR, RG, RB values are red, green, blue values of red plate measured by using colorimeter; GRN, GGN, GBN values are red, green, blue values of green plate measured by using National Instruments LabVIEW software; GR, GG, GB values are red, green, blue values of green plate measured by using colorimeter; BRN, BGN, BBN values are red, green, blue values of plate measured by using National Instruments LabVIEW software; BR, BG, BB values are red, green, blue values of blue plate measured by using colorimeter.

Table 2. Calibration factors for the test materials.

	ɣR	ɣG	ɣB
Red plate	1,161232	0,519619	0,600362
Green plate	0,506287	1,025383	0,714016
Blue plate	0,432229	1,201444	1,413406

Red, green, and blue color plate measurements were taken at both devices to improve RGB color measuring efficiency (Figure 2).

Figure 2. Plates in red, green, and blue color.

Table 3. Color measurements on red, green, and blue plates.

RRN	RGN	RBN	RR	RG	RB	GRN	GGN	GBN	GR	GG	GB	BRN	BGN	BBN	BR	BG	BB
160	72	81	161	68	81	68	138	94	59	138	93	59	149	180	62	159	183
160	72	80	161	68	81	68	136	92	72	139	97	56	154	175	52	156	181
159	71	80	159	71	83	69	138	94	72	139	96	56	155	178	61	160	184
160	71	80	161	72	84	69	138	95	60	139	94	57	157	182	62	159	183
158	70	79	161	72	84	69	138	95	62	141	96	58	160	185	60	159	183
163	69	79	160	72	83	68	136	94	70	138	95	57	156	182	60	159	183
160	70	80	160	71	83	67	135	93	72	139	97	56	155	180	63	160	183
158	70	79	160	71	83	68	136	94	67	135	93	56	155	180	59	159	183
158	70	79	160	71	83	68	136	95	70	136	94	56	154	175	60	159	183
158	70	80	160	71	83	68	136	94	68	136	93	57	155	181	60	159	183
159	70	79	160	71	83	68	136	95	70	137	94	56	155	181	61	160	184
158	70	80	160	70	82	69	138	96	68	135	93	56	157	181	62	160	184
159	71	80	161	72	83	69	138	95	70	137	94	56	157	180	61	160	184
159	70	79	161	72	84	68	136	94	67	135	92	57	157	182	53	156	181
161	71	79	160	69	82	68	136	95	70	137	94	57	157	181	52	156	181
163	71	80	160	71	83	70	139	98	68	135	93	59	162	185	52	156	181
160	71	80	160	72	83	69	138	96	70	136	94	60	166	189	51	156	181
164	72	80	160	71	83	68	136	95	69	137	95	61	166	191	52	156	181
164	73	80	160	71	83	68	136	94	72	138	96	61	167	191	53	156	181
164	73	80	160	71	83	71	139	96	73	140	97	60	166	189	52	156	181

There are a lot of applications for color analysis in the literature. For example, Yeni and Shaowei (2017) used LabVIEW and machine vision to develop a fault inspection system for the carbonized bamboo cane. According to the findings of the experiments, this system can classify five different types of bamboo canes with flaws at a speed of 70 mm s⁻¹, and the average recognition rate of defect bamboo canes can exceed 90.6%.

The creation of a flame detection system in LabVIEW is the focus of Riyadi and Aisyah's study. They imply that for the development of fire early warning systems, flame detection systems are useful. In general, traditional fire detection systems that rely on heat detectors to detect temperature changes are unable to detect the presence of fire. A camera acting as an image scanner sensor could be used to identify the shape or color of a flame. The goal of the research is to create an image processing flame detection system using image enhancement, color segmentation, and filtering techniques, all of which are implemented using LabVIEW's Vision Assistant. They stress that, the system runs at 30 frames per second with a resolution of 1024 x 768 pixels, with a 98 percent accuracy.

Rice clusters were separated at the rice harvest by Yu *et al.* (2021), who worked for high yield and grain quality. They created a system that utilized X-ray and RGB scanning as well as deep learning. They created a pipeline for analysis and came up with five distinct ways to count rice. As a result, good accuracy ($R^2 = 0.99$) and speed were achieved. The classification of indica and japonica yielded a 91 percent accuracy. It is worth noting that this is a positive outcome for rice breeding.

Given the literature results, the research findings appear to be more successful than those found in the literature.

CONCLUSION

It is required to meet the ever-increasing requirements of the agriculture business due to the development of color vision technology. As a result, imaging technology will see more use and popularity in the future years. After reviewing the literature and evaluating the results, we can conclude that a LabVIEW video processing-based color detection system is functional and may be used as part of a sorting machine for this purpose.

High quality and safety standards have begun to be sought as consumer expectations for agricultural products have risen. These product characteristics should be determined precisely, rapidly, and objectively. To achieve these objectives, the new vision offers an alternative to an automated, non-destructive, and cost-effective technique. Various image processing methods based on image analysis in the agriculture business have been developed in response to these requirements.

The image investigation in this study was conducted using a color detection system based on LabVIEW video processing. We can easily and inexpensively obtain data in the sector by utilizing computer vision frameworks. This article shows how these procedures, as well as further calibration, can help attain accuracy. On three color plates, the study is conducted for agricultural purposes. Automation of sorting applications for improving and classifying item quality is a significant advancement. This study shows how LabVIEW can be used in agriculture. This technique is adaptable and is being employed in a variety of agricultural products. More productive work can be done with the help of developed algorithms and efficient working methods. Snapshot analysis is based on picture analysis and is still in the early stages of development.

DECLARATION OF COMPETING INTEREST

The author would like to declare that there is no conflict of interest.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

The author would like to declare that he solely developed all the sections in this manuscript.

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