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PROGRAMMING OPTICAL SENSORS TO INCREASE PERFORMANCE OF OLIVE SORTING SYSTEM

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Abstract: *Sorting is an essential task in the fruit industry, where ripeness is a crucial factor in the quality of fruits or products. In the olive industry, we have two essential products, olive oil, and table olives, which depend on olive quality. This paper describes a study on the empiric determination of olives colour to increase the performance of an automatic sorting machine that uses colour sensors to determine the colour of detected olives. For this study, we use a sample of 100 black olives and 100 green olives from one olive orchard. Using a spectrophotometer, we have taken three samples for each olive class to determine the correct spectrum for black and green olive.*
Key words: *sensors, fruit sorting, agricultural, spectrophotometer, RGB.*

1. INTRODUCTION

In the last years, automatic systems and robotics systems have entered the agricultural industry in various forms [1, 2], especially in the field of fruit collection but also to promote a return of the agricultural industry towards as natural products as possible [3].

Thus, the olive industry could not be circumvented by this technological development. Furthermore, there is an attempt to implement industry 4.0 to the technological process of olives so that the buyer knows where his table olives or olive oil come from, and to eliminate the counterfeit products as much as possible.

Olives are an important product for the Mediterranean Basin, especially for Greece [4]. Particular emphasis is placed on the sorting of olives due to the different characteristics of green olives (first stage of ripeness) and black olives (last stage of ripeness), especially the oleuropein content (the higher, the bitter the olive) [2, 4, 5]. After we have taken the first steps towards the implementation of the robotics elements for olive picking [2], we are now conducting a study on the performance of sensor use in automatic sorting. We use sensors because we are looking for low cost solutions such that they are affordable for entrepreneurs in this field. In Greece most olive orchards are small in size and expensive sorting devices are not cost effective [6, 7]. As we have shown in other research work, with the increase of the speed of the olive processing through the sensor, the accuracy of the reading has decreased [6, 7]. This is due to the fact that the sensor does not determine the color of the olives. In this paper we analyze the colors of the olives so as to increase the reading accuracy of the sensor by correcting the reading parameters, namely the RGB values (Red Green Blue color light).

2. MATERIALS

One Olea europaea variety for this study named Petroelia from central and North Greece in unripe stage (green color) and in full ripening stage (black color) [8]. In this experiment we take Petroelia variety because it belongs to the middle sized olives. It has low-grade fruits and is of dual use. It is used either as table olives or for the production of olive oil containing 20% - 25% oil [2, 9].

Also, we use only one variety of olives because we adjust the spectrum of colors (green to black) using a single batch of olives. For this experiment we use 100 samples for each color, 200 samples in total. For each sample we make 3 measurements, for a total of 600 measurements. For these measurements, we use a spectrophotometer datacolor 500, Figure 1.

Fig. 1: Spectrophotometer.

We use a laptop, Asus, with an i7 processor for programming Arduino sensors [10] (Figure 2) and the prototype sorting stand (Figure 3). Based on the results of spectrophotometer measurements, we calibrate the color sensor [11], Figure 2, for each of the colour classes on our sorting prototype stand Figure 3, that was describe in other papers.

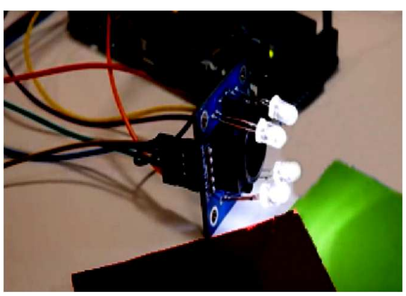

Fig. 2: Sensor testing at black and green color.

Fig. 2: Prototype sosrting stand.

3. METHODOLOGY

All spectrophotometer measurements were centralized by the olive color RGB value, Table I and II. For each batch we extract the minimum and the maximum value for R, G and B. Each one of the red, green and blue values are represented as 8 bit integer values ranging from 0 to 255 [12]. The combination of these three values give the spectrum of the colors that must be recognized by sensors.

Table 1

Value of green color olives.

Batch Name	Value		
	RGB R	***RGB G***	***RGB B***
P1 Gr. 1	129	109	66
P1 Gr. 2	130	111	71
P1 Gr. 3	135	114	71
…	…	…	…
P100 Gr. 1	131	145	59
P100 Gr. 2	120	127	55
P100 Gr. 3	137	153	55
Minim	112	90	55
Maxim	147	154	78

Table 2

Value of black color olives.

Batch Name	Value		
	RGB R	***RGB G***	***RGB B***
P1 B. 1	53	54	51
P1 B. 2	50	50	44
P1 B. 3	47	52	50
…	…	…	…
P100 B. 1	33	51	21
P100 B. 2	44	52	38
P100 B. 3	21	32	21
Minim	16	15	15
Maxim	55	55	53

The range from minim to maxim indicate the spectrum for green and black olives. Next, using this value we define the color spectrum for each color class, green and black, Figure 4.

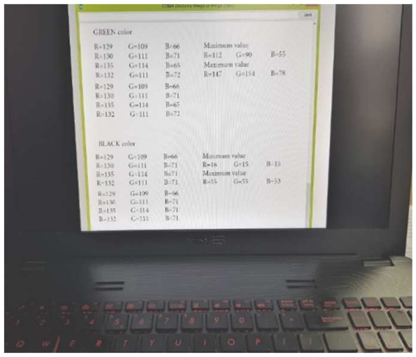

Fig. 4: Define the spectum vlalue for each color.

4. RESULTS AND DISCUSSIONS

The results indicate that, given the definition of the spectrum of green to black colors, the sorting accuracy has increased, even at higher speeds.

In order to determine the accuracy of the sensor with the optimized spectrum of green to black colors, we performed a test using 200 green olives and 200 black olives (described as the number of items variable in Table 3). The olives were in various randomized positions and distances from one another on the conveyor belt.

The displacement speed was varied from 0.5 to 10 cm/sec. The experimental data is showcased in Table 3.

Table 3

Accuracy of senzor.

Conveyor speed [cm/sec]	**Olive color**					
	Green			***Black***		
	Nr. of items	***Sensor accuracy***	***Precession {%}***	***Nr. of items***	***Sensor accurac***	***Precession {%}***
0.5	200	200	100	200	200	100
1	200	200	100	200	200	100
1.5	200	200	100	200	200	100
2	200	200	100	200	200	100
3	200	200	100	200	200	100
4	200	200	100	200	200	100
5	199	200	99.5	200	200	100
6	197	200	98.5	198	200	99
7	191	200	95.5	193	200	96.5
8	190	200	95	194	200	97.
9	192	200	96	193	200	96.5
10	191	200	95.5	192	200	96

4. CONCLUSIONS

Using our proposed method (defining the color spectrum), the recognition accuracy at low speeds has been increased, up to an accuracy of 100%. Moreover, we doubled the speed of the other components described in experiments [6, 7] and the accuracy continued to be very high (99%). At speeds of 10cm / sec the prototype's performance started deteriorating, which indicates that higher speeds are correlated with higher errors Table 4.

One solution to increase sorting speed would be to mount several color sensors on a larger conveyor belt.

It was observed that the errors occurred mainly due to mechanical delays.

Table 4

Prototype testing value comparation.

Conveyor speed [cm/sec]	**Old system**		**New system**	
	Green	***Black***	***Green***	***Black***
	Precession {%}	***Precession {%}***	***Precession {%}***	***Precession {%}***
0.5	100	99	100	100
1	98	97	100	100
1.5	93	92	100	100
2	86	87	100	100
3	83	83	100	100
4	80	79	100	100
5	No test	No test	99.5	100
6	No test	No test	98.5	99
7	No test	No test	95.5	96.5
8	No test	No test	95	97
9	No test	No test	96	96.5
10	No test	No test	95.5	96

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Creșterea preciziei de sortare prin programarea senzorilor optici

Rezumat: Sortarea fructelor este o etapă esențială în industria procesării fructelor, unde maturitatea fructelor este un factor crucial în calitatea fructelor sau a produselor realizate din fructe. În industria producătoare de măsline, avem două produse esențiale, uleiul de măsline și măslinele de masă, iar aceste produse depind de calitatea măslinelor. Această lucrare descrie studiul despre determinarea empirică a culorii măslinelor pentru a crește precizia unei dispozitiv de sortare automată a măslinelor care utilizează senzori de culoare pentru determinarea culorii măslinelor. Pentru acest studiu, folosim un eșantion de 100 măsline negre și 100 măsline verzi proveniți dintr-o livadă de măslini și, cu un spectrofotometru, am realizat trei citiri pentru fiecare măslină în parte, determinând astfel cât mai correct valoriile culorilor.

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