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OPTICAL SYSTEM USED FOR SORTING APPLES BY SIZE

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Abstract: A low cost sorting system by size for apples is presented. This kind of system will be very useful in a more complex sorting machine, where is appropriate to sort the products on their color, dimension or weight. The development of the system relies on the NIR (near infrared) technology and linked with microcontroller data processing. We proposed this technology as an alternative to the more expensive video processing systems. The infrared components were distributed in a 3D fashion in a chamber with black walls. The communication results between the sensors were interpreted by our proposed algorithm for the volume calculus of the apples. The system was tested on different sets of apples and proved to be a reliable one in each case. The final prototype can be used not only for sorting but for calibration too, thus permitting a more accurate sorting. This work will be a good starting point for the next building block of the sorting machine that we are working on.

Keywords: *NIR (near infrared), sorting, calibration, microcontroller, LED, photodiodes*

I. INTRODUCTION

Classification of fruits and vegetables after harvest is an essential step in the management of post-harvest. The first method of classification of fruits and vegetables were based on manual sorting. Gradually began to appear partially mechanized sorting devices until they got to the devices that are occupied entirely by washing, sizing and sorting fruits and vegetables. Various researchers have developed several types of classification according to application and processing aspects of the market. The general classification is based on the size, shape, weight, color and presence of faults. Classification of fruits and vegetables is an important operation that affect quality and preservation of product. [1] Manual product classification is expensive, requires more time and is inefficient.

Over the past few decades, different mechanical systems have been developed for non-destructive determination of horticultural product dimensional size. A possible classification of these systems could be made into six different groups, according to their principle of measurement:

i) system based on measurement of the volume of the gap between the fruit and the outer casing of embracing gauge equipment;
ii) system that calculate fruit size by measuring the distance between a radiation source and the fruit contour, where this distance is computed from the time of transmission of the propagated waves;
iii) system that rely on the obstruction of light barriers or blockage of light;
iv) two dimensional (2-D) machine vision system;
v) three-dimensional (3-D) machine vision system;
vi) other systems, which includes systems based on internal images, such as computed tomography or magnetic resonance imaging. [5]

Fruit and vegetable calibration implies the achievement of homogenous dimension products. Machines with different operation principle are used for the calibration process, like: drums with sieves, bands, cable systems, etc. A frequently used system is the one which contains sieves with different size of square holes. So in the front side, close to the power supply, the sieves present small holes while at the evacuation side the holes get larger. The device is working by tilting the drum by the telescopic legs and by rotating the drum.

The mechanical device which uses the divergent cables system is very common to sort the large size fruits and vegetables. The distance between the cables is enlarging from the entrance to the evacuation from the system.

In 1953 Malcolm and DeGarmo performed tests on fruits and potatoes, using band systems with rollers in which the speed of the rollers could be modified.

In 1956 Mack, Larson and White (1956) implemented an apple sorting machine based on a mesh with square holes made by wires. The hole sizes from this machine were defined in a manner that permitted to sort the apples in three categories: 50-57mm, 57-64mm and 64-71mm.

In 1957 Houston studied new criteria for fruit sizing and observed that different physical properties of the fruits, like the diameter, circumference and the cross sectional area could be used as sorting criteria.

The researchers succeed to develop machines capable to replace entirely the manual sorting. In 1966 Burt and Patchen developed and implemented a compact machine capable for cleaning and sorting of the apples, using rotational brushes instead of the classical rollers from the transportation band. Afterwards, in 1967 Burt introduced the polyurethane rollers with brushes. Gradually, in 2010, the researchers: Posselius and Cox, Nevkar, Suppavit and Butta, Ghuman and Kumar, Ukey and Unde, achieved the implementation of a fully mechanical system for precise classification and evaluation of wellbeing of the products [2][3].

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In the last 10 years the fruit and vegetable sorting operations become completely automatized. The majority of the mechanical sorting systems were replaced with electronic ones. Image processing and NIR technology were introduced in most of the sorting systems to analyze the fruits from all possible viewpoints. [3][4][5]

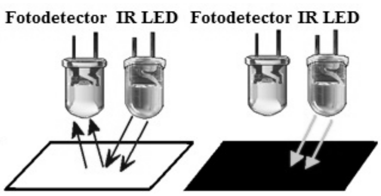
Image processing is relatively a new technology, used in fruit and vegetable sorting. Using this technology can obtain accurate information regarding the shape, the dimension, the color and the aspect of the products. The captured images, with a CCD camera placed on the top of the transportation band, are analyzed with a digital processing unit. [8][9][11]

In 1995 in Washington, the NIR technology was used for the first time to analyze the apples. After that, the researchers investigated the NIR technology to measure: the maturity of papaya fruits, the proteins from wheat, sugar content from fruit juices, etc. The NIR sorting system can be used in reflection mode when the infrared light is reflected or absorbed by the fruits, or transmission mode when the infrared light pass through the fruits. The NIR spectrum is between 800-2500nm.

The image processing systems consist in a large number of computation which have to be done by complex and expensive equipment. For this reason, we focused our work on the NIR technology to develop size sorting and calibration system for apple sorting with low cost implementation.

II. THEORETICAL FUNDAMENTALS

The relation between reflection and absorption is called emissivity. A scale was setup for the emissivity of the materials, scale which comprise values from 0 to 1. A perfect infrared reflector material has the emissivity value equal to 0 (Figure 1a), and at the other end of the scale a perfect infrared absorbing material has the emissivity equal to 1 (Figure 1b).



a) b)
Figure 1. a) reflection from a white surface;
b) absorption from a black surface.

Although the emissivity may vary depending on the thickness, temperature and wavelength, it is generally approximated by a constant:

$$\frac{E_M\left(\lambda,\theta,\Phi,T\right)}{A_M\left(\lambda,\theta,\Phi,T\right)} = I\left(\lambda,T\right) \qquad (1)$$

where: E_M is the emissivity of the material, A_M is the absorptivity, I(λ,T) is a function independent from the material, function called „black body radiation", T is the absolute temperature, λ is the wavelength and θ,Φ are the angles of emission.

III. IMPLEMENTATION

Any fruit or vegetable sorting system has three main components: power supply, the transportation assembly and the detection system. Among this essential parts, other components can be found, as we can see in our proposed system from Figure 2. In this configuration the main components are: 1- transportation band, 2- power supply, 3- sorting and calibration chamber, 4- pneumatic system, 5- control unit, 6- external wire or wireless device connection (PC, mobile phone, etc.).

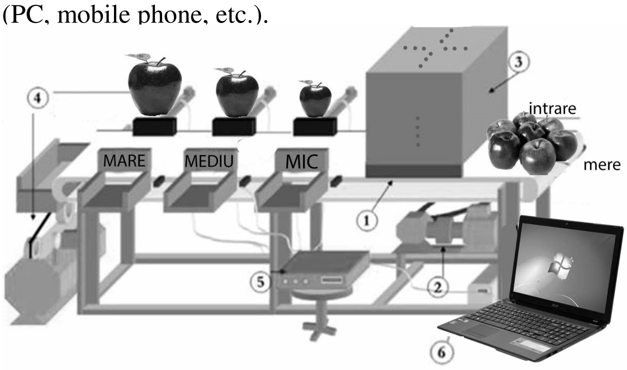


Figure 2. Sorting system example.

From this component chain of the sorting system, we present a detailed research regarding the sorting and calibration chamber. The chamber designed by us consist a number of seventeen NIR transmission elements disposed in a manner that can approximate the volume of the product to be sorted or calibrated. The advantage of the infrared transmission will be seen in the simple structure of the chamber which not require an isolation from the ambient light, beside the color detection chamber of the products that we presented in [14] where the sensor must be isolated entirely from the ambient light.

The basic building blocks of our system are presented in Figure 3. The sensor implemented is based on the principals of transmission presented in the theoretical fundamentals. For this approach we need seventeen light sources for the incident light flux and seventeen photodetectors to detect the presence of the transmitted light flux.

Figure 3. Building blocks of the detection system.

To choose the adequate electronic devices we took into account a few desirable characteristics of the system: low cost, low power consumption and long life operation. All these characteristics can be achieved using the IR LEDs for the light sources and photodiodes/phototransistors for light detection.

Table 1. IR LED parameters

LED	Emission angle (degrees)	Central Wavelength (nm)	Maximum Power (mW)
1. LL-503SIRCHB1BE	45	850	165
2. BPV10NF	40	940	215
3. TSAL5100	10	940	210
4. L – 53F3C	30	940	20
5. LL-503IRT2E-2AE	45	940	100

From the large market of IR LEDs, we choose five of them which had the same price range but different: central wavelength, emission angle and power consumption as can be seen in Table 1.

To use the most suitable LED we put under the same test all the LEDs. This test consists in the detection of the light emitted by the LED with a raw of photodetectors placed at the distance of 10cm, 12.5cm and 15cm from the LED. We want that the light emitted by the LED to be received only by the photodetector placed face to face with the LED, photodetector called the *corresponding photodetector*. In Table 2 we marked with YES if the light emitted by the LED is received by the neighbor of the corresponding photodetector and with NO if the light was detected just by the corresponding photodetector.

Table 2. Distance at which the IR LED light is detected

LED	Distance to the detector (cm)		
	10	12.5	15
1. LL-503SIRCHB1BE	YES	YES	YES
2. BPV10NF	YES	YES	YES
3. TSAL5100	NO	NO	YES
4. L – 53F3C	NO	YES	YES
5. LL-503IRT2E-2AE	YES	YES	YES

According to the test, the TSAL5100 model LED with the smalles angle of emission of only 10º proved to be most suitable for our application.

For a good polarization of this type of LED we have to provide a forward current of 100mA. Because our system will be built around the1280 Atmega microcontroller which can provide a maximum output current of only 20mA we have to use a current amplifier device. For the last one we targeted to the 2N3904 NPN bipolar transistor. The configuration of the driver is presented in Figure 4.

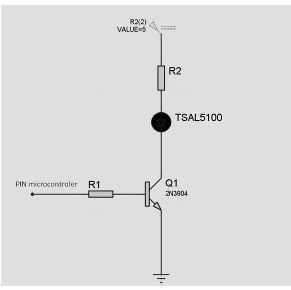


Figure 4. LED driver using bipolar transistor

The value of the R2 transistor is given from:

$$R_1 = \frac{V_{CC} - V_{FM} - V_{CEsat}}{I_F} \approx 39\Omega \quad (3)$$

where: Vcc = 5V, $V_{CEsat} \approx 0.2V$ and the forward voltage on the LED given from the datasheet is V_{FM}=1.6V. To ensure a good switching of the transistor R_1=1k Ω.

Taking into account that our LED has a central wavelength of 940nm, we had to look for a photodetector which has the highest sensitivity at the same wavelength or at least very close to this value. Another characteristic that we looked for is the high sensitivity, in other words for a small amount of light flux incident on the photodetector to obtain a considerable current. This last characteristic lead to the phototransistor class and removing the photodiodes from this options. In Table 3 is presented the tested phototransistors and their main parameters.

Table 3. Phototransistor options

Photodetector	Receiving angle (grade)	Central wavelength (nm)	Maximum Power (mW)
1. LTR 3208	20	940	100
2. BPV11F	30	950	150
3. IRE 5	20	940	100

From the above phototransistors the LTR 3208 and IRE 5 presented the same characteristic regarding the sensitivity under the same light flux from the TSAL5100 LED. In this case we choose the LTR 3208 which had a smaller price on the market.

To process de information regarding the presence of the light on the phototransistor we used the configuration from Figure 5, where the output voltage (collector-emitter voltage) is the input signal to one of the digital inputs of the 1280 Atmel microcontroller.

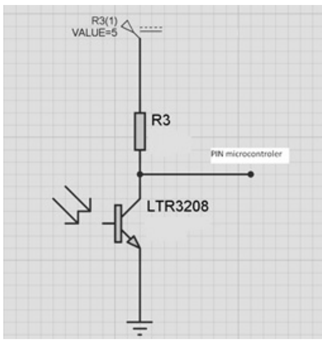


Figure 5. Phototransistor driver

For the R3 resistor value, we had to take into account that “0” logic level is for input voltages under 1.5V (close as possible to 0V), and “1” logic level for input voltages higher than 3V (close as possible to 5V). An approximation of the resistor value was made R3=2kΩ, using the dark current (100nA) of the phototransistor and the minimum value of the collector current (2mA) produced under a minimum incident light flux. The input voltage to the microcontroller digital port is given by:

$$V_{in\_microcontroller} = V_{CE} = V_{CC} - V_{R3} = V_{CC} - R_3 * I_{CE} \quad (4)$$

A schematic of the entire electrical design was implemented in Proteus (Figure 6), where we can see seventeen LEDs and for the photodetectors we used seventeen push-button switches.

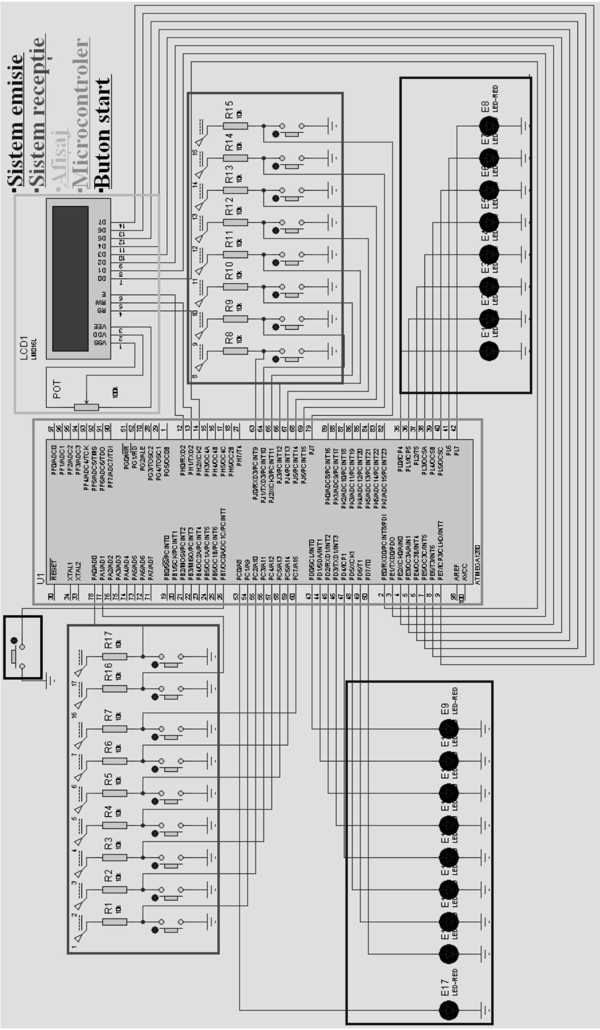


Figure 6. Schematic of the sorting system in Proteus

In Figure 7, is illustrated the response of the photodetectors from the position 1, 5 and 9. First time the LED from position 1 was activated and simultaneously the output value of the first photodetector was read, which show a 5V voltage. This indicates that is an obstacle between the emitted light and the corresponding photodetector. Sensor 5 detects an obstacle too and sensor 9 has a value of 0V indicating that is no obstacle in that direction.

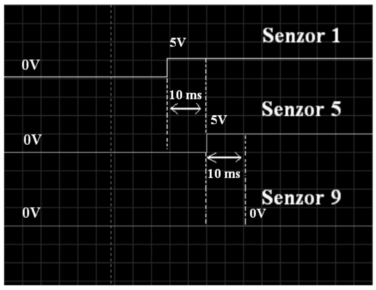


Figure 7. Signal diagram example

We can observe that is very important to activate the sensors at different times, for example with a 10ms delay between them. In this fashion the sensors will not interact with each other, so we can avoid possible reading errors.

The layout of the LEDs and of the phototransistors play an essential role for the proper evaluation of the apple's volume. Detecting a geometric form related to the apple's shape we could calculate an approximate volume for the apple. Thus, we decided to use a number of seventeen pair sensors (LED-phototransistor) in the following manner:

- on the bottom of the chamber 12 LEDs which emit to the top side where are mounted the corresponding 12 phototransistors;
- on the lateral sides of the chamber are disposed, on the same principle, a number of five LEDs and five phototransistors.

Each pair of sensor is activated for a period of 10ms.

We can group the sensor pairs in two categories (Figure 8):

- sensors with vertical emission (bottom-top configuration);
- sensors with horizontal emission (side-side configuration).

The vertical emission sensors were used to calculate the area which the apple covers. Depending on the fruit dimension's, a part of the sensors will be in blocked state and these values (L_1,L_2,L_3,L_4) will be used in the volume calculation. The vertical sensors are placed in "+" (plus) shape, and are activated in a spiral manner from inside to outside.

The horizontal emission sensors were used to determine the height of the fruit. At the same time these sensors are used to detect the presence of the apples. The sensors are aligned in a raw, with a constant distance between each sensor. These are activated from bottom to up, one by one, and the distance from the bottom to the last blocked sensor will be used for computing the volume.

To calculate the aria, we can use:

$$A = \frac{(L_1 + L_3) * (L_2 + L_4)}{2} \quad (4)$$

For the volume we have:

$$V = A * h \quad (5)$$

where:

V - is the volume of the parallelepiped which approximates the shape of the apple;

A – is the approximate area of the apple in sit position;

h – is the height of the apple;
L_1,L_2,L_3,L_4 are the distances between the center and the last blocked sensor on the 4 direction of the "+" shape.

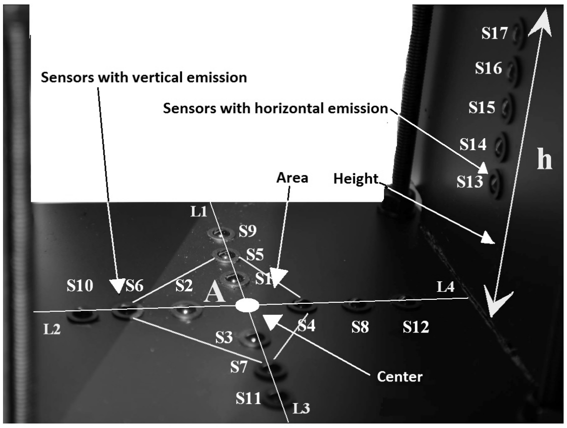


Figure 8. Sensor distribution in the chamber

After the decision regarding the distribution of the sensors in the horizontal and vertical plane and the volume calculation method, we had to choose the optimal distances for the placement of the sensors. For this step we started out by using 3 setups:
- setup 1: the horizontal sensors had a distance of 4cm – 5cm – 6cm – 7cm - 8cm from the bottom of the chamber; the vertical sensors had a distance of 1.5cm - 3cm - 4.5cm from the center.
- setup 2: the horizontal sensors had a distance of 4cm – 5cm – 6cm – 7cm - 8cm from the bottom of the chamber; the vertical sensors had a distance of 2cm - 3cm - 4cm from the center.
- setup 3: the horizontal sensors had a distance of 3.5cm – 4.5cm – 5.5cm – 6.5cm – 7.5cm from the bottom of the chamber; the vertical sensors had a distance of 1.5cm - 3cm - 4.5cm from the center.

The results of each setup is presented later in the experimental results section.

In Figure 9 we established a flowchart of the algorithm for the volume computation and classification of the apples in three categories: small, medium and big.

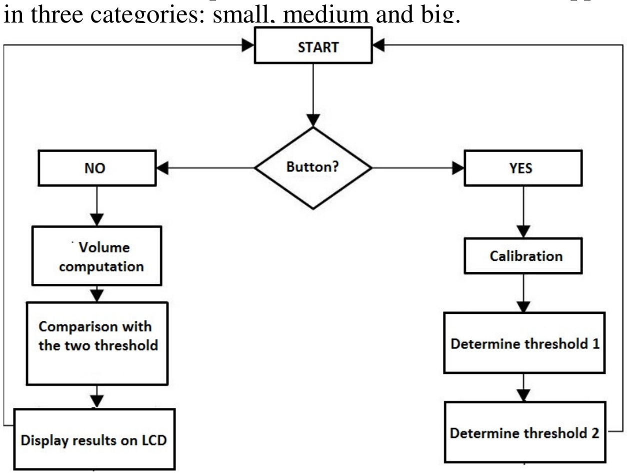


Figure 9. Flowchart of the sorting algorithm

The algorithm starts with the verification of the calibration button state. If the button state is active than the right side from the flowchart is executed: with two calibration apples we set the lower and higher ends of the medium sorting interval. At the end of the calibration process the algorithm starts from the beginning. If the calibration button state is not active, the system computes the volume of the apple by multiplying the area with the height. The calculated volume is compared to the two threshold values: if the volume is smaller than the low end threshold the apple is classified as small, if the volume is bigger than the high end threshold the apple is classified as big and if it's in the interval between the two threshold the apple is classified as medium size.

IV. EXPERIMENTAL RESULTS

To implement and test the three proposed setups, we used wooden plates to mount the LEDs and phototransistors with the help of 5mm clip heads, as seen in Figure 10. This solution offered a cheap, reliable and easy reconfiguration.

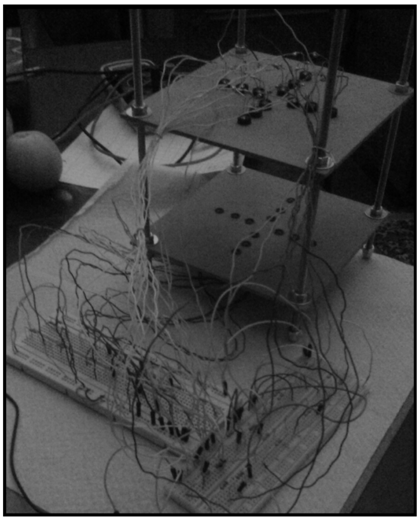


Figure 10. Chamber prototype used for the three setup

Each setup was under test with a set of 30 apples (Figure 11): 10 apple considered small, 10 apple considered medium and 10 apple considered big ones. At this first stage, the electronic devices were mounted on breadboards.

Figure 11. Set of apples used for sorting

Because the apples do not present a perfect spherical shape we placed the apples inside the chamber in two different positions, to test the volume computation proposed by us. The two positions are presented in Figure 12, and can be checked in the next tables under the name of Position 1 and Position 2.

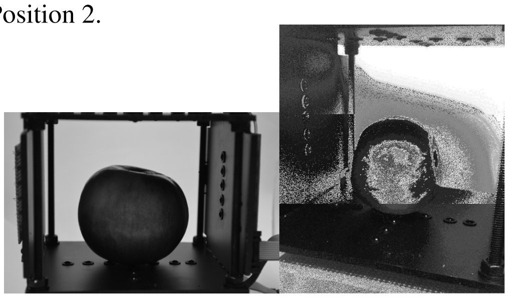


Figure 12. Two different position of the same apple in the chamber (Position 1, Position 2)

For each setup a table was completed with the most five significant apple measurement from each class (small, medium and big) and for each position of apple placement in the chamber. Thus, we present a total of 6 tables with partial results. The apple numbers from these tables, with index 1 are from the small class, index 2 are from the medium class and index 3 are from the big class.

Table 4. Apple measurements using setup 1 distribution of the sensors and position 1 of the apple in the chamber

Apple Number	**Position 1**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 1 cm^3**
Apple 1.1	1.5	1.5	1.5	1.5	4	18
Apple 1.2	1.5	1.5	3	3	5	55.65
Apple 1.3	3	1.5	3	1.5	5	45
Apple 1.4	3	3	3	1.5	5	67.5
Apple 1.5	1.5	3	3	1.5	4	40.5
Apple 2.1	3	3	3	3	6	108
Apple 2.2	3	3	3	4.5	6	135
Apple 2.3	3	3	3	3	6	108
Apple 2.4	4.5	3	3	4.5	6	168.75
Apple 2.5	3	4.5	3	4.5	7	189
Apple 3.1	4.5	4.5	3	3	8	225
Apple 3.2	3	4.5	4.5	4.5	7	236.25
Apple 3.3	4.5	3	4.5	3	8	216
Apple 3.4	4.5	4.5	4.5	3	8	270
Apple 3.5	4.5	4.5	4.5	4.5	8	324

Table 5. Apple measurements using setup 1 distribution of the sensors and position 2 of the apple in the chamber

Apple Number	**Position 2**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 2 cm^3**
Apple 1.1	1.5	1.5	1.5	1.5	4	18
Apple 1.2	1.5	1.5	3	1.5	5	34.5
Apple 1.3	1.5	1.5	3	1.5	6	40.5
Apple 1.4	1.5	3	3	3	5	67.5
Apple 1.5	3	1.5	1.5	1.5	5	34.5
Apple 2.1	3	3	4.5	3	6	135
Apple 2.2	3	3	3	3	7	126
Apple 2.3	1.5	3	4.5	3	7	126
Apple 2.4	3	3	3	4.5	7	157.5
Apple 2.5	4.5	3	3	3	8	180
Apple 3.1	3	4.5	3	4.5	8	216
Apple 3.2	3	3	4.5	4.5	8	225
Apple 3.3	4.5	4.5	4.5	3	7	236.25
Apple 3.4	3	4.5	3	4.5	8	216
Apple 3.5	4.5	4.5	4.5	4.5	8	324

Table 6. Apple measurements using setup 2 distribution of the sensors and position 1 of the apple in the chamber

Apple Number	**Position 1**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 1 cm^3**
Apple 1.1	2	2	2	2	4	32
Apple 1.2	2	3	2	2	4	40
Apple 1.3	3	2	2	3	5	62.5
Apple 1.4	3	3	2	2	4	50
Apple 1.5	2	3	3	3	4	60
Apple 2.1	2	3	3	3	5	75
Apple 2.2	3	4	3	4	6	144
Apple 2.3	3	3	3	3	5	90
Apple 2.4	3	3	3	4	6	126
Apple 2.5	4	4	3	2	6	126
Apple 3.1	4	3	4	3	7	168
Apple 3.2	3	4	4	4	6	168
Apple 3.3	4	3	3	3	7	147
Apple 3.4	4	3	3	4	7	171
Apple 3.5	4	4	4	4	8	256

Table 7. Apple measurements using setup 2 distribution of the sensors and position 2 of the apple in the chamber

Apple Number	**Position 2**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 2 cm^3**
Apple 1.1	2	2	2	2	4	32
Apple 1.2	2	2	2	2	5	40
Apple 1.3	2	3	2	2	5	50

Apple 1.4	3	2	2	2	5	50
Apple 1.5	3	2	3	2	5	60
Apple 2.1	2	2	3	3	6	75
Apple 2.2	4	3	3	3	6	126
Apple 2.3	2	3	3	2	6	5
Apple 2.4	2	3	3	4	7	122.5
Apple 2.5	3	4	3	2	7	126
Apple 3.1	3	3	4	3	8	168
Apple 3.2	3	4	3	3	7	147
Apple 3.3	4	3	4	3	7	168
Apple 3.4	3	4	4	3	8	196
Apple 3.5	4	4	4	3	8	224

Table 8. Apple measurements using setup 3 distribution of the sensors and position 1 of the apple in the chamber

Apple Number	**Position 1**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 1 cm^3**
Apple 1.1	1.5	1.5	1.5	1.5	3.5	15.75
Apple 1.2	1.5	1.5	3	3	3.5	35.44
Apple 1.3	3	1.5	3	1.5	3.5	31.55
Apple 1.4	3	3	3	1.5	4.5	60.75
Apple 1.5	1.5	3	3	1.5	4.5	45.56
Apple 2.1	3	3	3	3	5.5	99
Apple 2.2	3	3	3	4.5	4.5	101.25
Apple 2.3	3	4.5	3	3	5.5	123.75
Apple 2.4	4.5	3	3	4.5	5.5	154.68
Apple 2.5	3	4.5	3	4.5	5.5	148.5
Apple 3.1	4.5	4.5	3	3	6.5	182.81
Apple 3.2	3	4.5	4.5	4.5	5.5	185.62
Apple 3.3	4.5	3	4.5	3	6.5	175.5
Apple 3.4	4.5	4.5	4.5	3	6.5	219.37
Apple 3.5	4.5	4.5	4.5	4.5	7.5	303.75

Table 9. Apple measurements using setup 3 distribution of the sensors and position 2 of the apple in the chamber

Apple Number	**Position 2**					
	L1 cm	**L2 cm**	**L3 cm**	**L4 cm**	**h cm**	**Volume 2 cm^3**
Apple 1.1	1.5	1.5	1.5	1.5	3.5	15.75
Apple 1.2	3	1.5	3	1.5	4.5	40.5
Apple 1.3	1.5	1.5	3	1.5	4.5	30.37
Apple 1.4	1.5	3	3	3	4.5	60.75
Apple 1.5	3	1.5	1.5	1.5	5.5	37.12
Apple 2.1	3	3	4.5	3	5.5	123.75
Apple 2.2	3	3	3	3	5.5	99
Apple 2.3	1.5	3	4.5	3	5.5	99
Apple 2.4	3	3	3	4.5	5.5	123.75
Apple 2.5	4.5	3	3	3	6.5	146.25
Apple 3.1	3	4.5	3	4.5	6.5	175.5
Apple 3.2	3	3	4.5	4.5	7.5	210.93
Apple 3.3	4.5	4.5	4.5	3	7.5	253.125
Apple 3.4	3	4.5	3	4.5	7.5	202.5
Apple 3.5	4.5	4.5	4.5	4.5	7.5	303.75

Comparing the results obtained for each setup we can observe that the two threshold is not influenced by the position of the apples in the chamber. In Table 10 is presented a possible threshold option for each setup.

Table 10. Classification intervals obtained in the three distribution setup of the sensors

Results for the first setup (Table 4 and Table 5): Small apple ($100cm^3$) < Medium apple (cm^3) < Big apple ($200cm^2$)
Results for the second setup (Table 6 and Table 7): Small apple ($70cm^3$) < Medium apple (cm^3) < Big apple ($145cm^3$)
Results for the third setup (Table 8 and Table 9): Small apple ($95cm^3$) < Medium apple (cm^3) < Big apple ($160cm^3$)

All the three setup proved to be working correctly. For a compact prototype we choose to implement the third setup. From the above tables we observed, that typically the apples dimensions don't exceed certain values, so we placed the sensors walls to a distance of 10cm and 12.5cm respectively (Figure 13). The plexiglass for the chamber was painted in black to provide a very good absorption of the infrared light.

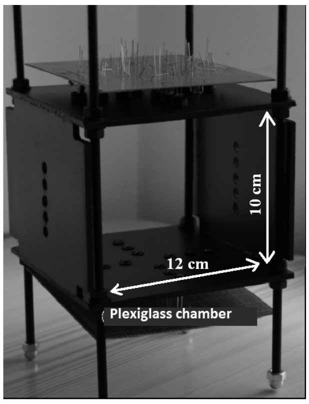


Figure 13. Plexiglass chamber dimensions

The new plexiglass system's sorting indicator was initially implemented with colored LEDs: green for small apple, blue for medium apple and red for big apple (Figure 14).

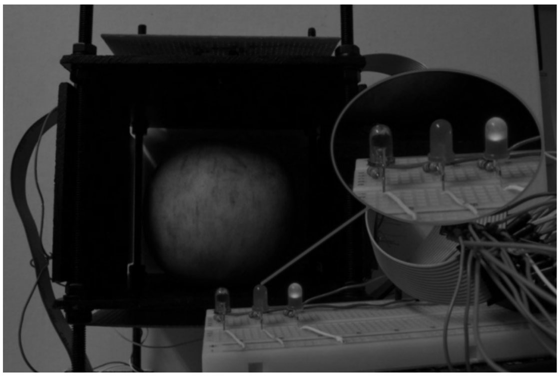


Figure 14. Prototype of the sorting system with LED

In Figure 15 the final apple sorting prototype is pictured. The IR LEDs and the phototransistors are mounted on four test boards. The atmega 1280 microntroller was soldered on a PCB to permit a THT mounting on the test board. All the interconnections between the test boards are managed with 10 and 14 wire ribbon cables. A 2x16 capacity LCD was attached to show the classification class of the apple to be sorted.

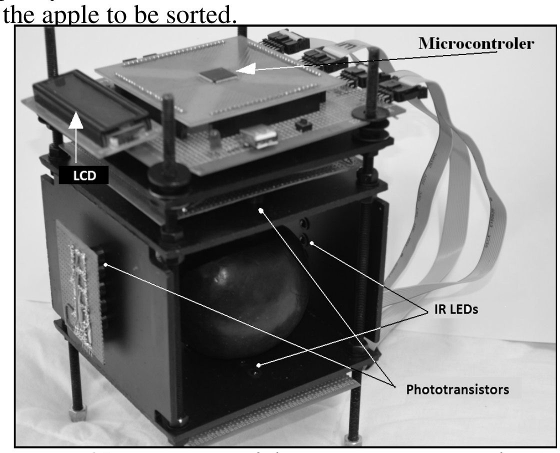


Figure 15. Prototype of the sorting system with LCD

CONCLUSIONS

Over the last decades the economic development brought an improvement in the living standards, thus the fruit consumption increased significantly. The costumers have higher and higher expectations from the fruit quality that they buy. Because of this demand a lot of small and medium growers cannot sell their products. A basic sorting is needed to be competitive on the market, like color and size sorting. The majority of the sorting machines are dedicated for the big growers, and this machines have a prohibitive price for a small or medium grower. In our research we try to bring out low cost implementation for sorting machines which can be suitable for the small and medium growers.

In the present paper we focused our research on a sorting system of apples by their size. The prototype developed and tested by us is based on the NIR transmission technology. We considered that the volume of an apple is direct proportional with the volume of a parallelepiped delimited by the sensors which interact with the apple. This approach was confirmed by the test we made on three different special arrangement of the sensors. Another positive feedback was the independence of the classification thresholds in relation with the position of the apple introduced in the chamber. Our system presents a group of vertical emission sensors and a group of horizontal emission sensors. The total number of the sensors is seventeen pair IR LED – phototransistor.Taking into account that each pair of sensors is activated sequentially for 10ms, that means that the classification of one apple requires an average time of almost 200ms. In this situation the sorting speed of the system is around 5 apple/s. Among the sorting capability, our system permits a calibration of the classification thresholds for the desired classes.

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