

# Real-time object detection and selection with the LabVIEW program

Original Scientific Paper

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**Abstract** – Nowadays, the demand for production is increasing due to the increase in the human population. For this reason, different developing technologies are used to meet the required production. In developing technologies, image processing techniques are used to save manpower and time and to minimize possible errors. In this study, image processing techniques were used to detect and select the colors and shapes of the objects coming over the conveyor belt system. Real-time images were preferred in the study. In the implemented system, the selection process was carried out by using the LabVIEW program to define the colors and shapes of the objects. LabVIEW NI-IMAQdx was used to find the colors of the objects. To facilitate the definition of shapes, the images taken from the Vision Assistant module in the LabVIEW program were converted to HSL format, and shape definitions were made using different algorithms. After these processes were done, the servo motors in the conveyor belt system were enabled to communicate with each other with the help of the Arduino program and the selection of the objects was carried out. According to the results obtained, the average accuracy rate for three-dimensional objects was 95.349 %. This rate is considered to be a very high rate for object detection of correct color and shape.

**Keywords:** Color and shape detection, Conveyor belt system, Image processing, LabVIEW

## 1. INTRODUCTION

One of the most important factors for increasing the level of welfare in human life is the increase in the level of production in the industry. This increase is made possible by the advancement of technology. With the advancement of technology, simple operations where people spend their time intensively are carried out with the use of appropriate machinery and equipment. One of these machines is the conveyor belt system, which is used in the rapid transportation, detection, and selection of products in the industrial industry.

The selection process in the conveyor belt system is made using image processing technology. Before the development of image processing technology, all the steps of detecting suitable objects were done by humans. For this reason, it was not possible to prevent time loss and human-induced errors in production. The use of image processing technology in the industry and industrial processes is also aimed to solve the working problems in areas that are risky for human health.

Scientists have used a technique to automatically detect and track objects using the color feature in their studies. In this way, they enabled the identification of

objects, their monitoring, and obtaining information about objects [1]. In 2013, camera-assisted image processing methods were used to analyze the surfaces of tomatoes in motion on the conveyor belt system. In the study, the cracks and colors on the tomatoes were analyzed and the damaged tomatoes were selected [2]. Studies have been carried out to find the coordinates, dimensions, and shapes of objects on a real-time image using the LabVIEW program [3].

In some studies, real-time images were taken and measurements were made from apple, orange, and lemon samples using the LabVIEW program. Caliper measurements were also taken from the samples obtained together with the measurements. With the results obtained, it has been shown that the measurement values used in determining the size of agricultural products can be used more effectively [4]. In some studies, using the LabVIEW program, the age factor of tomatoes was calculated with image processing techniques. While determining the age factor, the transformation stages of tomatoes from green to red were followed and it was determined when the harvest time would be [5]. Designed to meet the evolving needs of Industry 4.0, such systems are easily used to categorize objects with different properties. Objects to be determined with the help of image

processing techniques are selected at lower costs. As a result of the observations and research, image processing techniques have been used because they are faster, healthier, and more practical.

In addition, studies have been carried out to define the colors and edges of images for patients with color blindness. In such studies, the wireless camera from which the image will be taken and the computer are paired, and the resulting image is processed using the LabVIEW IMAQ image assistant and displayed on the screen [6]. By using image processing techniques and the LabVIEW program, cancer cells in the human body were identified and classified. By performing automatic detection, segmentation, and classification steps with image analysis, normal cells were distinguished from cancerous cells [7]. In a study published in 2011, a bolt and nut identification study was performed on the conveyor belt system using artificial neural networks, and a 92% recognition success was achieved [8]. Image processing techniques are used to perform quality control in the glass production system.

LoG, Canny, wavelet transform, cellular neural network, and Gabor bank algorithms were applied to the images obtained to detect defects such as broken, cracked, scratched, and bubbled glass. Errors on the glass were detected and the results obtained were compared with the reference images. At the end of this study, the researcher determined that the most successful models were cellular neural networks with 91.46% and Gabor bank applications with 89.55% [9]. In another study, fault detection and classification of objects passing over a belt system were performed with a robot arm with three degrees of freedom. It has benefited from Artificial Neural Network algorithms for the detection of objects [10].

## 2. MATERIALS AND METHOD

In this study, the process of selecting objects in motion according to their different colors and shapes was made using real-time images. After determining the color and shape of the object coming over the conveyor belt system, the selection process was carried out with the help of the arms connected to the servo motors. In the conveyor belt system, 2 servo motors and 2 DC motors with a voltage level of 5V are used.

LabVIEW program was used to control servo motors and communication was provided between LabVIEW and Arduino UNO R3. The appropriate Package Manager VI was used for Arduino to be recognized by the LabVIEW program. Afterward, LINX software was loaded so that the information sent by the LabVIEW program can be used by Arduino. In this way, servo motors were controlled with the software platform developed in the LabVIEW program.

The hybrid model structure is used in the article. Since the methods used in the article have a hybrid structure, the deficiency in one model is reduced as a result of

the combination of another model. For this reason, it can show its effect in industrial applications at the rates where the color separation can be made sensitively. The relationship of mobile technology with the environment can become much more compatible with color distribution models. Color segmentation is the first step for industrial applications. The environments in which industrial applications interact with the real world often change dynamically. In addition, technological developments in recent years have made sensor technology and automation systems available to react to many options in daily life. Automation systems use color model algorithms to further improve environmental adaptation and consider this a good option.

As the object to be defined, cube and cylinder-shaped objects were determined in 4 different color types and the evaluation phase was started. A webcam camera with a resolution of 640x480 and 5-megapixel was used to obtain object images. Color and shape selection was made with the buttons created in the system interface. Objects are detected according to the specified boundary selection values.

Objects are directed to appropriate parts of the conveyor belt system if they conform to predetermined specifications. To determine the color and shape of the object correctly, 2 different functions are used in the block diagram. The first of these functions were used to perform the color test correctly, and the second to make the shape detection correct. The color spectrum obtained from the NI-IMAQdx color learning function was used to find the color. After the correct color of the object has been determined, special algorithm structures have been created with the Vision Assistant module. With the help of the algorithms used, the shape of the object whose correct color was determined was determined. The block diagram structure of the system is shown in Fig. 1.

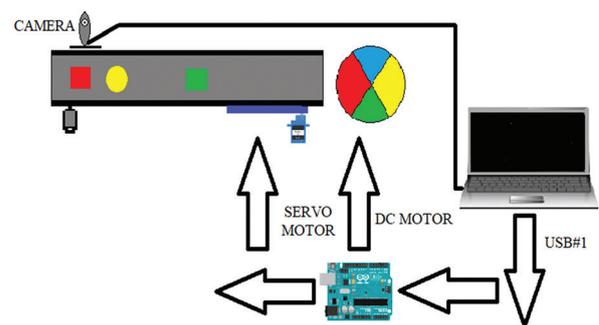


Fig. 1. Block diagram structure of the system

## 3. DEFINING OBJECT COLORS

Examining the block diagram of the application, there are four icons representing the USB webcam driver. These icons are IMAQ USB Unit for the initialization unit, IMAQ USB Grab Setup for the configuration unit, IMAQ USB Grab Acquire for the image acquisition unit, and IMAQ USB Close for the drive shutdown unit [11]. There

are two icons on the LabVIEW Vision platform. These are the IMAQ Create and IMAQ Color Learn functions that calculate the color spectrum [12]. These symbols carry out similar mathematical calculations as in other software programs. To define the color, the color information in the predetermined images is used by making use of the color spectrum. Color information is encoded in the index array tab in the block diagram in the LabVIEW program, and then the threshold values of the color pixels are determined. Minimum and maximum pixel values are used to determine the full dynamic range of the image. The minimum and maximum values of the pixels determine the appearance of the image. The z coordinate value in the LabVIEW program is calculated with the formula given in equation 1.

$$z = \frac{s - y}{v - y} x 255 \quad (1)$$

In Equation 1, where the z value is an 8-bit pixel value, the x value is a 16-bit pixel value. The minimum intensity value is defined as y and the maximum intensity value as v [13]. While converting the pixel values in the program input to the actual coordinate values, some errors occur. The error values of the pixel coordinate points show the largest estimated position value for the actual coordinate values. The error value in the LabVIEW program is calculated with the formula given in equation 2. This technique applied minimizes possible errors when changing light, angle and other parameters change [14].

$$e(i, j) = f \sqrt{(s - s_{reas})^2 + (y - y_{reas})^2} \quad (2)$$

Colors are represented by three different components: hue, saturation, and lightness (HSL) [15]. In HSL, the colors of each hue are obtained by placing neutral colors ranging from black to white in a radial slice around a central axis [16]. Hue indicates the base color in degrees or numbers [17]. Saturation can be defined as the ratio of color to brightness and is always expressed as a percentage, with 100% saturation meaning that the color is fully saturated. Luminance is defined by the brightness of the illuminated white color and is expressed as a percentage. 100% of the brightness defines the white color and 0% defines the black color [18]. Color and tonal values are shown in Table 1.

**Table 1.** Color and tonal values.

Color	Tonal (Degree)	Tonal (Value)
Red	0 or 360	0 or 6
Yellow	60	1
Green	120	2
Cyan	180	3
Blue	240	4
Magenta	300	5

The HSL color space handles color processing functions such as color matching, color positioning, and color pattern matching. This situation makes HSL the best choice for many image processing applications, such as color matching. In the literature, it is necessary to determine the color tone components, which are the basic idea of brightness, in the calculation of brightness, saturation, and hue components. Equation 3 is used to determine the color components.

$$H = \begin{cases} \arccos \frac{0.5[(R - G) - (R - B)]}{\sqrt{(R - G)^2 + (R - B) \cdot (G - B)}} & B > G \\ 360 - \arccos \frac{0.5[(R - G) - (R - B)]}{\sqrt{(R - G)^2 + (R - B) \cdot (G - B)}} & G \geq B \end{cases} \quad (3)$$

In Equation 3, H is expressed in degrees. To get results faster, it is necessary to reduce the number of multiplications and avoid subtracting the square root. The results that allow accelerated application is shown in equation 4.

$$H = \begin{cases} Undefined & R = G = B \\ \frac{\pi}{3} + \arctan \left( \frac{\sqrt{3} \cdot (G - R)}{G + R - 2B} \right) & \min(R, G, B) = B \\ \pi + \arctan \left( \frac{\sqrt{3} \cdot (B - G)}{G + B - 2R} \right) & \min(R, G, B) = R \\ \frac{5\pi}{3} + \arctan \left( \frac{\sqrt{3} \cdot (R - B)}{B + R - 2G} \right) & \min(R, G, B) = G \end{cases} \quad (4)$$

It does not need trigonometric functions because the mathematical area can be calculated simply. Therefore, the expression can be reduced to equation 5.

$$H = \begin{cases} Undefined & R = G = B \\ \frac{G - B}{3 \cdot (G + R - 2B)} & \min(R, G, B) = B \\ \frac{B - R}{3 \cdot (G + B - 2R)} & \min(R, G, B) = R \\ \frac{R - G}{3 \cdot (B + R - 2G)} & \min(R, G, B) = G \end{cases} \quad (5)$$

Therefore, the image taken from the camera in the Red, Green Blue (RGB) form has been converted to the HSL form. The mathematical equations for converting from RGB to HSL are shown in equation 6. Equation 6 is obtained if the saturation component is added to equation 5 in addition to two equivalent formulations. In the equations, the value of H varies in the range of  $[-180^\circ, +180^\circ]$  [19].

In Equation 6, the intensity value decreases the saturation of the color as it approaches the limit values. This allows the best classification of the components of a surface in the absolute and visual field, which increases its perceptibility and allows for selectivity. In the study,

the method used for matching is normalized cross-correlation and the square of the Euclidean distance between the two images is used as a measure of similarity [20]. The template image on which the correlation application was applied is shown in Fig. 2. In the correlation application, the  $w(x,y)$  pixel dot in the  $(k,l)$  size template image transforms into a target image shape of  $(x+y)mxn$  size. The target image to be obtained at the end of the correlation process is calculated with equation 7 [21].

$$H = \begin{cases} \max(R,G,B)=0, & 0^0 \\ \max(R,G,B)=R, & \frac{G-B}{\max(R,G,B)-\min(R,G,B)} \\ \max(R,G,B)=G, & 2+\frac{B-R}{\max(R,G,B)-\min(R,G,B)} \\ \max(R,G,B)=B, & 4+\frac{R-G}{\max(R,G,B)-\min(R,G,B)} \end{cases}$$

$$L = \begin{cases} \frac{\max(R,G,B)+\min(R,G,B)}{2} \end{cases} \quad (6)$$

$$L = \begin{cases} \frac{\max(R,G,B)+\min(R,G,B)}{2} \end{cases}$$

$$S = \begin{cases} \frac{\max(R,G,B)-\min(R,G,B)}{\max(R,G,B)+\min(R,G,B)}, & L < 0.5 \\ \frac{\max(R,G,B)-\min(R,G,B)}{2-\max(R,G,B)+\min(R,G,B)}, & L > 0.5 \end{cases}$$

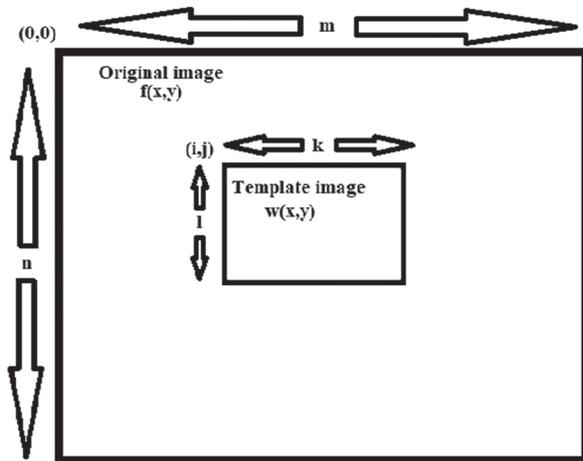


Fig. 2. Correlation process image

$$d^2(i,j) = \sum_{x=0}^{l-1} \sum_{y=0}^{k-1} [w(x,y) - f(x+i,y+j)]^2 \quad (7)$$

Considering the total energy of the template image as constant and it is calculated by equation 8.

$$\sum_{x=0}^{l-1} \sum_{y=0}^{k-1} w(x,y)^2 \quad (8)$$

$$\sum_{x=0}^{l-1} \sum_{y=0}^{k-1} f(x+i,y+j)^2 \quad (9)$$

As a result, the original and template image values are superimposed. The obtained cross-correlation expression is given in equation 10.

$$C(i,j) = \sum_{x=0}^{l-1} \sum_{y=0}^{k-1} w(x,y)f(x+i,y+j) \quad (10)$$

If the original and template image values obtained are superimposed on the  $(i,j)$  coordinate value, the obtained images are similar. If the image energy position changes, the matching fails. In such cases, a normalized correlation term is calculated. The mean intensity in the template and the mean intensity value of the target image in the region overlapping the template are expressed as  $t(i,j)$ . The normalized correlation function is calculated by equation 11 [22].

$$t(i,j) = \frac{\sum_{x=0}^{l-1} \sum_{y=0}^{k-1} (w(x,y) - \bar{w})(f(x+i,y+j) - \bar{f(i,j)})}{\sqrt{\sum_{x=0}^{l-1} \sum_{y=0}^{k-1} (w(x,y) - \bar{w})^2 \sum_{x=0}^{l-1} \sum_{y=0}^{k-1} (f(x+i,y+j) - \bar{f(i,j)})^2}} \quad (11)$$

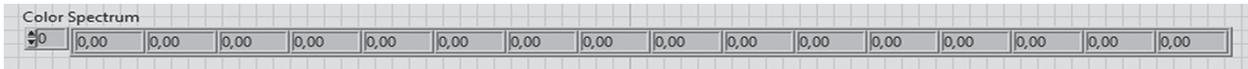
The pyramid matching model used in color detection is divided into two methods. These methods are the gray value method and the gradient method. While normalized pixel values are used in the gray value method, filtered edge pixels are used in the gradient method. In addition, the vector correlation method is used instead of normalized cross-correlation in the gradient method. Since the gradient method uses less data, it gives faster results than the gray method. However, at very low-resolution values, since the strength and reliability values of the edges decrease, the gradient method works at a higher resolution than the gray value method.

Each interval value in the color spectrum is expressed as a percentage of color pixels in the image. A spectrum of colors with more divisions represents higher color resolution. There are three different color sensitivities as low, medium, and high [23]. In the study, using low color sensitivity values, the tonal color space is divided into seven tabs. In this case, a total of 16 color spectrum ranges were obtained. Each range represents different color pixels, with the first range value being saturation.

If there are  $n$  ranges in the color space, the color spectrum array contains the range values of  $n+2$  color spectra [24]. The color spectrum ranges to be applied using the LabVIEW program are shown in Fig. 3. The colors of the objects taken from the real-time images were compared concerning the measured color pixel values to find the range values of the colors in the spectrum. The pixel values taken from the color spectrum range are shown in Table 2.

**Table 2.** Color pixel values in the color spectrum range.

Colors	Color Spectrum Range															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Red	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Blue	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,78	0,00	0,22	0,00	0,00	0,00	0,00
Green	0,00	0,00	0,00	0,00	0,00	0,00	0,98	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yellow	0,00	0,00	0,05	0,95	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

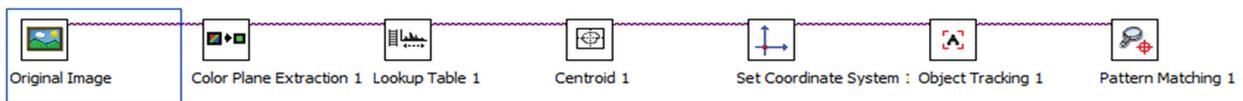


**Fig. 3.** The color spectrum of the image

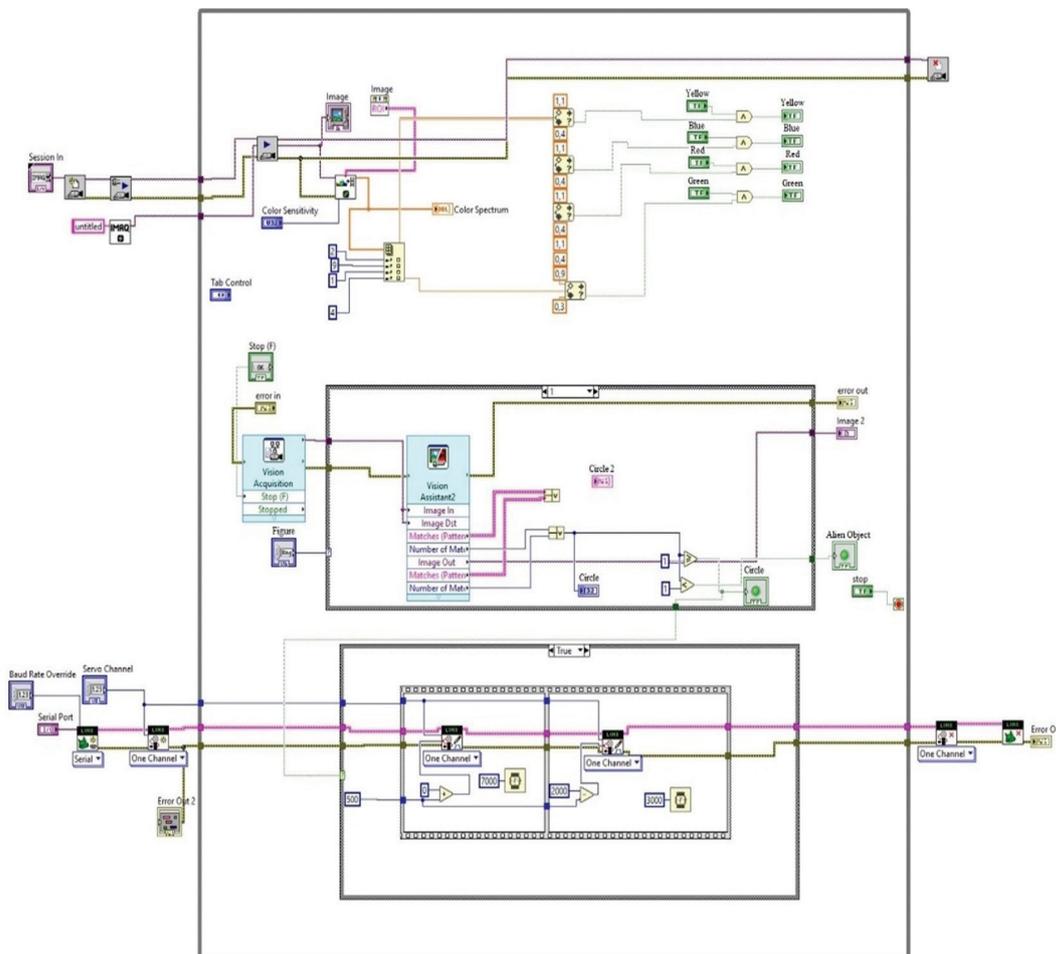
#### 4. DEFINING OBJECT SHAPES

The Vision Assistant algorithm in the Vision Development Module is used to detect shape. The Vision Assistant algorithm is shown in Fig. 4. The Vision Acquisition module was used to take the shape image of the object, and the Vision Assistant module was used to

operate the image processing part. The real-time image is transmitted to the Vision Assistant module and the image is processed with the help of the algorithm used. In the LabVIEW program, 2 different objects are defined as a cube and a circle. Different algorithms are used to identify objects. The block diagram designed in the LabVIEW program is shown in Fig. 5.



**Fig. 4.** Vision assistant algorithm



**Fig. 5.** Block diagram structure in the LabVIEW program

The original image obtained was converted from a color plane extraction RGB color model to an HSL color model. With this process, the hue, saturation, and lightness components of the color image are revealed. To determine the shape of the displayed object more easily, the color definition of the image was made with the lookup table 1 tab. In the next step, the energy center of the image is selected with the centroid tab. The coordinate values of the object are calculated by determining the reference value with a set coordinate system. Then, the object tracking feature was used to follow the object on the conveyor belt system and pattern matching was performed to define the shape.

## 5. DETERMINING THE COLORS AND SHAPES OF OBJECTS

In the program created with LabVIEW, shape, and color detection work simultaneously and independently of each other. The color and shape of the object to be detected are selected on the user interface screen. After the selection process made on the buttons, the color determination is made when the object in the conveyor belt system appears on the fixed camera screen. Color and shape detection images obtained from the LabVIEW program are shown in Fig. 6.

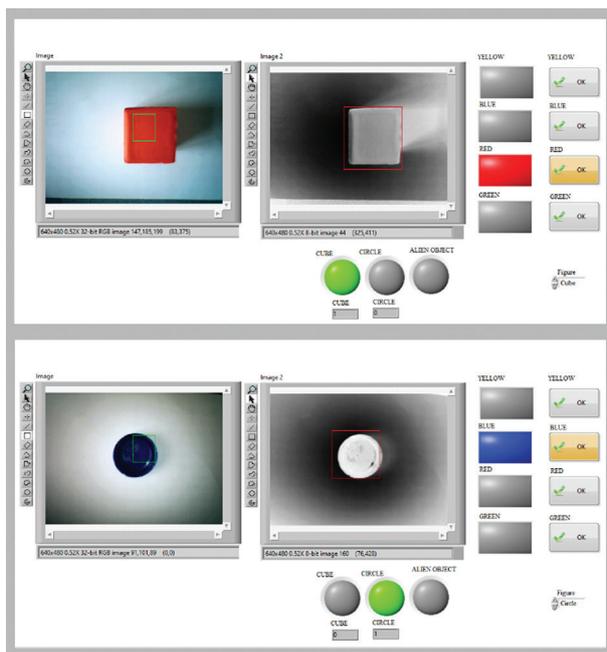


Fig. 6. Color and shape detection

During color detection, the color pixels falling on the camera's focal point are in the range of the color spectrum, and the relevant color is detected and displayed in the user interface. The case structure block is used to detect objects in the block diagram designed in the LabVIEW program. If the object to be detected on the conveyor belt is a cube, the section with a default value of zero becomes active. If the object is a circle, the section with a default value of one becomes active. For the object to be detected more easily, the image is con-

verted to gray color so that the object is different from the background color. In this way, the detection of the moving object is made quickly and easily.

## 6. IMPLEMENTED CONVEYOR BELT SYSTEM STRUCTURE

Conveyor belt systems are mechanical transport vehicles that allow objects to be transferred from one location to another. In the study, the transfer of objects was successfully carried out using the conveyor belt system. The conveyor belt system is manufactured using plastic-coated Styrofoam. The length of the conveyor belt system is 80 cm and the width is 25 cm. The movement of the conveyor belt system is provided by 2 DC motors with a voltage of 5V. The movement of the arms that provide the selection process in the conveyor belt system is provided by 2 servo motors used in the system. For the belt rollers in the system to rotate easily, 2 bearing structures of 7x8x22 mm were used. The LINX interface in the LabVIEW program was used for programming the Arduino. In this way, the program developed in the LabVIEW environment is processed by Arduino and the servo motors used in the system are controlled. The image of the conveyor belt system structure is shown in Fig. 7.

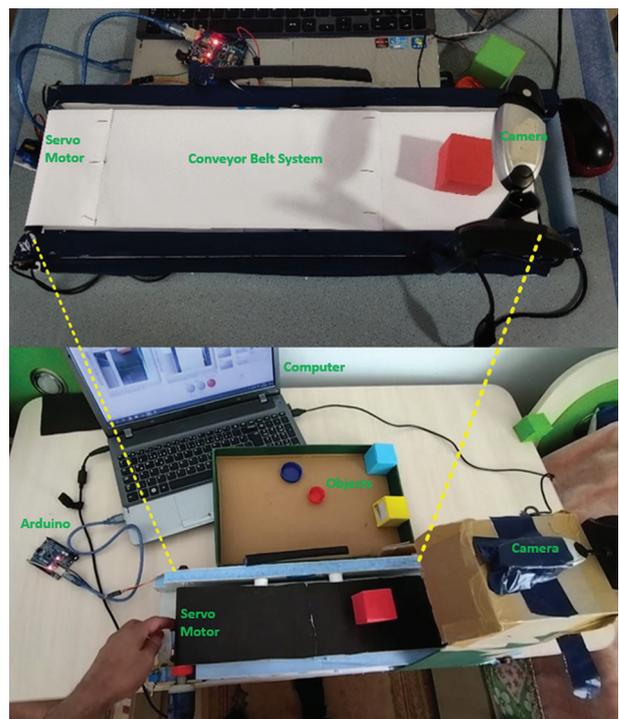


Fig. 7. Image of conveyor belt system structure

## 7. FINDINGS AND RESULTS

In the study, four different colors red, blue, yellow, and green, and two different shapes cube and circle were used. The colors and shapes of the objects to be defined on the conveyor belt system were successfully determined and the selection process was carried out. Some problems occurred in identifying the

object when the environment was not properly illuminated. For this reason, the importance of the lighting system used during the identification process has been revealed. In addition, the resolution value of the camera used in the study had a great effect on the success of the study. This effect caused a decrease in the detection time of the object. A webcam camera with a resolution of 640x480 was used in the study. By using cameras with higher resolution and making light angle adjustments clearly, the problems that may be encountered in detecting objects will be eliminated. Shape and color determination was carried out by deducing the front faces of the 3D objects in the conveyor belt system. Then, the color, shape, coordinate values, and accuracy rates of these objects were determined on the computer screen. The colors, shapes, coordinate information, and accuracy rates of 3D objects in the conveyor belt system are shown in Table 3.

**Table 3.** Colors, shapes, coordinate information, and accuracy rates of objects.

Colors	Shapes	Coordinate	Accuracy Rates
Red	Cube	250.43, 175.45, 224.87	89.941 %
Red	Circle	366.97, 241.29, 247.39	96.153 %
Blue	Cube	270.31, 232.68, 347.14	89.688 %
Blue	Circle	366.32, 230.92, 197.88	97.617 %
Green	Cube	273.44, 272.75, 162.63	98.835 %
Green	Circle	265.87, 220.45, 201.15	97.563 %
Yellow	Cube	348.14, 289.54, 252.99	97.721 %
Yellow	Circle	379.71, 246.08, 238.43	95.274 %

## 8. CONCLUSIONS

LabVIEW is a programming language that can provide graphical results, unlike other text-based programming languages. The most important feature that distinguishes this study from other studies in the literature is that it was developed with LabVIEW programming in real-time. Image processing techniques used to detect objects are systems with a very complex structure. However, such systems consist of maintenance-free and highly efficient structures.

The established system has many advantages. The most important of these advantages is that it can work with a webcam. It is possible to communicate with the webcam via USB by using the appropriate drivers in the system. Otherwise, expensive cameras must be used to communicate between the LabVIEW program and Ethernet. Another advantage is that it uses the color spectrum in real-time and can simply identify colors. In the system, the color of the object is defined by the camera's detection of the object. Illumination of the object is very important when using image processing techniques at the time of identification. In case of a large amount of light falls on the object, shadow or reflection events occur on the image. If the light value falling on the object is low, it becomes difficult for the camera to detect the object.

The identification process in the study was made for the colors blue, red, yellow, and green. With the color definitions to be made on the LabVIEW program, objects with different colors can be selected. Appropriate modules are used for the communication between the LabVIEW program and the Arduino. Servo motors are controlled via Arduino LIFA base in the LabVIEW program. In addition, since the Arduino LIFA Base interface causes a slowdown in the data rate to be transmitted to the servo motors, the LINX interface is also used in the study. Thanks to the additional program add-ons, the color, and shape of the object were instantly detected in real-time and the selection process was carried out. As a result, various algorithms were applied in the LabVIEW program using the webcam, the colors and shapes of different objects were determined and the selection process was carried out successfully. When the results were compared with similar studies in the literature, the average accuracy rate in other studies was around 93%, while the average accuracy rate in this study was 95.349%.

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