Fabric Defect Detection through Conveyor Belt System Designm and Image Processing

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Introduction

In classical fabric production, the product produced by the tailor is subject to control since its production and this control process continues until delivery. While the speed of production increased as a result of the increase in machine production with the 1st Industrial Revolution that emerged in the 18th century, this situation brought some problems with it. While the fabrics started to be produced quickly by the machines, the fabric control process started to be done by the "quality control" personnel in the factories. As a result, more responsibility falls on the responsible person compared to the past. Today, the progress in software and the inventions in the world of informatics help us to understand the problems that may occur in production. The aim of this study is to approach the above-mentioned problem with the "Image Processing" techniques, which have been widely used in the field of military, production and security in the last twenty years.
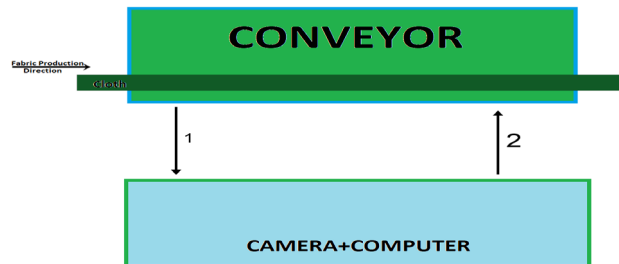

Figure 1. Modeling the system

The system included in this section, as summarized in Figure 1, consists of a computer, camera and conveyor. Represented by the number 1 arrow is the photograph of the fabric. Information will be taken from the camera as video, but this image will be analyzed on the computer as a frame, as if it were more than one photo per second. The number 2 arrow represents is the energy supply connected to the Arduino of the conveyor.

Materials Used in the Construction of the Project

Arduino UNO

Arduino UNO is a board with digital and analog inputs and outputs, as well as a development environment platform with ready-made libraries based on processing / Wiring. The Arduino board has an integrated Atmega328 model processor in its structure. It can be easily programmed with a computer by connecting to a computer with a USB cable and providing serial communication, and it can provide serial data communication (Kapusız & Uzun, 2021).
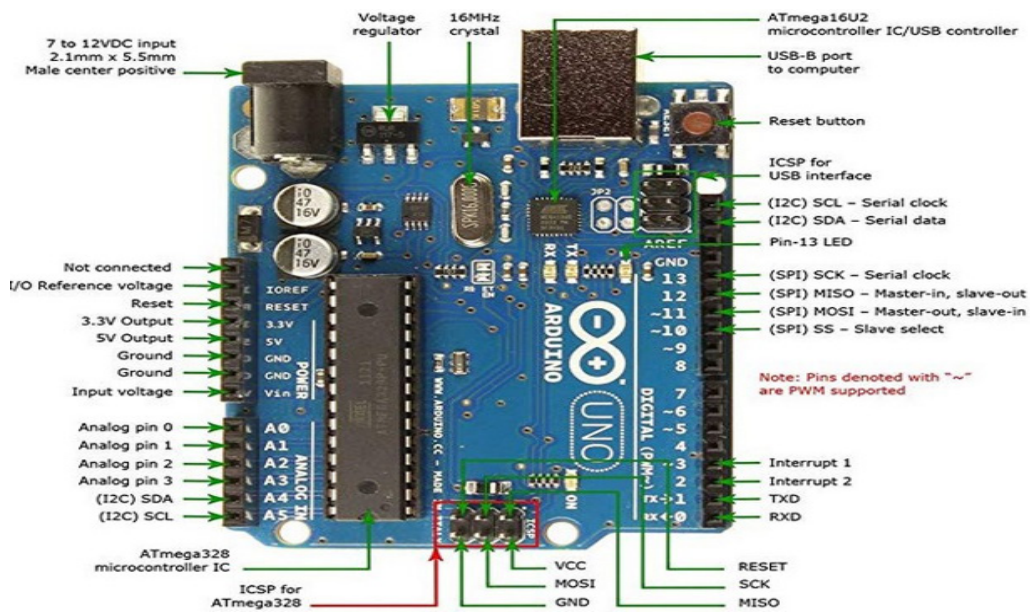

Figure 2. Arduino Uno

L298N Motor Driver

L298N motor driver circuit operates at temperatures between -20 and +135, between 5 and 35 volts and with a maximum of 2 amps (Celik & Gunes,2018). The motor driver board is designed to drive two motors at the same time. It has two channels and can give a maximum of 2 amps per channel.
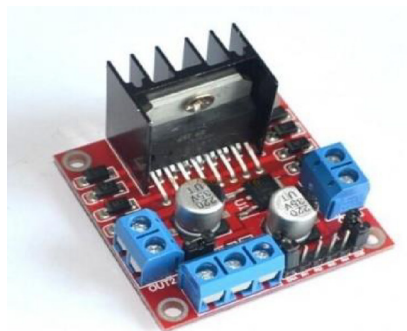

Figure 3. L298N Motor driver

DC Motor

DC motors consist of two parts, the fixed electrical part called the stator, and the rotor, where the rotation takes place (Gurgöze & Turkoglu, 2022). In this study, DC motor can be driven directly with Arduino. However, since high torque is required for the roller that will pull the fabric, DC motor is used with L298N motor driver.
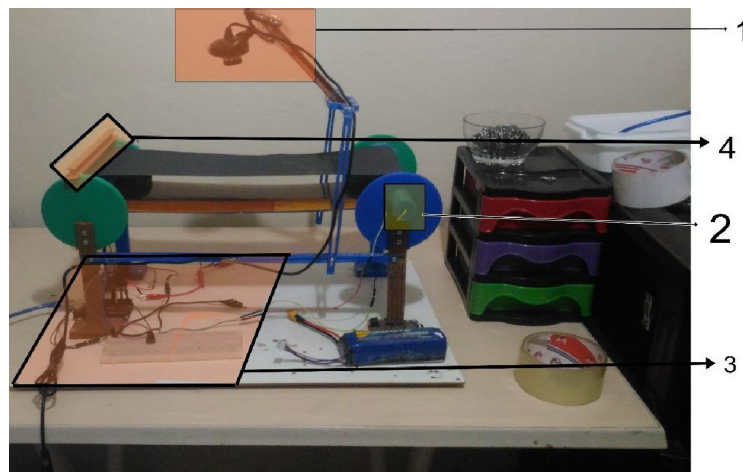

Figure 4. DC motor

Conveyor

Figure 5. Conveyor

1- The camera is 80 degrees away from the rotating belt and 14 cm from the belt.

2- The DC motor chamber is fixed so that the motor can stand still and rotate the cylinder connected to its shaft with minimum vibration.

3- Arduino is the part where the motor driver and breadboard are fixed.

4- Support Unit (Screw Jack) is a fixed support unit to provide tension on the band and to prevent the motor from vibrating during rotation.
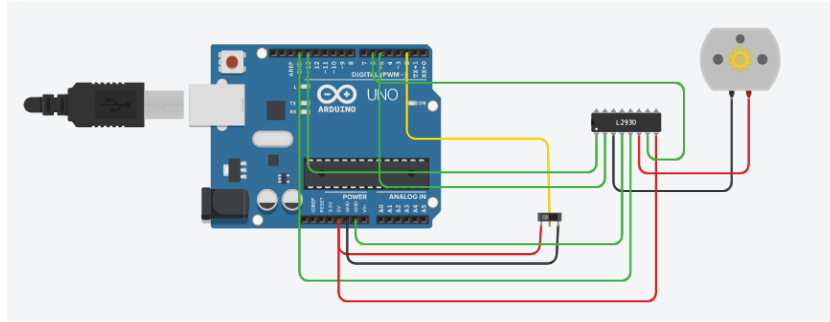
Figure 6. Electrical circuit design

Conveyor 3D Drawings

Conveyor belt design was designed in Solidworks program. In this design, two elbow profiles that can support the weight are used. These profiles are fixed to the ground so that they can lift the weight. In order to ensure the movement, the bearing is fixed to one part of the pulley and the other part of the pulley is fixed to the DC motor. An area is designed to fix the camera at the top of the profile in the middle.
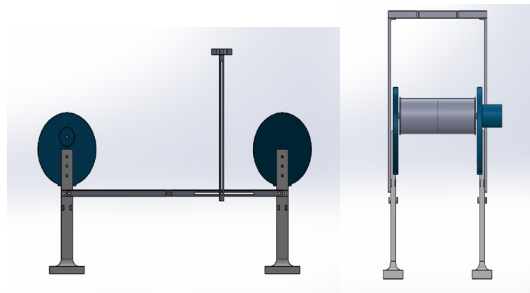
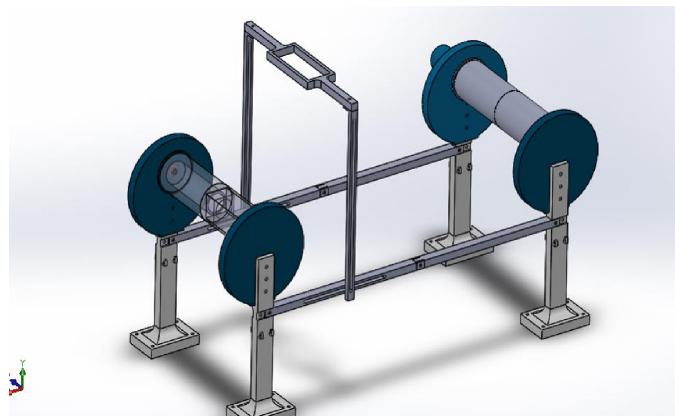

Figure 7. Side view of the conveyor

Figure 8. Detailed design of the conveyor

Tools Used in Project Construction

Microsoft Visual Studio

Microsoft Visual Studio is an integrated development environment (IDE) developed by Microsoft. Console and graphical user with native code and Windows Forms applications, websites,

web applications and web services with managed code for all platforms supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, .NET Compact Framework and Microsoft Silverlight interface is used to develop applications (Microsoft Visual Studio, 2022).

C++ is a multi-paradigm, widely used, general-purpose programming language that has been developed by Bjarne Stroustrup of Bell Laboratories since 1979. It was first named C with Classes, and its name was changed to C++ in 1983 (Ege, 2012). In this study, C++ programming language and OPENCV library were used. Visual Studio was installed according to OpenCV's instructions.
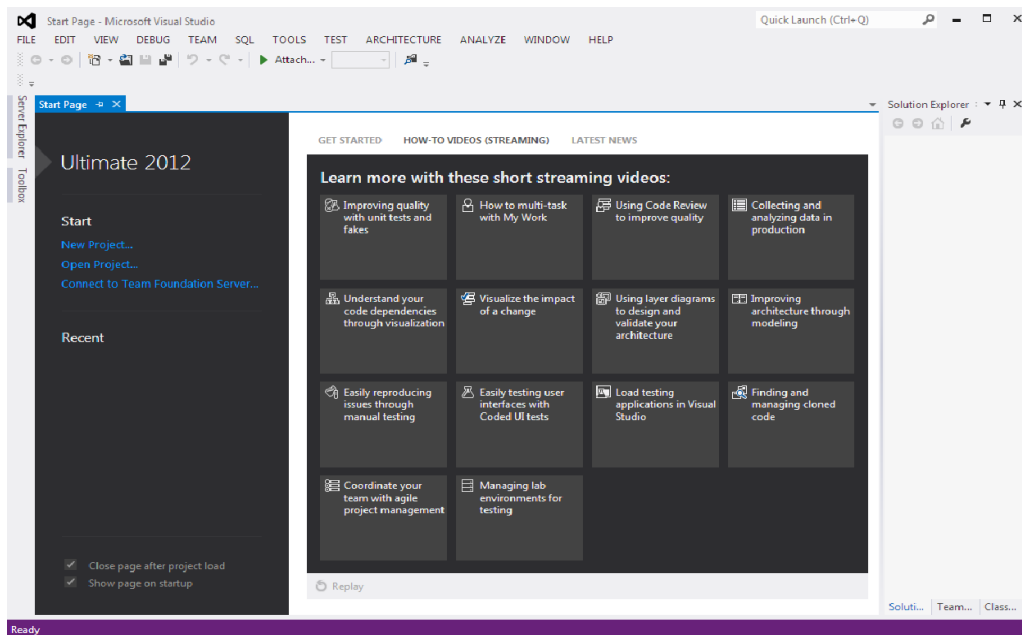

Figure 9. Microsoft Visual Studio

Arduino IDE

Arduino IDE code editor, while working as a compiler, is an application that can upload the compiled program to the card, and can run on any platform.
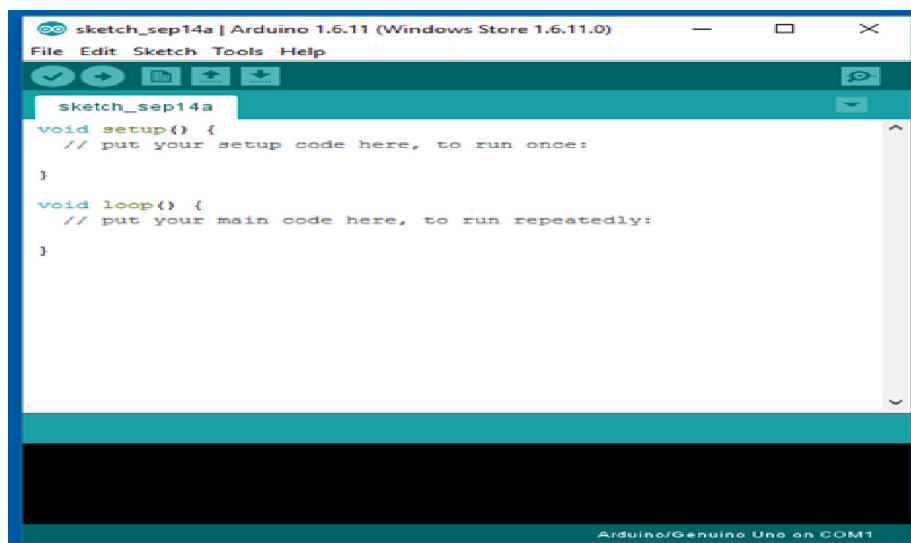

Figure 10. Arduino IDE

The interface required to program Arduino is an open source, free JAVA supported application software developed by Arduino. A screenshot of the program made to program the Arduino microprocessor is shown in Figure 10. It has an advanced debugging system used to detect errors that occur in programming. It also has the possibility to program all Arduino board types (Arduino, 2022).

OPENCV

OpenCV (Open Source Computer Vision) is an open source image processing library (Eristi, 2010). It was started to be developed by Intel in 1999, and then the development process continues with the support of companies and communities such as Itseez, Willow, Nvidia, AMD, Google. The first version, OpenCV Alpha, was released in 2000. It started to be developed with the C programming language in the first place, and then many algorithms were developed with the C++ language (Akkoca & Invention, 2021). The OpenCV library has more than 2500 optimized algorithms.

With the image processing algorithms in the OpenCV library, many applications such as object detection and recognition, motion capture can be realized. With these algorithms, operations such as face recognition, distinguishing objects, detecting human movements, object classification, license plate recognition, processing on three-dimensional images, image comparison, optical character identification OCR (Optical Character Recognition) can be easily performed (Tenekeci, Gümüscü & Aslan, 2014). OpenCV architecture and components are as follows (Akbal, 2019);

Core: It contains the basic functions of OpenCV and data structures such as size, matrix, and point.

HighGui: Contains methods that may be required for displaying images, managing windows, and graphical user interfaces. With this module, we can display an image with a single function, for example.

Imgproc: It is a package that covers almost all functions such as filtering operators, edge detection, object detection, color space management, color management and thresholding. Imgcodecs: It contains methods that perform image and video reading/writing operations over the file system.

Alternative Image Processing Libraries

The library to be used in image processing studies should be chosen in accordance with the purpose of the study. For example, it may not be necessary to integrate OpenCV into the work just to get images from the camera (usb, ip, etc.). For such cases and to understand why OpenCV is good, alternative image processing libraries are discussed below (Can, 2021).

MATLAB: Although Matlab is not an image processing library, it contains basic algorithms for image processing. It is a fourth generation and multi-purpose programming language. It can be preferred for basic image processing in academic research and when performance is not important. It is also possible to develop applications interactively with the OpenCV Library using Matlab.

Halcon: It is a commercial software focused on machine vision, which is preferred for industrial projects, has a library for various programming languages (C, C++, VS C++, C#, VB.NET) as well as its own development environment. It contains many ready-made functions, so that fast applications can be developed.

OpenCV is an open source, free library and focused on computer vision. It differs from Halcon in these aspects.

OpenFrameworks: This open source library developed for the C++ programming language, this project can run on OS X, Linux, Embedded Linux (ARM), iOS, Android platforms. It uses many algorithms of the OpenCV library and its main purpose is to develop applications easily and quickly. For example, with OpenCV, you can complete a job in 2t time, in 1t time, the main reason for this is that it can perform standardized works with a single line through its many functions (Object detection, tracking, color determination, comparison, etc.). CIMG is an open source image manipulation library. It works on Windows, Linux and OS X platform. It has support only for C++ language, but with written wrappers, applications can also be developed with Java and Python. It contains many algorithms, but it does not have as performance and a wide algorithm infrastructure as OpenCV.

Fiji: It is an open source GPL licensed image processing library developed for the Java platform. It runs on Windows, Linux and MAC OSX Intel 32-bit or 64-bit. It was developed for scientific image analysis. It has customized algorithms for fields such as genetics, cell biology, and neuroscience.

Camera, Video Viewing and Interpretation

Camera

Cameras consist of a lens that transforms the object area from the image plane to the image area (Egels, 2001). The cameras used in photogrammetry are metric cameras. Metric cameras are cameras that consist of a large number of lenses with known internal directing elements and these are cameras that can be considered perfect (Yıldız et al., 2005). These are also called measurement cameras. In general, it is possible to distinguish between analog and digital cameras. While analog cameras provide projection with lead bromide solution, digital cameras are cameras that provide projection to CCD and CMOS sensors (Ucar, and Ergun, 2004). The cameras consist of three parts.

First of all, the main task of the lens is to collect the images from the outside world through the lenses inside and deliver them to the camera body. The lens in the front of the lens collects the image, and this image reaches the camera body by reflecting specularly from the lenses further back. CCDs in the camera body convert these images into electronic signals (Ministry of Education, 2011). The camera body is the part where the image is processed and recorded. After the image falling on the CCD is converted into electronic signals, it starts to be processed in the body. This process takes place with electronic circuits inside the body and is triggered by a button located outside the machine. The main task of lenses is to produce a small image in front of the CCD. Video cameras often have variable focal length lenses. The focal length is to determine how narrow or wide an area the produced image will cover. lenses; It differs in wide-angle, narrow-angle, normal and variable focal lengths (Ministry of National Education, 2011).

What is Angle of View?

The viewing angle of a camera basically changes depending on two parameters. The first is the size of the camera's image sensor, and the other is the focal length of the lens, expressed in "mm". The table below shows the "horizontal", "vertical" and "diagonal" viewing angles for different sensor sizes and different lens types.
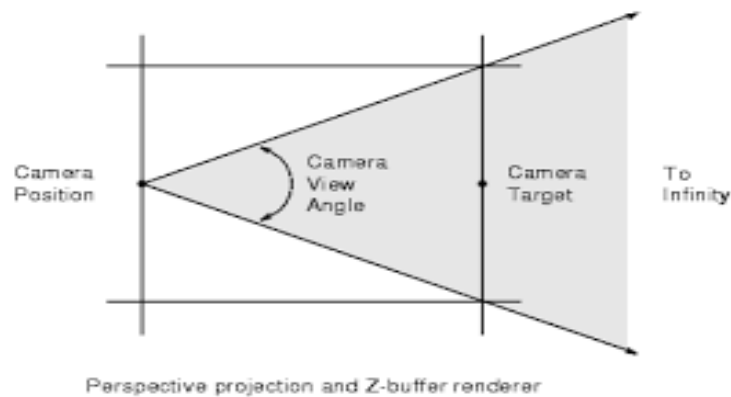

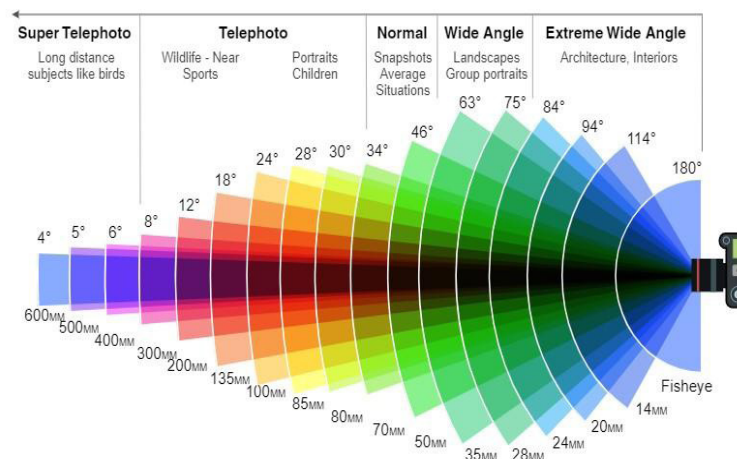**Figure 11.** Camera angle of view diagram

Figure 12. Lens focal lengths by camera sensor size and angle

The light transmittance of each lens is different. Some lenses pass more light, while others pass less. The light transmittance capability of the lenses is expressed as the "F" value. A small "F" value indicates that the lens passes more light and provides a brighter image. Lighter passing through a lens means that it will provide a brighter image in low-temperature environments.

Resolution

It is the number of points that make up the image. It is a unit of measure that shows quality in display technologies. Digital images are created by dots called pixels. 800x600 image resolution, left-to-right 800; It refers to an image created from a total of 480,000 small dots with 600 pixels from top to bottom (General Directorate of Security, 2017). Webcam used in the study has VGA resolution. This means that inferences will be made with the changes in the values of the elements in an 800x600 matrix in unit time.

Video Viewing Process

An image signal is any image converted to electromagnetic energy for sending or storing. This signal is called the other name (VF). In our study, we will focus on the transfer of the video signal on the television and how the digital data is sent to the receivers. The numerical data sent in our country depends on the B/G system. An image is made up of many small image elements combined. The maximum number of details in images is called resolution. The clarity of the image on a television or computer is also related to resolution.

On the screen, there are very small phosphor plates, called pixels, that emit different colors of light when electrons fall on them. Their number affects the clarity of the picture on the screen. These color-emitting plaques can be easily seen with a lens. The power of resolution (resultation) is explained by seeing the details of small objects, with a physical phenomenon opposite to that. Examining microbes under a microscope is also about resolution. It is aimed to ensure that the microbe or bacterium appears in detail enough to be recognized by making the microscope at sufficient magnification. Here, it is essential that the rays coming from different points of the small creature are separated from each other. In other words, it is essential that the piece of painting coming from these points does not overlap and should be seen separately (Isci, 2008).

The B/G system determined the number of details in the vertical and horizontal directions as 625. These numbers are called the number of rows and columns. Up to 320 pairs of contrasting colors (such as black and white) can be transmitted side by side in each line. White is represented by 1 volt and black by 0.3 volts. Since two contrasting colors together can be represented by one period of the sine signal, the most detailed image (625 x 320 =) consists of 200 000 sine signals. Moving image; for a moving image, the

screen should be scanned line by line, starting from the top left. It is assumed that the screen is scanned 25 times per second in analogue broadcasting. In other words, the television broadcast must be able to transmit 25 full-screen images, each consisting of a maximum of 200 000 sine waves, in one second. In other words, the bandwidth of the video signal is (200 000 x 25 =) 5 MHz.

Interlaced Scan

If the entire page were to be written and read in this way in interlaced lines, the same amount of information could be obtained with all successive lines as if written in a special way. Before interlaced scanning, all single lines are scanned from top to bottom of the frame. Even lines are then scanned, skipping odd lines. At the end of the vertical sweep, vertical reversal occurs rapidly and the electron beam returns to the upper part of the frame. Thus, all single lines are scanned from top to bottom, skipping previously scanned lines. Each frame is divided into two areas. The first is the Single line field with odd lines, the second is the Even line field with even lines. Scanning of 30 frames per second is completed. Since each frame consists of two fields, 60 fields will pass per second. In this case, the vertical scanning frequency to increase to 60Hz is due to the scanning of the electron beam by skipping lines one by one (Grob, 1975).

Interpretation of Frames

"VideoCapture video(0);" to create the object for which the frames should be interpreted. After the video images are taken with the Mat new Frame, the object to which the frames taken from the camera will be loaded is determined. This frame in RGB format is converted to HSV. Then the object to which the HSV image will be loaded is determined. After the object is prepared for the frame to be processed, the "HMAX HMIN SMAN SMIN VMAX VMIN" values, which are initially prepared as integers, are compared with these received frames. According to the HSV values, in order to reach the entire image that is desired to be taken as the original, point clarification is performed on the image with a 5x5 matrix. Next, erode(operandFrame, operandFrame, getStructuringElement(MORPH_ELLIPSE, Size(5, 5))); dilate(operandFrame, operandFrame, getStructuringElement(MORPH_ELLIPSE, Size(5, 5))); The images are deleted by scanning with a 5x5 matrix with their codes.

Conclusion

Testing the System

In this study, the factors affecting the system were examined under two headings as mechanical and software factors. For the conveyor belt formation process in mechanical factors, the material moving on the belt was chosen as rubber plastic. After the design of

the pulley and moving parts was made, it was ensured that it was printed in the form of PLA plastic on a 3D printer. A screw jack system is used to ensure the tension of the belt. It is necessary to turn the screw at the end of the band to provide tension on the screw jack. There are also some negative effects of the screw jack system. The pressure in the belt in general becomes difficult to detect when the screw is turned to provide adequate tension. In this case, the life of the rubber plastic band decreases and the screw must be turned to make adjustments. This situation creates a loss in terms of time.

After the conveyor belt is formed, one of the pulleys is fixed to the DC motor so that it can be placed between the two pulleys and given movement. Bearings are fixed on both ends of the other pulley so that it can be movable. Then, it was adjusted how high the camera should be positioned from the tape in order to see the tape at a full angle.

In terms of software factors, first of all, the quality of the camera that transmits the images should be at a high level and the filters selected should be of good quality. The program should be able to interpret the photograph well. The amount of light in the environment must be sufficiently constant. Depending on whether the light intensity falling on the band is low or high, after the first value is introduced manually, the threshold value can be determined with a parameter. The amount of light is fixed over the specified parameter.
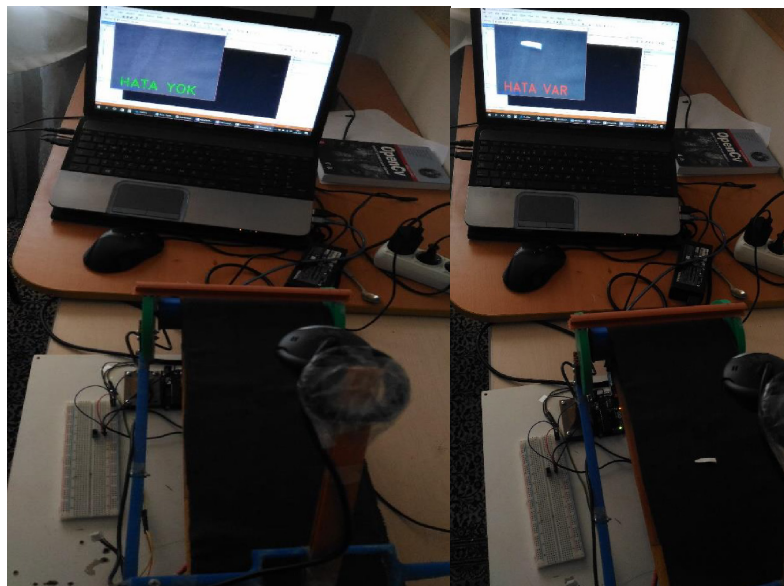

Figure 12. Testing the system

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