DESIGN OF AN EXPERIMENTAL MODEL OF A SYSTEM FOR PRODUCT SORTING THROUGH IMAGE PROCESSING
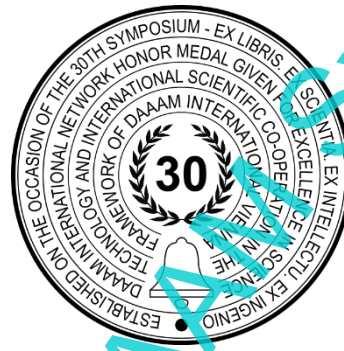
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Abstract

During the production process, a lot of undesirable or defective things are also produced. Since they cannot be used or distributed on the market, these things need to be weeded out. In modern industrial applications, checking the integrity and quality of the product is one of the most important procedures, being also the result of the optimization and efficiency of the production process. The automatic product verification and sorting system is the fastest and most efficient system that achieves compliance with the quality standards of one or more products. These systems are classified as critical in some applications because replacing them with human personnel requires a large number of employees and related costs. This paper presents an experimental model with the help of electronic and 3D printed components that through image processing will manage to sort different kind of products.

Keywords: Product design; image processing; sorting; quality; LabVIEW

1. Introduction

Object sorting is one of the most important phases in industrial production lines. During the production process, a lot of undesirable or defective things are also produced. Since they cannot be used or distributed on the market, these things need to be weeded out. It takes a lot of time, money, accuracy, and effort to manually classify those inappropriate commodities. With the use of machine vision, this task can be done with greater accuracy in less time and at a lower cost. However, technological problems could appear infrequently.

Both cameras and software for machine vision are freely accessible. Due to the effectiveness of the programme, automated inspection has already found applications. The user merely needs to provide inputs to the software. However, users are free to create their own programmes. A machine vision application is analogous in theory and application [7]. Applications can also be created to become more and more crucial as a user's experience grows.

There are optical devices to detect and measure various characteristics of objects, such as size, shape, color, imperfections: X-rays that uses electromagnetic radiation to check defects that are difficult to detect by the human eye; ultrasound uses sound waves that are sent through the material and returned in case of detection of an imperfection or gaps encountered; video camera, the simplest, use the optical sensor to capture the image that can be analyzed later for various defects.

The paper [1] presents the application of a 4DOF fruit sorting robot based on color and size in a packaging system. The sorting is made possible by image processing where color is recognized by HSV analysis, and the diameter is known in the grayscale image and setting the thresholding.

An algorithm for indirect egg defect recognition using image processing and also a developed graphical user interface for recognizing defective eggs in the MATLAB environment, based on computer vision are proposed in [2]. The values of the egg samples are collected by image processing and HSV and YIQ color spaces are used for egg defects recognition.

Hafiz [3] proposed a thorough analysis of recent work on the automated grading and sorting of agricultural products. On the basis of image processing, a complete end-to-end system for automatic and effective fruit sorting and grading is provided. The preliminary experimental results demonstrate the proposed structure's efficacy.

Two CCD cameras, two capture cards, a suitable lighting system, and other mechanical components make up the system designed for fruit sorting that is presented [4]. The fruit is initially removed from the backdrop by the algorithm. In front of the cameras are samples of various lemon grades that have been calibrated offline. The retrieved data is then saved in a database along with estimates of the fruit quantities and HSI color values. The final grade of the passing fruits is calculated by comparing the data collected during the sorting step with the data that is present inside the database.

To contribute to a better understanding what and how is changing in manufacturing in the era of AI, the paper [9] describes five innovation challenges that will, in the view of the authors, shape the future of manufacturing. Focusing on changes in innovation focus, importance of data, need for increased collaboration, impact of customer experience and shortage of talent, valuable insights are offered on how manufacturing companies should approach innovation challenges in the next decade.

With the help of the images the camera takes, the software created [6] will run algorithms to sort the objects based on their attributes and save the locations of the sorted objects in a database. The data from the sorted objects may then be used for pick-and-place operations that work in tandem with the actuator controller. The steps in the sorting process include detecting the object, figuring out color, size, and shape, finding the sorted object, and calculating the actual gripping position.

In this paper the purpose was sorting a group of 3D printed toothed gears through image analysis according to their characteristics (number of teeth, outer diameter, bore diameter, shape and degree of tooth damage). The system used for sorting is created with the help of 3D printing at a low cost. The technical and dimensional characteristics are taken from the execution drawing of a toothed wheel that is part of an assembly with a pinion and a worm coupling.

2. Materials and Methods

The control of the characteristics of a piece in the field of machine technology has a critical importance. With the purpose of designing a simple and efficient system at a low cost, the paper presents a solution for product sorting. The system can be used for various components in the manufacturing industry, by only changing the image processing algorithm and functions for color analysis or particle analysis can be implemented. For prototyping the sorting system, a versatile additive manufacturing technology was chosen, capable of using biodegradable plastics and allowing parts obtainment which are feasible to be used in a prototype, FDM technology (Fused Deposition Modeling). For the 3D printing Ultimaker S5 3D printer was operated using the above-mentioned technology with a filament of 2,85 mm made out of PLA (polylactic acid) and a precision of ±0,1 mm. The technological parameters used were the printing temperature of 220°C, the printing speed of 40 mm/s, the filling density of 100% and the deposition angle of 0°.

The components of the proposed system are: 1. The DC motor, 2. The DC motor driver, 3. 12V power supply, 4. The servo motor, 5. Stroke limiter, 6. Structural framework, 7. Forward arm, 8. Redirected Product, 9. Video camera, 10. Belt stretching system, 11. The ultrasonic sensor, 12. The Arduino microprocessor, 13. Conveyor belt. The belt stretching subsystem has the following main components: the sliding screw, the nut on the right side, the bearing inside it, the shaft from the cylinder that sets the system in motion, the support on which the screw slides. Thus, when the nut is tightened, the screw moves forward with the shaft, respectively the belt (fig. 1). Some limitations of the system are given by the dimensions of the conveyor belt: length 800 mm and width 400 mm.
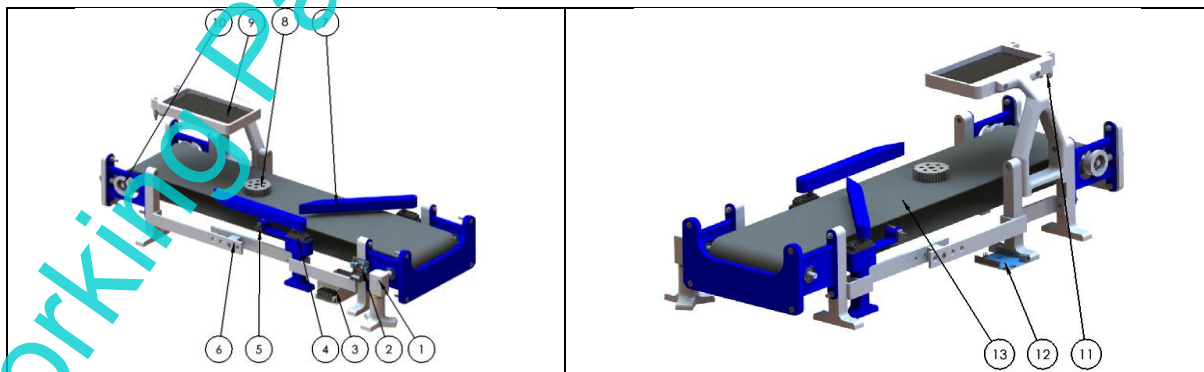

Fig. 1. 3D model of the experimental system

The camera used is ESP32, a system-on-chip microcontrollers with integrated Wi-Fi. The sorting designed works thus: the product is placed on the conveyor belt, when the sensors detect the presence of a part, the camera takes a picture and then the image is processed through NI Vision Assistant and LabVIEW programs The product is redirected from the conveyor according to the signal given by the applications as can be seen in fig. 2.
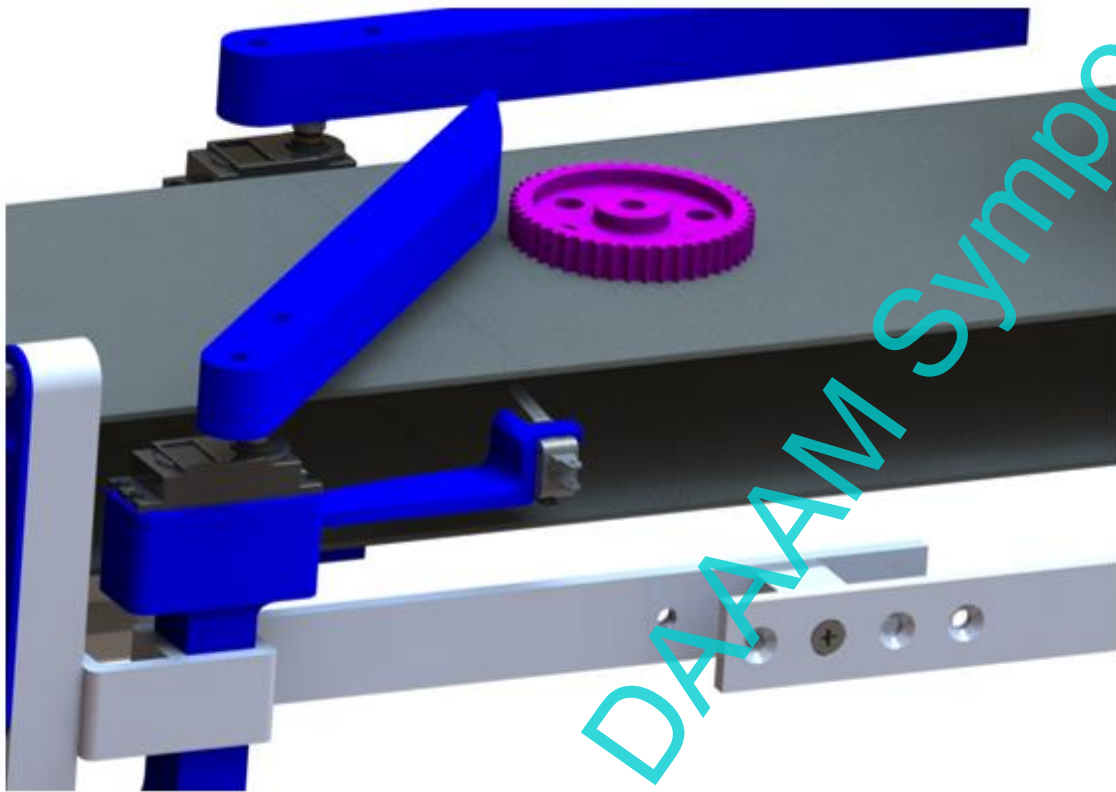

Fig. 2. Separation subsystem

The separation subsystem redirects the products from the belt in two distinct directions through a redirection arm that is actuated by a servo motor. When the product is removed from the belt, due to the weight of the product and the flexibility of the belt, it will actuate a limiter that will signal the servomotor to bring the arm to its initial position. The conveyor motion subsystem is formed by: motor, coupling between the motor shaft and the cylinder axis and the cylinder that sets the system in motion. Vision Assistant is a tool for prototyping and testing image processing applications. The Vision Assistant scripting functionality was used to create an algorithm for image processing. Every stage of the processing algorithm is documented through the scripting feature. Through image processing, a product in this case a gear wheel is checked from the point of view of the diameter, the number of teeth, the number and size of the bores. A digital image can be obtained in many ways, such as a sequence of images or an image at a certain time [4], in the graphical programming environment LabVIEW with different installed modules (Vision Acquisition, Vision Assistant). The algorithm for analyzing the images for the products starts from the product image (toothed wheel) and follows a series of functions to process the image and the export the data to LabVIEW software.

In order to distinguish the product from the background more easily, a suitable plane is chosen based on how well it is highlighted in the image. After a plane has been extracted, the image is used for subsequent tasks like particle classification or fundamental morphology [8]. The most crucial phase in this kind of non-contact analysis is image acquisition. The creation of a space with the right lighting has the biggest impact on the purchase process. The photos are acquired using a smart vision camera, which digitises and processes the images in real time. Application data monitoring is done using the LabVIEW programme. Before picking the best algorithm for measuring or inspecting components, the advantages of each image processing technique must be weighted.

The application for image acquisition and processing uses the image acquisition function from the IMAQdx library from LabVIEW and writes this image into a new PNG file using the IMAQ Write File function. The image reaches the image processing program through the Express Vision Assistant and has as output the data retrieved after the image processing. In NI Vision Assistant, the script was made using functions for Color Plane Extraction, Image Calibration, Threshold, Set Coordinate System and Find Edge [5]. The data are exported and received as in fig. 3, but there are also data that need processing to reach the information relevant to the application.
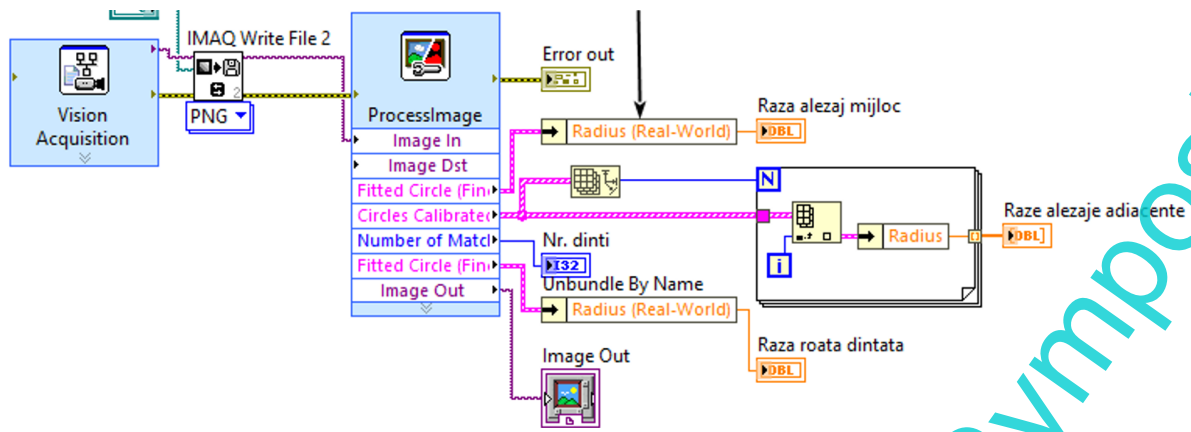
Fig. 3. LabVIEW application

The gear wheel radius is checked through a comparison with two manually entered values that are taken from an array and it is checked if the radius falls between the two values. Thus the radius may have a dimensional tolerance entered manually. The radius of the middle bore is checked similarly. The number of teeth does not need a margin of error and thus a simple check is made between what is received from image processing and what is entered manually. The process of checking the adjacent bores is a little more complex, the data taken from the image being some arrays that must be checked individually (fig. 4).
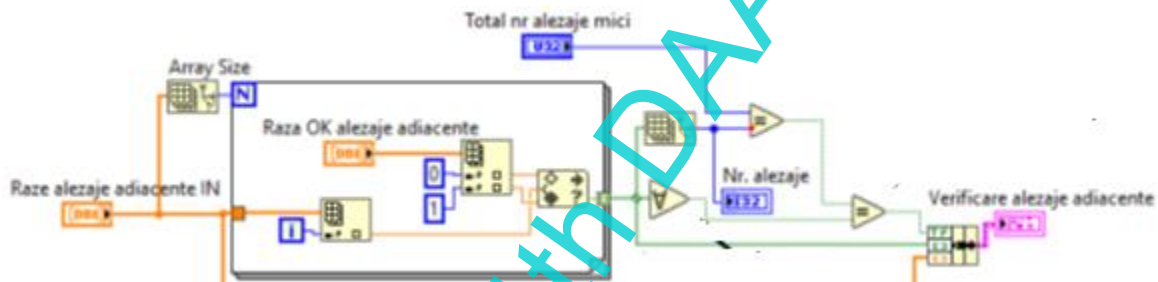

Fig. 4. Checking the characteristics of the analyzed product

The programming of the electronic components and the control of the motors were also done with the help of the LabVIEW program. For the DC motor control, the entries are used by the Digital Write function and set to N channel, the motor is considered being a switch that builds an array with its value and the negation of this value. Another array shows the pins that the driver uses to control the sense. The PWM Set Duty Cycle function controls the motor speed and is used by pin 5 on the Arduino board. At the top, a button deactivates the switch for motor direction if the speed is greater than 0, thus the direction cannot be changed during operation (fig. 5).
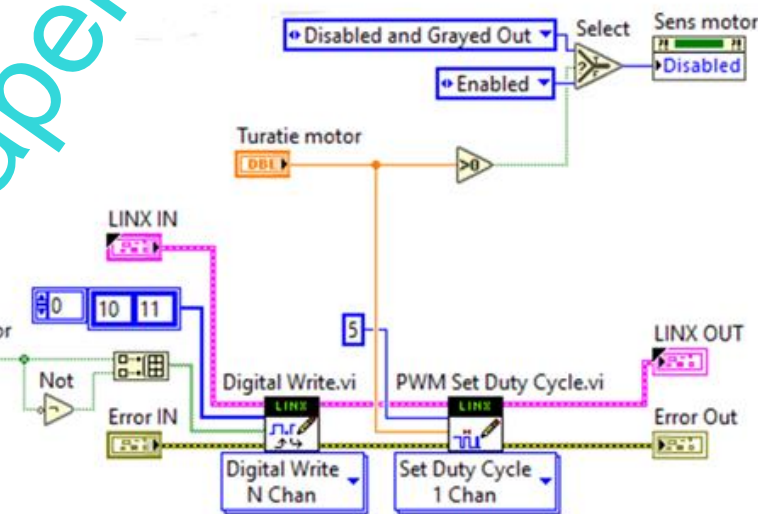

Fig. 5. VI for the control of DC motor

The part detection program presented in fig. 6 uses LINX's Read function from LabVIEW to read the distance from the ultrasonic sensor. It has as inputs the session, error and the pins used by the sensor. The output shows the session, the error and the distance in centimeters that is converted into millimeters, and if this distance is less than 80 millimeters, the program detects the part after it waits 8 seconds to take the photo.
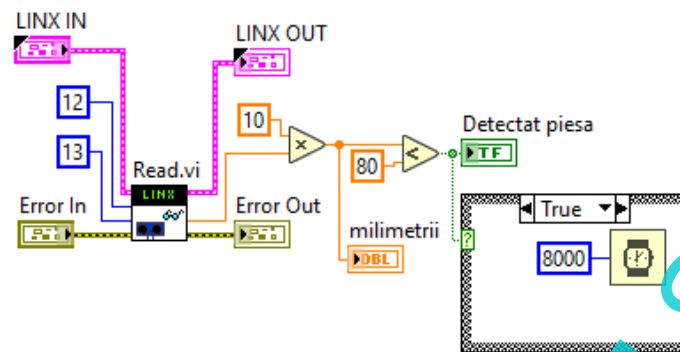

Fig. 6. Product detection algorithm

The results of the sorting process are then saved and converted into signals that are used to communicate with the actuator control system to carry out the sorting tasks. The control of the servomotors is done with the help of a sequential structure that performs in 3 steps: the arm is set at 45 degrees, the product is expected to leave the belt and the program will realize that it has done so when the system activates the stroke limiter. The While structure closes and it can move to the last step: the arm is reset and repositioned to the initial state, 0 degrees (fig. 7).
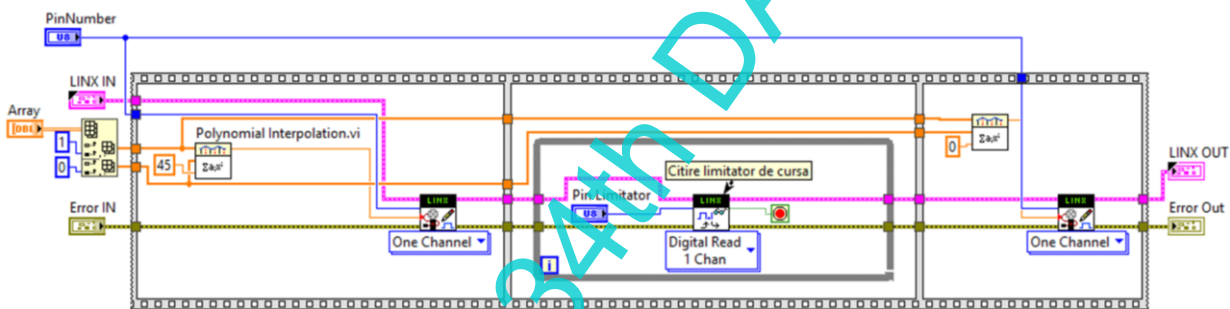

Fig. 7. Servomotor control

All the programs previously presented as subVIs with modified icons are integrated in the main VI in LabVIEW that is used for sorting the products, as suggested in fig. 8.
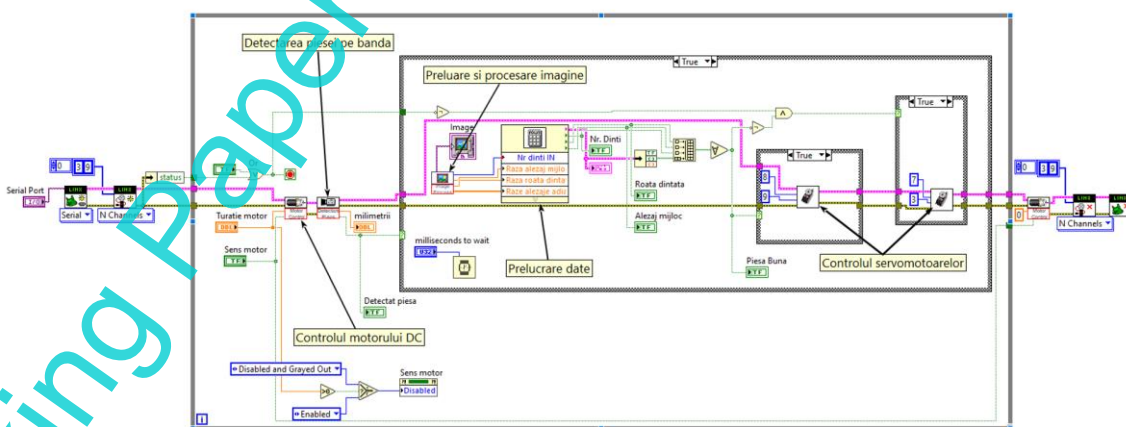

Fig. 8. Main VI in LabVIEW

3. Conclusion

The disadvantages of current commercial sorting systems are their high cost, complexity, dimensions and maintenance because they require specific equipment to function properly. This paper presents an experimental model of a system for product sorting using image analysis and developed graphical user interface for sorting in the LabVIEW environment, based on computer vision. The user interface is modular, allowing to upgrade the processes and algorithms used.

In order to ensure the highest possible functionality and reduce errors during system operation, the following key points of the system were analyzed and tested: constant engine speed to ensure that everything will run optimally; establishing an optimal speed for running the system; development of the algorithm for image processing, which will result in more accurate identification; training the recognition algorithm with as many qualitative images as possible; commanding the servo motor based on the information generated by the algorithm; detection of the shape and position of the product; determining the optimal position of the camera in front of the conveyor belt; the possibility that the algorithm does not recognize the object; finding a solution for the case of non-identification. This type of system can be programmed to perform various tasks, increasing versatility and it can gather useful information while operations are running, giving important insights to improve operations and make data-driven decisions. The future research plans are represented by testing the system and algorithms on various products to reduce the response time and by using the system to identify and separate waste with distinct textures.

4. References

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