Implementation of Image Processing and SCARA Robot for Nut Bolt Sorting

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Abstract- The paper discusses about the need for robotics in most of the industrial operations and thus the applicability of the same at an effective cost becomes important in the market. The work in this paper proposes the design and develops a mechanical structure of a SCARA robot that can perform certain tasks for educational, research and exhibition purposes such as pick and place operation. The paper discusses the steps used in design and development of a 4 degree of freedom (DOF) SCARA robot which includes specification definition, conceptual design, product development, and testing. To elaborate and simplify how different products manufactured in a factory can be put on a single conveyer for its proper distribution and data logging in a random sequence. To upgrade this process, images captured by the webcam can be processed with image processing techniques using software like MATLAB.

Keywords- SCARA robot, Image processing, manufacturing processes.

I. INTRODUCTION

Over the last few decades, robotics has played a very important part in process automation, with robot manipulators assuming a leading role in the development of several productive areas. Nowadays, industrial robots are used for the automation of a variety of tasks such as assembling, transfer of materials, all kinds of welding, precision cutting of materials, palletizing, painting, remote surgical procedures, among many possible applications.

The work presented in this paper aims to project a design for constructing a single conveyor belt arrangement for multiple objects in a random sequence, for its proper distribution and data logging. The goal is to develop a conveyor belt which will play a vital role in small scale as well as large scale industries for and logging the data, consequently reducing the cost of labor and multiple conveyors. The system leverages a conveyor belt with 2 motors, a mechanism to sort the products and a Webcam in proximity of the apparatus. The webcam is mounted in parallel to the assembly line focused on the products on the conveyors in order to have known the product and its sequence. The apparatus sends image processed readings and measurements over wires to a microcontroller for further processing. Code running on the microcontroller in conjunction with a code in MATLAB generates an output on the appropriate pins configured by user by a program, which controls the speed and direction of the conveyor belt. This quality in MATLAB image processing toolbox and Arduino has made it possible. This research thus implements an industrial assembly line with methodology in image processing.

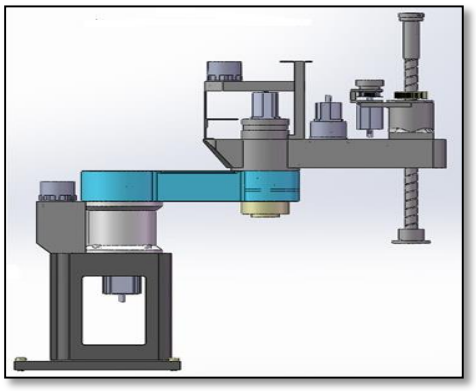

Fig.1. Structure of SCARA Robot

As mentioned already, the design and development is categorized in four degrees of freedom. In specification definition phase, the specifications of the SCARA robot are first determined. After that, the best conceptual design of the SCARA robot is chosen after making concept evaluation in the conceptual design phase. Then, in third phase which is the product generation, the chosen design of the SCARA robot is fine-tuned. Stress analysis using finite element analysis is carried out before a prototype is developed. The direct and inverse kinematics, dynamics of the robot is then modeled. Off shelf parts are also selected based on the derived parameters from calculations. Electronic parts such as sensors and dedicated controller using low cost microcontroller are then developed. Finally, the developed SCARA robot is tested to see whether it fits the targeted specifications.

A single assembly line has been developed for the classification and sorting purpose of different objects using electronic systems, advanced sensors and image processing

technique in MATLAB on the basis of physical and color characterization of each object. The work presented here involves the identification of shape and size of an object which is done by a webcam acting as color sensor which identifies the object's shape, size and sends the signal to the ATMEGA microcontroller.

The microcontroller in response to the received signal; generates an appropriate control signal which is send to the circuit which drives the various motors and it also synchronizes the movement of the belt with the sorting mechanism. Based upon the color detected, the linear actuator pushes the object to the specified location. It aims in classifying and sorting the objects which are coming on conveyor belt by placing them in their respective pre-programmed place.

The GUI based system helps to control and monitor the whole conveyor belt. With this it is possible to calculate the number of items with their respective colors and predefined weights which will make packaging much easier and controllable. Due to this only one conveyor is sufficient instead of many, Thereby achieving high accuracy and speed in the work; while eliminating the monotonous work done by human.

II. LITERATURE SURVEY

In general, industrial robots are employed to carry out repetitive jobs and/or those that require precision and speeds difficult to achieve by human beings. This has made it possible to improve the quality of products and the efficiency of their manufacturing. On the other hand, industrial robots can perform tasks during many hours per day without getting tired or losing precision or effectiveness, because they are currently highly developed and robust devices that practically do not fail. Thus, to know, study, improve, reprogram, and adequate these systems to different scenarios becomes necessary, so users can profit as much as possible from them.

SCARA has four degree's of freedom (DOF); *viz* three rotational axes which operate on X-Y plane, and the vertical axis performs up and down movement on Z plane. Three rotational motions are provided by Joint1 is the main arm, the forearm is Joint2, third rotary axis roll is the gripper, Joint3. The gripper is usually belt driven from a motor at the fixed end of the arm.

The importance of this configuration is that it keeps the gripper, and hence the work piece at a constant angle with respect to the bench independent from the arm movement. The vertical axis is also important for positioning of SCARA. The basic objective of the work presented here is to study and implement SCARA robot as well as to study object sorting algorithms for nut bolt sorting.

One of the research paper discussed about a fully functional sorter machine which can be implemented by using a structure of parallel and independent channels in order to increase the overall throughput which results with a forecasted performance [1]. The sensor handling systems which drive the pick and place robot to pick up the object and place it into its designated place. A cost effective Mechatronics system can be designed using the simplest concepts and efficient result can be observed.

An object sorting system for domestic/industrial control had been developed using the concepts of Image Processing, Robotics Mechanism and parallel communication without help of DSP processor [2]. Hence for fast manipulation the algorithm is implemented in the MATLAB which is suitable for our sorting problem.The algorithm implemented for nut bolt sorting results into 90-94% accuracy and depends upon various atmospheric factors.

Few researchers implemented the idea of sorting the objects using the colors with the help of robot arm in conjunction with image processing using MATLAB programming. The USB webcam serves as an eye of the system which captures the real time image of the objects. The robot arm picks the faulty quality object and places it at predefined place, while good quality object continues its motion on conveyor belt and finally drops into object carrier system.

Today, technology is developing in the same direction in line with rapidly increasing human needs. The work done to meet these needs makes life easier every day, and these studies are concentrated in robotic arm studies. Robot arms work with an outside user or by performing predetermined commands. Nowadays, the most developed field of robot arms in every field is the industry and medicine sector. Designed and realized in the project, the robot arm has the ability to move in 4 axis directions with 5 servo motors. Thanks to the holder, you can take the desired material from one place and carry it to another place, and also mix it with the material it receives. While doing this, robot control is provided by connecting to the android application via Bluetooth module connected to Arduino Nano microcontroller.

Pick and Place Robotic Arm Implementation Using Arduino, A robotic arm is designed using arduino to pick and place the objects via user commands. It will pick and place an object from source to destination safely. The soft catching gripper used in the arm will not apply any extra pressure on the objects. The robot is controlled using android based smart phones through Bluetooth. Based on the commands given by the user the robot moves accordingly. At the receiver end there are four motors interfaced with the micro controller. Two for the vehicle movement and the remaining two are for arm and gripper movement. Blue control application is used for the controlling of robot. Keywords: Pick and place robotic arm, Blue control app, soft catching gripper.

Design and Development of A 4–Dof SCARA Robot [4] presented the design of a mechanical structure of a SCARA robot that can perform certain tasks for educational, research and exhibition purposes such as pick and place operation. Stress analysis using finite element analysis is carried out before a prototype is developed. The direct and inverse kinematics, dynamics of the robot is then modeled. Off shelf parts are also selected based on the derived parameters from calculations. Electronic parts such as sensors and dedicated controller using low cost microcontroller are then developed. Finally, the developed SCARA robot is tested to see whether it fits the targeted specifications.

Auto & Manual Control of Robotic Arm Using PLC[5], discussed about the control of Robotic Arm manually and automatically by using Programmable Logic Control(PLC) to pick the moving object on a conveyor belt. There are several disadvantages by using these processors like micro controllers cannot work in the environments with the high levels of vibrations, corrosion, humidity, and other environmental factors. All these problems are overcome by using Programmable Logic Controller (PLC) which acts as a brain to control the robotic arm.

III. PROBLEM FORMULATION

Generally, sorting out the objects is done manually, which consists of four integrated stations called distribution, testing, processing and handling. Old sorting method uses a set of inductive, capacitive and optical sensors do differentiate object color in the testing station. Handling is done by using a programmed manipulator. No vision capability exists in the system to improve its performance and flexibility. In this case, there is a possibility of minor error which will affect the accuracy in sorting. Also for huge systems, time and manpower required will very high. Automated systems can be used to remove such human errors and also it saves time and money.

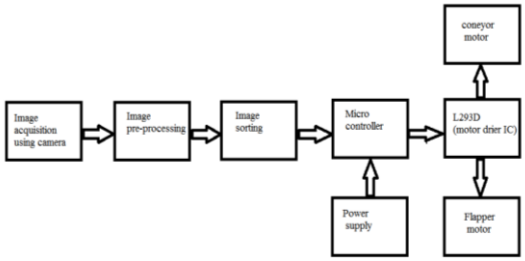

Fig.2 Block diagram

In the work presented, the idea of the nut bolt sorting has been expanded to color detection technique with measurement of size of a object by using MATLAB. The hardware implementation will include the flapper motor for sorting of object and using a camera in place of IR sensor.

IV. METHODOLOGY

The problem is to design a robotic arm with SCARA configuration having 4 DOF which is used for pick and place operation of an object having dimensions 20x20x50mm and payload capacity of 0.150kg. The aim of this study is to provide Robotic arm as a learning material to Engineering colleges at lowest possible cost. The stages involved in this process are as follows;

A. Image Acquisition

To start with when the object on the conveyor is detected by the camera, image is captured by the camera and is sent to the MATLAB workspace. The input image obtained from the webcam cannot be directly given for processing. Pre-processing is done on the image such as thresholding. Then only object image is converted in binary format. This final threshold image of object is now ready for processing as shown in figure 2.

Fig.3. Image Acquisition for MATLAB workspace

B. Camera

The camera used in this case will be overhead camera; it will take the snapshot of the object for colour sensing purpose. The image captured by the camera will be processed by image processing using MATLAB.

C. Image Processing

The objects are sorted on the basis of color and predetermined shape. To identify the color, firstly the image is converted into gray format and then thresholding is done.

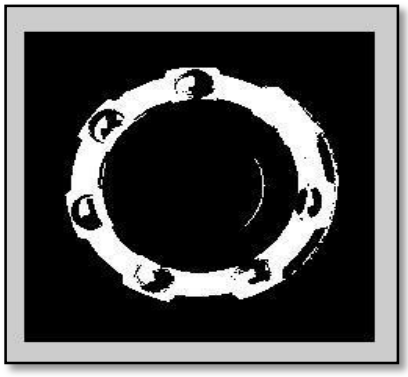

Fig.4.Gray Format of Image Processing Stage

After thresholding color components are extracted and the image is converted into black and white format which is called as binary format. Find region properties & bounding box and the color are identified.

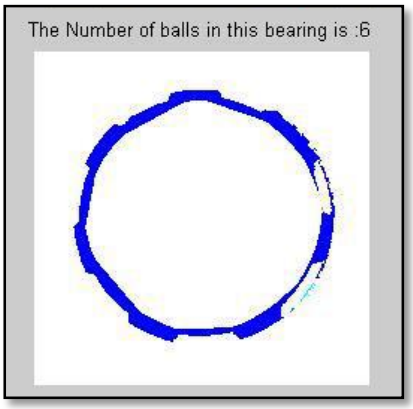

Fig.5. Binary format for Color Extraction

Fig.6. Threshold Completion Stage

D. Sorting Mechanism

The sorting mechanism consists of a linear actuator, servo motors and a conveyer assembly. After identifying the colour with predetermined size, command will be sent to direct the linear actuator through COM port of the computer via the development board. Conveyor assembly is in OFF state for this period. According to the size and colour the servo motors with help of linear actuator places the objects in their specified place.

E. Microcontroller

The ATmega328 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the Atmega 328 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

F. Conveyor Belt

The conveyor motor receives power and signal from the central supply through rectifier and control circuit. The control circuit consisting of a potentiometer will allow the user to manually control the speed of conveyor belt by the regulatory knob. Polyester is used as a belt material. A conveyor belt consists of two or more pulleys, with a continuous loop of material - the conveyor belt - that rotates about them.

As shown in fig.2, block diagram of our system proposes an hitech vision system for sorting bottles without cap or labels from conveyor line. Here, we have utilized hi-speed cameras which captures continuous images of bottles and this images are been processed using MATLAB real-time. As soon as the bottle without cap or label is detected the controlling signals are sent from PC to controller to control the flapper in two different directions using predefined angle of rotation.

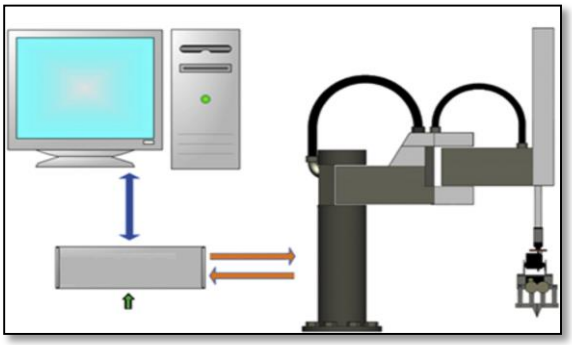

Fig.7.Arrangement of Components

V. CONCLUSION

In this paper, the design and development of a SCARA manipulator with six degrees of freedom was designed and implemented. This constitutes a physical platform on which variety of control techniques can be tested and studied. The development of the PC-Controller's software, which is the same as the electronic interface, despite the complexity of its design and implementation, allowed an optimum functioning of the complete system. This software, among other functions, also enables the generation of multiple trajectories for the robot. Mechanical, electronic, and control systems could be integrated satisfactorily, yielding excellent results, materialized in robot.

VI. FUTURE SCOPE OF WORK

The conveyor belt design can be upgraded to sorting of more number of products automatically on a single conveyor belt and to be delivered at a convenient distance with faster speed. Algorithm can be improved with more precision using image processing techniques and optimally planned logistics for creating a finished product much faster than with present methods. The future of conveyor belt will be large-scale development, expand the scope of use, automatic sorting, reduce energy consumption, and reduce pollution.

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