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Sorting Robot using Machine Vision Inspection System

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***Abstract*—Sorting is an important aspect of any industrial application based on various attributes related to the product under consideration. This project aims to create a machine vision inspection system for sorting objects based on color, and texture using MATLAB for image processing. The gantry setup achieved through the XY table helps in locating the gripper near the object of interest and the positional accuracy is achievedthrough the microcontroller. The gripper is used to hold the object of interest and sort them based on pre-instructed commands through MATLAB software thus achieving automation in the system for creating the Machine Vision Inspection System (MVIS). The Machine Vision Software packages thus employ various digital image processing techniques to extract the required information and often make decisions (such as sorting which tote bin) based on the extracted information. The MVIS discussed here explodes the ability to create a machine for sorting based on complete automation where the machine vision industry market had continually grown over the last 20 years due to the ever-increasing capability of processors allowing the technology to be employed on a huge increasing complexity of applications. A continuous pick and drop can be achieved by further experimentation and analysis. In this work, MVIS has been created successfully.**

Keywords*—Image Processing, MATLAB, Gripper, Inspection System, Object Sorting

I. Introduction

Industrial automation as of now reaching its zenith heights yielding the industries a global marketing ability in a short period which would have been highly impossible without the invention of electronics, mechanical structures, and the contributing fields for every complete automation. Sorting objects is widely implemented in the industrial application taking in certain specific factors of their product and analyzing them to obtain qualified results. Machine Vision Inspection System is achieved through camera capturing of images at frames per second, yielding fast accurate input to get output. It is a widely applied field in the industrial process for packing goods based on varying attributes of their products. Products are analyzed accurately like proper filling of bottles, packaging, and separation of color variations with a fast analysis of components are taken into consideration.

The choice of automation industry generally adheres itself to an inspection system depending on classifying objects for packing, separating, fault detection, proper filling of bottles, testing a hollow glass tube for cracks, etc., The industries work based on making a mark in a global market. To achieve that, it requires extreme care on giving quality products as output, making promises on its component departures that speak for themselves in a packet or a printed cover, manufacturing goods must be packed and classified in a given time journey from firm to reach the market. Thus, automation is need of an hour in this fast-growing globalized world where imported and exported extremely fast and need easy access with high reliability of an industries goods without spoiling its reputation (say a wrongly packed product in a packet, any damaged product, a defect one, a wrong one, etc.,)needs an inspection. With this general view of automation as discussed, this project of object sorting using a machine vision inspection system employs components like hardware and platform for software which upon integration results in sorting objects.

The significance of a machine vision inspection system includes advantages using a machine vision inspection system includes a few of the following factors such as, high speed provides excellent production efficiency, high consistency, measures dimensions within thousandths-of-an-inch accuracy, high reliability and resolution, increased control over quality management, flexible installation, easy user interface for reduced operator burden, eliminate customer complaint and return of investment to mention a few.

There are four types of automation namely, Fixed, Programmable, Flexible, and Integrated. An important consideration when selecting a robot includes the number of axes, kinematics, working envelope (reach), carrying capacity (payload), motion control, power source, and drive [1].

The main advantages of automation are increased throughput or productivity, improved quality or increased predictability of quality, and improved robustness (consistency), of processes or products.

A. *Types of Automation*

Different types of automation are used in different types of industries. In industrial settings, different types of automation provide benefits to companies including decreased part-cycle times, higher quality products, and increased worker safety [2].

- Industrial Automation
- Numerically Controlled Machine
- Industrial Robots
- Flexible Manufacturing Systems

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B. Limitations of Automation

Current technology is unable to automate all the desired tasks. As a process becomes increasingly automated, there is less and less labor to be saved or quality improvement to be gained. Similar to the above, as more and more processes become automated, there are fewer remaining non-automated processes.

The aim is to sort objects of interest automatically using robotic implementation. The gantry setup created holds the XY table directly over the conveyor belt thus creating the workspace for the robot to move. Arduino Uno board is the controller which instructs the motors and sensors. The gripper is actuated to grip the object and release as instructed depending on the color variation loop is varied in the programming part.

II. Hardware Setup

A. *Introduction*

Geometric shape recognition is the problem of determining the pose and dimensions of objects for which the shape of objects is known, not the size. INGEN- INference engine for GENeric object recognition uses a data-driven approach. Size and Pose estimation are facilitated by a geometric reasoning process that extends objects in the direction away from the sensor until they physically contact other objects in the scene. INGEN thus guides the Robot integrated with a camera that takes 15 frames/second along with process namely, merging, aggregation, geometrical reasoning, so working on result generation. The use of information derived from geometrical contacts between objects enables it to determine object dimensions [3].

Following that, the image processing part transforms images using spatial for image correction mainly for affine transformation which is the subset of projective transformation. The mathematical equations were framed for scaling, shearing, rotation, and translation. the deployment was made through MATLAB giving input images using transform and output images [4].

Al-Mamun et al., (2007) dealt with the Processing of Digital images, Computer Vision – to solve Industrial problems, sorting of meat and fish industries, Image segmentation based on pixel information, and feature-based technique. Only grayscale images were taken into account, following conversion of color images from RGB (Red, Green, and Blue) to HSV(Hue, Saturation, and Value) and executing intensity and color-based algorithms and applying threshold level approach. Feature and object-based algorithm for the various shape, textures, the relation between different objects in an image, and orientation/ angles. For, multiple features based on the learning process, the clustering approach is carried out. An improved feature-based approach by careful selection of features, searching and matching features, and identification based on extracted features were attempted. The matching process was done by object identification technique. To conclude, Sorting-Industrial Application-practical experimentation is required to justify the performance [5]. Thus, in this work, the gap proposed in this paper has been fulfilled by applying the theoretical knowledge to detect, stop the robot, pick and place in respective bins without human interface and that stands out to be the novelty of this work. Hence, the object sorting machine vision inspection system has been proposed in this work.

Takashi Toriu et al., (1988) discussed sorting books using an algorithm based on the discrimination model had been used. This discrimination model is generated based on object classes by learning, and objects are effectively-recognized. The algorithm consists of an image normalization process, a feature element extraction process, and a recognition process. Feature recognition takes input from normalized images and takes it to convert to pyramidal representation. A decision tree approach is made through in recognition process. Experiments performed on the simulation system verified the experiment works effectively. The learning process generates the discrimination model which specifies the combination of feature elements to represent the differences between classes with a small number of features [6]From this work, sorting concepts were taken into account.

Bdiwi, M. et al., (2012) had discussed sorting systems based on image processing, a hybrid control robot system based on force control to automate the sorting of library books. The hardware, Software, control algorithms as well as vision algorithms for object detection, object characterization, and classification, Code identification, order algorithm of gripping objects for position priority ad code priority to sort books were discussed. The paper yields a user-friendly environment to access the books even in presence of a human in the working environment of a robot [7]. The integration of the sorting technique to the control of robot manipulator theory is taken into consideration in this work. Here, the Gantry setup is created using the XY table for the part of the robot being under discussion, and the significance of avoiding human interaction is considered in this work.

Zheng Wei et al., (2010) discussed distinguishing semantic objects from video data for a content-based analysis. The calculation for shape features, Luminance features, and rhythm features on an experimental data Analysis was discussed. Results show the proposed algorithm is suitable for sports video with a high recognition accuracy rate of 80 percent [8]. Thus, freezing a video and taking frames from the obtained/captured video have been conceptualized for better control of the camera have been taken from this work. Thus, improving the stop/start function of the robot is under the command of software based on input from the video feed which purely depends on the camera specifications taken into work.

Cheolkeun et al., (2013) had described an efficient approach for irregular moving object detecting and tracking in the real-time system based on color and shape information of the target object from a realistic environment. Firstly, the data is gotten from a real-time camera system at a stable frame rate. And then, each frame is processed by using the proposed method to detect and track the target object immediately in consecutive frames. Finally, the target position-based modifying controlling signal is used to control the pan-tilt-zoom camera (PTZ camera) to automatically follow the target object. Our experiment results were obtained by using a pan-tilt-zoom camera Sony EVI D70 under a variety of environments in real-time and our algorithm is verified that it can be implemented effectively and accurately at high frame speed, even 29.97 fps [9]. As freezing and capturing are based on the camera specification, the angular adjustments such as external

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environment lighting conditions and exceptions were considered in this work (i.e., ambiance control).

Yanan Miao et al., (2012) had proposed high-speed and high-precision detection of the wall and floor tiles products' smoothness, this paper presents a fast calculation method of the high-precision crooked degree of boundary and center and develops an online detection system, which is composed of transmission, detection, and classification, of the smoothness of the tile-based on PLC and HMI. The detection system uses the optical triangulation detection method, applies the high-precision non-contact laser displacement sensors for information collection, and pinpoints the moving tiles sampling location by the encoder, the main computer system carries on the smoothness operation for the collected surface information after the conversion process, drives the classification device to make the grade marking and grading to the tiles based on the operation results. The spot experiment data show that the average detection speed of the tile smoothness detection system is 30(m/min), the repeated measurement precision of the same direction is ± 0.04mm and the detection accuracy can be achieved at more than 95%, which can meet the tile production enterprises' requirements for the high- precision online detection of the smoothness [10].

Dongping Qian (2009) et al., researched real-time fruit quality detection with machine vision as an attractive and prospective subject for improving marketing competition and post-harvesting value-added processing technology of fruit products. However, the farm products with different varieties and different quality have caused tremendous losses in the economy due to lacking the post-harvest inspection standards and measures in China. Given the existing situations of fruit quality detection and the broad application prospect of machine vision in the quality evaluation of agricultural products in China, the methods to detect the external quality of pear by machine vision were researched in this work. It aims at solving the problems, such as fast processing of a large amount of image information, processing capability and increasing precision of detection, etc. The research is supported by the software of Lab Windows/CVI of NI Company. The system can be used for fruit grading by the external qualities of size, shape, color, and surface defects. Some fundamental theories of machine vision based on virtual instrumentation were investigated and developed in this work. It is testified that machine vision is an alternative to unreliable manual sorting of fruits [11].

Koley, C (2012) et al., presented a computer vision-based system for automatic grading and sorting of agricultural products like Mango based on maturity level. The application of a machine vision-based system aimed to replace the manual-based technique for grading and sorting fruit. The manual inspection poses problems in maintaining consistency in grading and uniformity in sorting. To speed up the process as well as maintain consistency, uniformity, and accuracy, a prototype computer vision-based automatic mango grading and sorting system was developed. The automated system collects video images from the CCD camera placed on the top of a conveyer belt carrying mangoes, then it processes the images to collect several relevant features which are sensitive to the maturity level of the mango. Finally, the parameters of the individual classes are estimated using Gaussian Mixture Model for automatic grading and sorting [12].

Xiurong Zhao et al., (2011) had dealt with a variable-spray control system based on machine vision which is highly required for real-time image acquisition, processing as well as driving the actuator rapidly and stably. To reduce the developing cycle and programming difficulty, the VB program language is used for its high executive efficiency to collect real-time information and control signals; meanwhile, MATLAB software is adopted for its excellent image processing function. The requirement of fast reaction for the control system is satisfied with the COM component, it is introduced to combine VB and MATLAB to control the variable-spray system, and it provides the foundation for future development and application [13].

Qin Guo et al., (2010) presented a fruit size detecting and grading system based on image processing. After capturing the fruit side view image, some fruit characters are extracted by using detecting algorithms. According to these characters, grading is realized. Experiments show that this embedded grading system has the advantage of high accuracy of grading, high speed, and low cost. It will have a good prospect of application in fruit quality detecting and grading areas [14]. The literature review provided various processing steps but everything was unique as per research variation and a color sorting based on inspection for an object of interest requires a proper finding of the procedural tasks required. Industrial applications were the need for a sorting operation and the level of analysis varies from mere packing using a vacuum gripper to deep analysis of part inspection before completing the process, thus the project work taken here is a work that is a stint of the big process that happens in every manufacturing industry in the real world. Based on many conclusions as discussed in every paper the output is beneficial in some cases and leads to a clear path for future researchers in some other cases.

B. *Camera AVT Stingray F201C*

The extensive built-in image processing possibilities (image pre-processing) result in outstanding image quality, reduced retouching, less CPU load, and overall higher performance. As one captures the video footage of object flow frames per second need to be selected properly.

A typical inspection system is comprised of a camera, an object of interest, and a mechanical machine say a robot providing actuation or accessing the component if needed mechanically rather than a human for the advantages of a machine over a human in an industrial point of view, and a programming language to embed and access the mechanical components based on signals and systems that eventually improve the accuracy and precision level of a component under inspection. A closed-loop feedback control system is advantageous over an open-loop if a complex task is being carried out else if a system is comprised of certain definite tasks like a component is certain to be present may be a human is giving an input then an open-loop would help much better than the closed-loop system. The camera used in this work is shown in Fig. 1 and the specification is shown in Table I.

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Fig. 1 AVT Stingray F201C

TABLE I. Specifications of camera

Parameter	Specification
Camera(mono/color)	color
Camera resolution	1624x1234
Cell size	4.4 µm x 4.4 µm
Shutter speed	48 µs to 67 s
Interface type	IEEE 1394b

C. M DC Motor Pittman GM9236 Series

For precision motor control, optical encoders are available in 2 channels with 500 CPR to meet position, velocity, and direction feedback needs. This motor provides the required torque to move the XY table and conveyor belt, a total of 3 in number for each. The motor used to run the conveyor belt in the current setup is shown in Fig. 2 and the specification is shown in Table II.

Fig. 2 DC Motor Pittman GM9236 Series

TABLE II. Specification of DC Motor Pittman GM9236 Series

Parameters	Specifications
Reference Voltage	30.3 v
Torque constant	8.24 oz.in/A
Back-EMF Constant	6.09 V/krpm
Peak Current (stall)	7.74 A
No-load speed	4916 rpm
Peak torque	61.8 oz.in

The contributing fields for carrying out this work are shown in Fig. 3. The components including hardware and software are shown in Fig. 4.

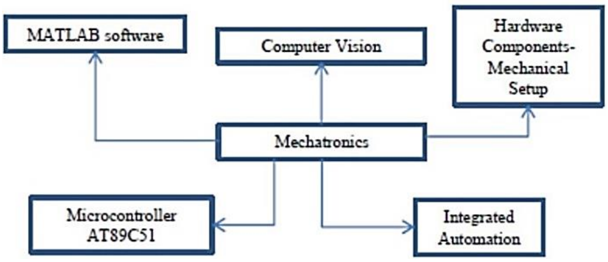

Fig. 3 Contributing Fields

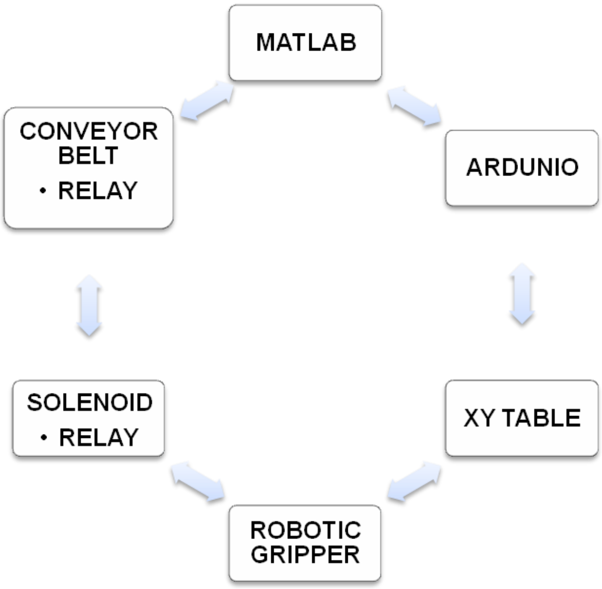

Fig. 4 Working Components of Object Sorting Inspection System

D. Microcontroller AT89C51

The specification of microcontroller AT89C51 is shown in Table III.

TABLE III. Specifications of Microcontroller

Parameter	Specification
Type	CMOS 8-bit µc
No. of write/erase cycles	1000
RAM	128x8-bit internal RAM
No. of I/O Pins	32
No. of Timers/Counters	Two 16-bit
No. of Interrupt Sources	6
DC Output current	15 mA
Maximum operating Voltages	6.6 V

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The actuating gripper to hold the object of interest is shown in Fig. 5

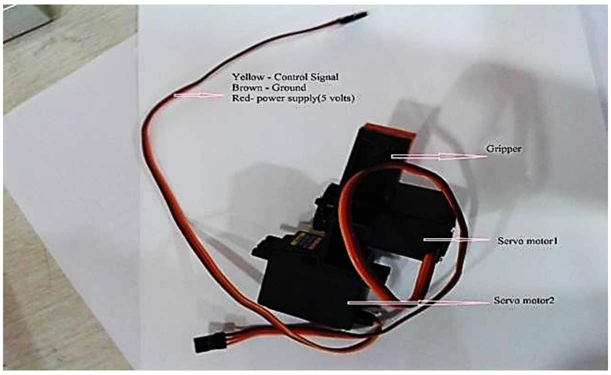

Fig. 5 Gripper

E. XY Table

An XY table is used for cutting, engraving, and marking. The standard versions of this machine range from 51"x100" back to 15"x15". Most of the manufacturers allow for wide configuration latitudes making it possible for a client to acquire the right XY table for their application or applications. Standard XY table lines meet and even exceed the performance ratings of any competitor's product as they have been manufactured from the best, heavy-duty steel forms, which include stainless steel. When built, these XY tables are built to last the test of time while requiring the least amount of maintenance possible. An XY table that features higher accuracy is available with the minimum amount of vibration allowed through extensive experience in vibration by this manufacturer.

XY Table provides horizontal and vertical motion to make the gripper move to the object's position is duly to be achieved. Belt-driven type is used here. The software compensates automatically for whatever belt stretch that may be experienced, which results in better accuracy. The XY table used in this work is shown in Fig. 6 and the specification is shown in Table IV.

Each axis of the XY table has an attached home switch that provides feedback back to the regulator giving the software one reference point for all future positioning commands. Such an XY table package could include documentation, setup tools, home switches, all the necessary hardware, and the table for linear positioning.

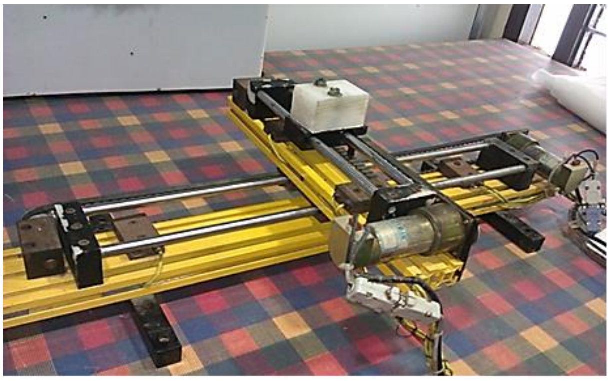

Fig. 6 XY Table

The possible tools would be a camera, an engraver, a sensor, an adhesive dispenser, a pneumatic gripper, a miniature drill, and a test probe. Payloads may differ, but some XY tables can work with about 15 pounds, as any heavier will show decreased accuracy and speed.

TABLE IV. Specification of XY table

Parameter	*Specification*
Type	Belt driven
X-axis Travel length	52 cm
Y-axis Travel length	30 cm

F. Conveyor Belt

The Conveyor belt is a continuous flow type. The Setup is shown in Fig. 7, which has a width of about 13 cm length nearly 65cm. Conveyors are durable and reliable components used in automated distribution and warehousing. In combination with computer-controlled pallet handling equipment, this allows for more efficient retail, wholesale, and manufacturing distribution. It is considered a labor-saving system that allows large volumes to move rapidly through a process, allowing companies to ship or receive higher volumes with smaller storage space and with less labor expense.

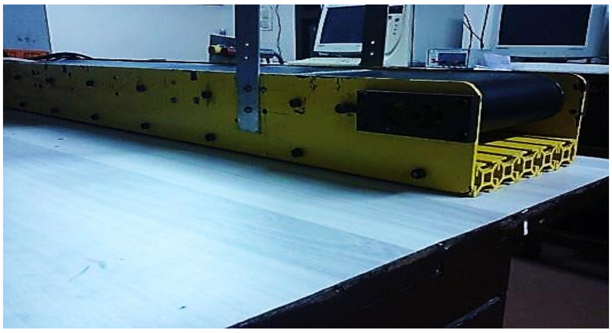

Fig. 7 Conveyor Belt

III. METHODOLOGY

This project presents the sorting of an object of interest using a machine vision inspection system by actuating a pneumatic gripper utilizing a microcontroller program. The object of interest is kept over a conveyor belt which moves with a constant velocity. A gantry-type setup of XY table is made over the conveyor belt. The gripper is fitted to the Y-axis movement of the XY table. As the conveyor belt starts, the camera captures the image and checks in for objects at a periodic interval of seconds. The methodology approach is given as a workflow diagram in Fig. 8.

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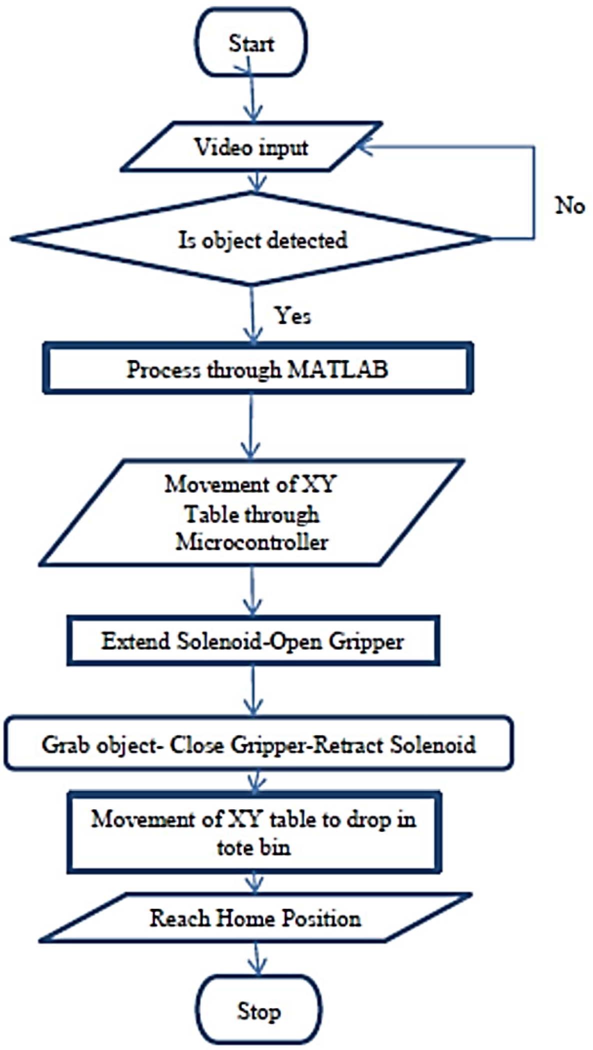

Fig. 8 Workflow of Machine Vision Inspection System

Once the object is located in the conveyor belt, the gripper should move along the axis of the belt (X-Axis), and to cover the width of the belt Y-axis movement occurs and retracts the gripper at a speed to hold the object. The gripper is servo actuated and the object is reached in a precise to the end position of the entire range of travel. The integrating software platform is MATLAB for Image processing and motor controls and a gripper actuation Microcontroller must be employed.

A. Video Image Processing

Video Image processing is one of the Image Processing applications where a video is processed to acquire information from it such as Feature extraction, Region growth, and Shape recognition to detect objects. The Video is obtained through camera captures at the rate of 14 frames per second or any specified level depending on the manufacturer's data. Thus as per the video obtained, the image is to be processed to obtain an object say a triangular shape, thus to detect and locate the object at a particular time is determined based on the speed of video and software integrated with a camera to detect the objects.

B. MATLAB

Here in this project, MathWorks owning MATLAB R2010b version had been proposed for usage for Image Acquisition and Processing. MATLAB is a user-friendly software and has various toolboxes under one menu, thus it is been chosen. Toolboxes namely Video Image Processing Toolbox, Parallel Computing Toolbox, Image Acquisition Toolbox, Image Processing Toolbox are all to be included to makea program coding for the purpose to detect and locate an object based on camera working and Image conditions or criteria from which video is been obtained.

Moreover, an object of interest is to be kept over a conveyor belt that runs at a speed as given as input and during image detection and location, the speed and acceleration of the object are to be calculated to locate the object before it comes to the end line of the conveyor belt, which is the workspace forthe gripper that is to be fitted to a Gantry setup.

C. Gantry Setup

It is achieved through XY table implementation over the conveyor belt with X-axis travel length to cover up the movement of a belt from home to end position. For Y-axis travel, the width of the conveyor belt is to be covered. The gripper is fitted to an electrically actuated solenoid, the object is to be held by proper and timely actuation of the air supply and it is accounted as z- and z+ action, i.e., z- action travel of solenoid helps the gripper to grip the object and retract with necessary force, $F = W.N/\mu$ .As the mechanical and electrical and electronics parts were to be listed in subsequent chapters. Combining the hardware with the software makes this to be a Mechatronics project. The object of interest is predetermined to classify based on shape, size, and color with a two- dimensional analysis. The control of movements of the XY table and the conveyor belt is achieved through a motor circuit board (LM239 IC Chip, board) and for the conveyor belt the same IC Chip. The motor directional control and instructions are made through Microcontroller chip 8051, thus the program is to be written to make the continuous flow of the conveyor belt and XY table movement to make a start and stop as per the proximity sensors available. The gripper can hold a load of a maximum of 200 grams. Ability to be used with 2 servo motors for gripper open/close and wrist rotate. It can grip and lift to 200 grams of load in form of small objects. The maximum opening is 3 cm.

D. Camera Details

The camera is to be fitted in the home position to capture an image from the video (caused due by conveyor belt movement), the image obtained is to be analyzed for an object of interest along with its colors of it. Once the speed calculation of the object along with the location is made and the same is to be instructed tothe XY table through coding so that X-axis travel chases the target along with the conveyor belt or exceeds its speed of it so that the target is achieved before it misses the end line. The Y-axis covers the width and depending on the position of the object, the gripper is made to open/close as its senses.

In addition to this Color coding to determine the color of objects has been carried out using MATLAB. Here, Image Acquisition Toolbox enables one to acquire images and video from cameras and frame grabbers directly into

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MATLAB and Simulink. It can detect hardware automatically and configure hardware properties. Advanced workflows let one trigger acquisition while processing in-the-loop, perform background acquisition, and synchronize sampling across several multimodal devices. The schematic construction of the object sorting machine vision inspection system is shown in Fig. 9.

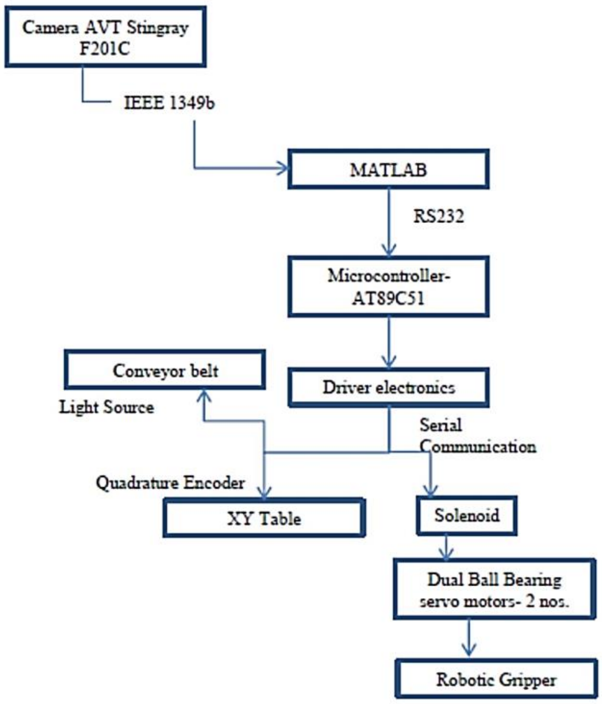

Fig. 9 Object sorting robot actuating setup

With support from multiple hardware vendors and industry standards, one can use imaging devices ranging from inexpensive Web cameras to high-end scientific and industrial devices that meet low-light, high-speed, and other challenging requirements.

E. Color concept

Additive color is light created by mixing light of two or more different colors. Red, green, and blue are the additive primary colors normally used in additive color systems such as projectors and computer terminals. In this project erasers and sharpeners of various colors were considered and the method of color detection up on classification from hue variation. Hue is one of the main properties of a color, defined as "the degree to which a stimulus can be described as similar to or different from stimuli that are described as red, green, blue, and yellow. The range of red reads as 2-14, blue as 60, and green as 80, the threshold value is determined based on repeated trials and taken in for a coding purpose.

F. MATLAB Code explanation

MATLAB is a user-friendly computational language with toolboxes available for specialized operations. The Image acquisition toolbox stores the image only when the object enters the scene of interest, this is done by checking the mean values of each pixel, and the mean value varies peculiarly if a color object is in the place of a conveyor belt, the color of the belt is almost black, so the mean value peaks. Then, the color image is calculated for the centroid of the object, and the color is determined based on hue calculation. Based on the area of objects, the pixel value varies and the area for a sharpener and eraser varies with a pixel range plus 10000. Hence to display the name of the component that had entered the field of view, the centroid part is extracted with a square value for a pixel of 40*40, and the color is extracted. Thus data is stored in MATLAB. The gripper with actuating solenoid for the process of moving along the Z-axis as per the Cartesian coordinate system is shown in Fig. 10.

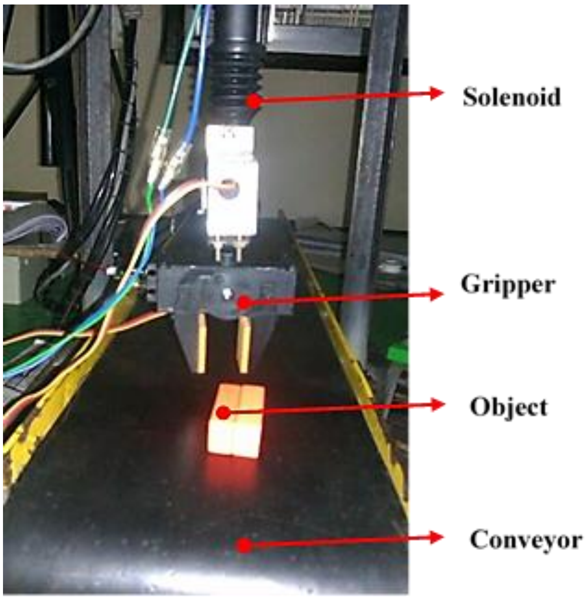

Fig. 10 Pick and Place Gripper setup with the object of interest

A solenoid is a coil of wire in a corkscrew shape wrapped around a piston, often made of iron. As in all electromagnets, a magnetic field is created when an electric current passes through the wire. Electromagnets have an advantage over permanent magnets in that they can be switched on and off by the application or removal of the electric current, which is what makes them useful as switches and valves and allows them to be entirely automated. Like all magnets, the magnetic field of an activated solenoid has positive and negative poles that will attract or repel material sensitive to magnets. In a solenoid, the electromagnetic field causes the piston to either move backward or forward, which is how motion is created by a solenoid coil. The Pin-connected for solenoid control from the Arduino board is A0. The supply voltage of 12V must be given. The Relay circuit is linked using ULN2003. The connections are shown in Fig. 11 and the specification is shown in Table V.

The instruction for the solenoid is proper on and off of signals depending upon the need of time needed as per the process required. Here a signal of ON for 5 seconds is given as the subsequent step of opening and closing of gripper requires a 3-second time for its function to get executed. When compared to a pneumatically actuated cylinder, linear solenoids fill the need with easy installation and working as suitable to the operation. Thus, linear actuated solenoid up on extension gives a length of 2 cm clearance which is preferred well as the surface contact is avoided.

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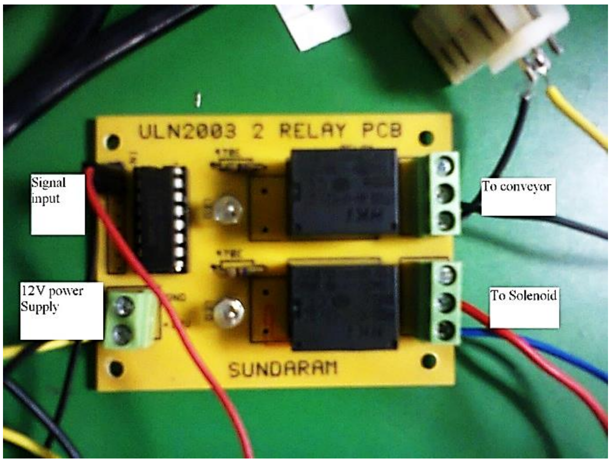

Fig. 11 Relay unit circuit connection

TABLE V. ARDUINO Pin connections for machine vision setup operation

Arduino Pin	***Configuration***
Pin 2	X motor-enable
Pin 3	X motor supply
Pin 4	X motor supply
Pin 5	Y motor-enable
Pin 6	Y motor supply
Pin 7	Y motor supply
Pin 8	X-axis limit sensor-home
Pin 9	X-axis limit sensor-end
Pin 10	Y-axis limit sensor-home
Pin 11	Y-axis limit sensor-end
Pin 12	Servo motor control sensor
Pin 13	IR Sensor

- Input Image

The input image captured using various objects of color and dimension has been narrowed to decide the values for the selection process. Here, blue, green, and red are targeted object colors and nominal sizes that can fit into the gripper and corresponding bins to collect the objects at the end of the operation. The input image taken for analysis is shown in Fig. 12.

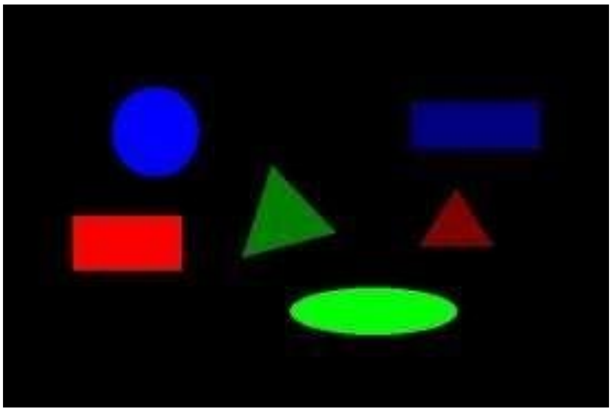

Fig. 12 Input image

The corresponding results of the processed image are shown for only the selected zone of white the input image is having no white image as per the region mapping algorithm, so the black image is captured and is shown in Fig. 13. The color images for corresponding objects from blue, green, and red are shown in Fig. 14, Fig. 15, and Fig. 16 respectively.

- Output Image for White

Fig. 13 Output Image for white

- Output Image for Blue

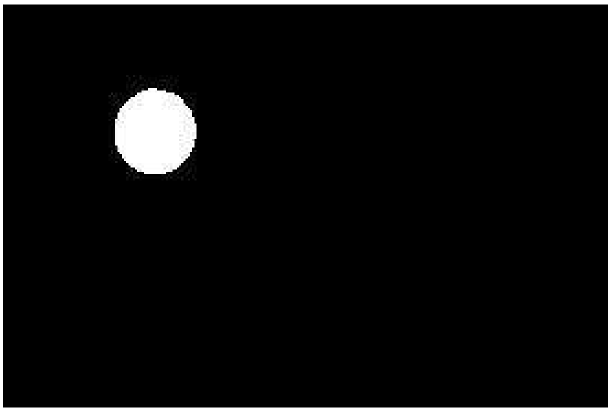

Fig. 14 Output image for blue

- Output Image for Green

Fig. 15 Output image for Green

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- Output Image for Red

Fig. 16 Output image for Red

The object sorting machine vision inspection system constructed and executed considering the pick and place robot concept is shown in Fig. 17.

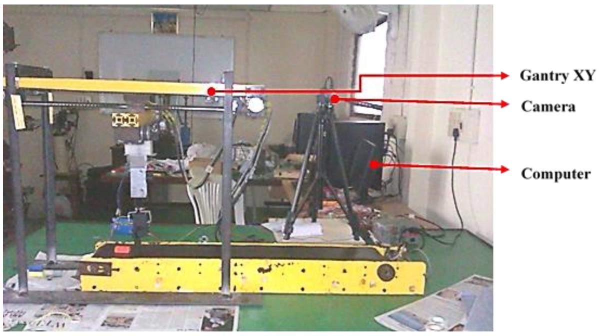

Fig. 17 Object sorting robot using machine vision inspection system

IV. Conclusion

The sorting robot is considered one of the toughest applications on a high industrial profile where several components needed to be analyzed in to make a product a success with minimal default in creation to compete in this fast globalized world around us. The principle and work include a camera to make a video analysis of the movements or flow of a conveyor belt, hence coding the camera to make this automatically without any human intervention to capture, process, and yield result to a personal computer is software-based challenging criteria.

The result obtained is to be interfaced with the hardware (gripper fitted to XY table inverted as gantry set up along the length of the conveyor belt), thus commanding the Z action of the gripper to retract and up once an object is sensed and held. The whole setup needs to achieve a proper timely based interface to pick the object and then sorting based on memory from image analysis is a big task considering accuracy, speed calculations, acceleration, time is taken to hold and sort is to analyzed very precisely for successful completion of the objective. The proposed sorting robot is a miniaturized version of larger applications with the increase in no. of proximity sensors for good and timely control of the conveyor belt so that the pick and place actuation can be decidedly by the software/system under consideration and hence for large use in manufacturing, packaging industries, automobile assembly zone in automobile industries, etc., as per the desired output required.

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APPENDIX

CODING TO POSITION XY & SERVO:

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo

            // a maximum of eight servo objects can be created

int pos = 0;    // variable to store the servo position


int eny= 5;
```

```
int c = 6;
int d = 7;

int enx = 2;
int a = 3;
int b = 4;

void setup()
{
  // initialize the digital pin as an output.
  pinMode(enx, OUTPUT);
  pinMode(a, OUTPUT);
  pinMode(b, OUTPUT);
   pinMode(eny, OUTPUT);
  pinMode(c, OUTPUT);
  pinMode(d, OUTPUT);
    myservo.attach(9);
    void halt(void);
    void servo(void);
    void back_ynm(void);
    void front_yfm();
}
void loop()
{
  {
front_yfm();
back_ynm();
halt();
servo();
  delay(100);
}
}
 void halt()
 {
  {
   digitalWrite(enx, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(a, LOW);
   digitalWrite(b, LOW);
   delay(500);
  }
  {
   digitalWrite(eny, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(c, LOW);
   digitalWrite(d, LOW);
   delay(500);
  }
}
void servo()
{
for(pos = 137; pos < 180; pos += 1)  // goes from 0 degrees to 180 degrees
 {                                  // in steps of 1 degree
   myservo.write(pos);              // tell servo to go to position in variable 'pos'
   delay(15);                       // waits 15ms for the servo to reach the position
 }

 for(pos = 180; pos>=137; pos-=1)     // goes from 180 degrees to 0 degrees
 {
   myservo.write(pos);              // tell servo to go to position in variable 'pos'
   delay(15);                       // waits 15ms for the servo to reach the position
 }
delay(3000);
}
void back_ynm()
{
 {
   digitalWrite(enx, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(a, LOW);
   digitalWrite(b, HIGH);
   delay(200);
 }
  {
   digitalWrite(eny, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(c, LOW);
   digitalWrite(d, HIGH);
   delay(200);
 }
}
void front_yfm()
{
 {
   digitalWrite(enx, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(a, HIGH);
   digitalWrite(b, LOW);
   delay(100);
 }
  {
   digitalWrite(eny, HIGH);   // turn the LED on (HIGH is the voltage level)
   digitalWrite(c, HIGH);
   digitalWrite(d, LOW);
   delay(100);
 }
}
```


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