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Design and Development of Machine Vision Based Colour Sorting Gantry Robot

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Abstract— robots are extensively used in industries for their precision work and amount of work that one can obtain without any defects.In this paper we are using a gantry robot for as it doesnot occupy the floor space therefore reducing the distance for reachability of the parts and hence reducing unnecessary material for guide way. Robots work in strictly defined path and there is no or very little change in such systems inorder to overcome this we are using a vision based control system to make the system dynamic in nature the images are picked by using a USB camera processed images of the object is transmitted via serial communication to the Arduino Mega 2560 microcontroller and processed using pythons open source computer vision (Open CV) image to process the image captured by the USB camera to find the exact colour and to pick the object and sort it.

Index Terms— Gantry Robot, Machine Vision, Image Processing, Arduino Microcontroller, OpenCV, Python

1 Introduction

The aim of the project is to design the vision based control of the Gantry Robot. A Gantry Robot has three degrees of freedom and has three prismatic joint which produces three linear motion along X, Y and Z directions. The design of three degrees-of-freedom (DOF) Gantry robot, covering the entire mechatronic process, involving kinematics, control design and optimizing methods. It is used in many industrial applications, but majority of these applications are single purpose. Robots of these applications work in a strictly defined domain on strictly defined parts. There is no or very little change in such systems. Vision based control allows such systems to be dynamic. It allows the system to incorporate more changes and recover from errors. USB camera is used as a vision sensor to detect the dimensions of the object to be picked. The USB camera collects the image of the object is transferred to the python program with image processing modules to process the image. The processed dimension of the object is transmitted via serial communication to the Arduino Mega 2560 microcontroller. The appropriate PWM signal is generated by Arduino respectively to the servomotors. The robotic arm is designed with servomotors and 3D printed parts. Open source computer vision (Open CV) is used for real time capturing the image to process the image captured by the USB camera to find the exact dimension of the object thereby to assist the robot to sort it based on size.

2 Literature Review

[1] This paper investigates the relative target-object (rigid body) pose estimation for vision-based control. A closed form target pose estimation algorithm is developed and implemented. Moreover, PI-based visual control was designed and implemented in the camera (sensor) frame to minimize the effect of errors in the extrinsic parameters of the camera. The performance of the vision-based control algorithm has been verified on a 7-DOF industrial robot

[2] We have presented a fruit grading machine vision system for colour and size classification which is being comercialized in Spain. The vision system is part of a modular fruit grading system that integrates mechanics, control unit, user interface, weight cells and output control units, all linked with a real time CAN based network and a LAN for non-real-time communications. The system can process up to 15 fruits per second per line, and sort them according to its weight, size and color.

[3] Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which the input is an image or a video and output may be image or characteristics associated with that image. It is among the rapidly growing technologies today, with its applications in various aspects of business. Image Processing forms a core research area within engineering and computer science disciplines too. Visual images are probably the most important means by which human beings experience their environment. However the information required by the human beings is often only a small part of the data in the image. Under some circumstances it becomes extremely inefficient in extracting information. Thus there is a demand for techniques that process the image after capture but before presentation to the human being in a manner that makes it easy for us to extract the information we require. Industrial automation and robotics are at a high demand in the industry as both of them directly affect the growth of the industry. The system is developed with the purpose to optimize the productivity, minimizing the cost of labour and make no human mistake.

[4] Aimed at the industrial sorting technology problems, this paper researched correlative algorithm of image processing and analysis, and completed the construction of robot vision sense. The operational process was described as follows: the camera acquired image sequences of the metal work piece in the sorting region. Image sequence was analyzed to use algorithms of image pre-processing, Hough circle detection, corner detection and contour recognition. in the meantime, this paper also explained the characteristics of three main function model (image pre-processing, corner detection and contour recognition), and proposed algorithm of multi-objective center and a corner recognition. the simulated results show that the sorting system can effectively solve the sorting problem of regular geometric work piece, and accurately calculate center and edge of geometric work piece to achieve the sorting purpose.

3 METHODOLOGY

1.0
Design of Robot using solidworks softwares individual parts were designed using the solidworks software designed parts were analsyed using solidwork simulation by applying load and the results obtained were used for further changes in design and then remodeled until it met our specification the parts that were tested are

- Frame
- Guide Wheels
- Acrylic Plates

The Frame had to withstand self weight and the weight of the stepper motors and acrylic plates
The guide wheels had to have minimum deformation so as to provide precisie movement based on stepper motors input
The acrylic plates has to withstand the load of the stepper motor and shouldn't bend so as to provie proper power transfer to pulley
2.0
Assembling the parts in solidworks helped us to create changes with respect to placement of parts resizing and interference between parts while joining were redone by placing holes where there are no interfernence
3.0
Maufacturing of parts, the acrylic parts were laser cut so as to get clean cuts with the help of drafting made with solidworks and the frame material used was readily available in the market the fixtures holidng the frames were 3d printed
4.0
Electronics selection the Micrprocessor was selected for its storage and compability with CNC Sheild and stepper motor driver, we wanted the setup to be modular so as to change the affected part rather than the whole setup which would be a costly

4 HARDWARE USED

The main objective of this paper is to visually track the object and transmit the image to PC running python programming to find out the object dimensions and send the appropriate control signals to the Articulated Robot via Arduino microcontroller to pick and place the object and sort them at expected location from unknown location. The system can be controlled by Python and Arduino Mega in PC.

The overall system articulated robot was designed using solid works 3d cad software and a 3D printer. The material used is Polylactic Acid (PLA) a biodegradable polymer and has characteristics similar to polypropylene (PP), polyethylene (PE), or polystyrene (PS). It can be produced from already existing manufacturing equipment (those designed and originally used for petrochemical industry plastics). This makes it relatively cost efficient to produce. The total system was controlled using three stepper motors and stepper motor divers. The stepper motor torque is 3.2Kg.cm with 1.8° step angle (200 steps/revolution).

4.1. Bearings

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may vary, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. The type of bearing used in this are

Radial Ball Bearing (624ZZ), Flanged ball Bearing(F686ZZ), Thrust ball bearings(51105).

4.2. Stepper Motor Driver

Stepper motors don't rotate in the manner of a traditional motor instead, they step. Steppers make repeated movements of small, fixed increments, appearing to the naked eye as continuous motor rotation. The size of each step is determined by the motor, and the power behind these steps comes from the stepper motor driver as previously stated we are using a Arduino mega 2560 microcontroller and letting it control the stepper motor can take up a lot of the processing and not leave you a lot of room to do anything else to overcome this short coming we are using a purpose built stepper motor driver chip A4988 manufactured by Allegro Microsystems.

4.3. Stepper Motor

A stepper motor, also known as step motor or stepping motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed. Switched reluctance motors are very large stepping motors with a reduced pole count, and generally are closed-loop commutated. The type of stepper motor used in this project is a Nema 17 stepper motor which has torque is 3.2Kg.cm with 1.8° step angle (200 steps/revolution).

4.4. Switch Mode Power Supply (SMPS)

The SMPS is a versatile power supply as we can choose from different topologies like Step – up (Boost), Step – down (Buck), power supplies with isolation at input and output depending on the type of application. The prime problem with batteries is the voltage is either too high or too low. Hence, an SMPS will provide a regulated DC output.

4.5. Arduino Mega 2560

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

The Arduino Mega 2560 R3 is an open source precise microcontroller board Successor to the Arduino Mega based on the ATmega2560 SMD chip. The Mega 2560 R3 also adds SDA and SCL pins next to the AREF. In addition, there are two new pins placed near the RESET pin. One is the IOREF that allow the shields to adapt to the voltage provided from the board. The other is a not connected and is reserved for future purposes. The Mega 2560 R3 works with all existing shields but can adapt to new shields which use these additional pins.

• Arduino Mega 2560 is a microcontroller board based on Atmega2560. It comes with more memory space and I/O pins as compared to other boards available in the market.

• There are 54 digital I/O pins and 16 analog pins incorporated on the board that make this device unique and stand out from others.

• Out of 54 digital I/O, 15 are used for PWM (pulse width modulation).

• DC power jack is coupled with the board that is used to power the board.

• ICSP (In-Circuit Serial Programming) header addition to Arduino Mega which is used for programming the Arduino and uploading the code from the computer.

• This board comes with two voltage regulator i.e. 5V and 3.3V which provides the flexibility to regulate the voltage as per requirements as compared to Arduino Mini which comes with only one voltage regulator.

5 SOFTWARE USED

5.1. Python

Python is a broadly utilized general-purpose high-level programming language .Its syntax structure permits the software engineers to express ideas in less lines of code, compared to different programming languages like C, C++or java.

5.2. OpenCV

OpenCV **[9]** (Open Source Computer Vision) is a library of programming capacities fundamentally used for continuous PC vision/image processing**.**

5.3. Numpy

Numpy is a package that characterizes a multi-dimensional Array object and related quick math works that work on it.Numpy is an augmentation to the Python programming language, including support for vast, multidimensional array and matrices, along with an extensive library of high – level mathematical capacities to work on these arrays.

5.4. Pyserial

This module encapsulates the access for the serial port . It provides backends for Python running on Windows, OSX, Linux, BSD . The module "serial automatically selects the appropriate backend. This module allows us to control the microcontroller from python which gives advantage to customize for any application

5.5. Tkinter

Tkinter is the standard GUI library for Python. Python when combined with Tkinter provides a fast and easy way to create GUI applications. Tkinter provides a powerful object-oriented interface to the Tk GUI toolkit.

5.6. Arduino IDE

A program for Arduino **[8]** hardware may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers: AVR Studio (older) and Atmel Studio (newer)

6 CONCLUSIONS

Starting with rough drawings of Robot frame and by using a 3D visualisation & Aluminium profiles, model is created to find its working area, movements and degrees of freedom. The designed model working has been studied by moving all links with respect to its motions with the help of DC stepper motors. During this experimental study it is found that the model is working as per the required movements and motions of the links

7 FUTURE SCOPE OF WORK

The robot can be further fitted wih faster processing systems for more rapid work and high quality cameras can help identify slight visiual differences in colour and can be used to identify counterfeits products and also can identify any changes in product colour by reffering to the required colour and hence can also be implemented in inspection.

8 REFRENCES

[1] [1]Mana Saedan and Marcelo H. Ang "3D Vision-Based Control On An Industrial Robot", Proceedings of the IASTED International Conference on Robotics and Applications, Nov 19-22,2001,Florida , USA,pp.152-157

[2] Conference: Emerging Technologies and Factory Automation, 2001. Proceedings. 2001 8th IEEE International Conference on, Volume: 2

[3] M. Sabin's, V. Thakur, R. Thorat, G. Yeole, and C. Tank, "Object Sorting in Manufacturing Industries Using Image Processing," International Journal of Computer Engineering and Applications, Volume IX, Issue V, May 2015

[4] Survey of vision-based robot control Ezio Malis, Manuel Vargas (2007),INRIA, Sophia Antipolis, France

[5[5]Rani a. Magadum & Dr. Uttam l. Bombale "Intelligent color based object sorting using robotics" International Journal of Robotics Research and Development (IJRRD) ISSN(P): 2250-1592; ISSN(E): 2278-9421 Vol. 9, Issue 1, Jun 2019, 43-48

[6]Liu Z, Zhao B, Zhu H (2012) Research of sorting technology based on industrial robot of machine vision. In: 2012 fifth international symposium on computing intelligent description, no 1, pp 57–61

[7] https://en.wikipedia.org/wiki/Computer_vision

[8]Pearl Mary .S, C. Mahesh "Machine Vision Based Automated Color Inspection And Sorting" International journal for trends in engineering & technology volume 6 issue 1 – june 2015 - issn: 2349 - 9303

[9] Real-time colour-based sorting robotic arm system, Conference: 2017 IEEE International Conference on Electro Information Technology (EIT) Conference Paper · May2017DOI:5.1109/EIT.2017.8053385

[8] https://www.arduino.cc/

[9] https://opencv.org/