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Master Slave Robotic System for Industrial Applications

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Abstract: Robots play a vital role in Industry Automation. In industries, robots are programmed to perform specified tasks like pick and place, packaging, transporting etc. Every robot needs to be programmed individually to accomplish the tasks given. In this proposed work, one master robot is designed and programmed in such a way that can train number of slave robots sequentially to perform multiple tasks at different processing lines of an industry This reduces the complexity in programming individual robots for different operations and also without programming the slave robot. The proposed system master robot is used to control or train more than one slave robots in sequential manner. This robot arm has freedom of rotation upto 180 degrees. The proposed model comprises of master arm and slave arm connected to a single Arduino Nano development board that controls the entire mechanism, servo motors to achieve rotational motion of the robotic arm and potentiometers to train the slave robot.

Keywords: Master Slave robot, Industrial Applications, Servo motor, Arduino Nano, Potentiometers

I. INTRODUCTION

Robots are used in different fields such as industrial, military, space exploration, and medical applications. These robots could be classified as manipulator robots and cooperate with other parts of automated or semi-automated equipment to achieve tasks such as loading, unloading, spray painting, welding, and assembling. Generally robots are designed, built and controlled via a computer or a controlling device which uses a specific program or algorithm. Programs and robots are designed in a way that when the program changes, the behavior of the robot changes accordingly resulting in a very flexible task achieving robot.

Robotic arm is a mechanical arm to perform the desired task. In today's world there is an increasing need to create artificial arms for different inhuman situations where human interaction is difficult or impossible. The robotic arm is controlled manually by using wired and wireless. The conventional industry robot for object pick and place is shown in figure 1. The system can do the pick and place operation in different directions and angles. Figure 1 shows the three possible movements of the system for pick and place operation with the freedom movement of 180 degree.

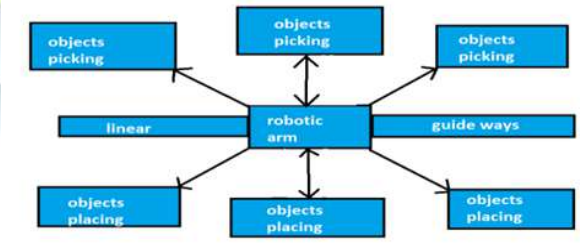

Fig 1.Rotic arm processing for pick and place operation

The paper is organized as follows. Section II describes existing robotic arm system and proposed system is given in section III. Section IV explains the

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implementation. Section V is about results & section VI is the conclusion.

II. EXISTING WORK

Devendra P. Garg and Manish Kumar [1] presents the formulation and application of a strategy for the determination of an optimal trajectory for a multiple robotic configuration. Genetic Algorithm (GA) and Simulated Annealing (SA) have been used as the optimization techniques and results obtained from them are compared. The simulations performed for both the cases show that although both the methods converge to the global minimum, the SA converges to solution faster than the GA.

Jegede Olawale et al[2] designed with designing a haptic robotic arm, which can be used to pick and place the objects. In their work, a robotic arm with four degrees of freedom is designed and is able to pick the objects with a specific weight and place them in a desired location. To facilitate the lifting of the objects, Servomotors with a torque of 11 kg are used. The programming is done on ATMEGA-328 Microcontroller using Arduino programming.

The Microcontroller along with input pins is soldered on a PCB board. The input is given using a remote, which is an arm, made of Polycarbonate fitted with Potentiometers with a certain angle of rotation. The Potentiometers detect the angle of the rotation and the signals are sent to the Microcontroller accordingly. In the world of robotics, this Robotic arm has been turned out to be trendy. This kind of the arms have many applications in the field of industrial robotics where the automation is required.

Haidari, A. M et al . [3] discussed the interfacing of servo motors with robotic arms. Hao, G. W et al [4] designed PC based robotic arm with 6 degree of freedom in movements. . Bejo, A., Pora [5] designed 6 axis robot arm controller with low cost microcontroller.

II. PROPOSED SYSTEM

The circuit diagram of the proposed Master slave robot system is shown in Fig.2. A prototype robotic arm is designed and controlled using ATMEGA328P Microcontroller based development board programmed using Arduino IDE.

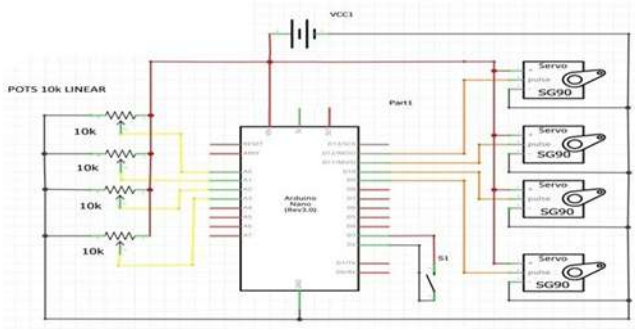

Fig..2. Proposed system

This process works on the principle of record and play. Potentiometers play an important role in the system. The remote is fitted with potentiometers and the servos are attached to the body of the robotic arm. The rotational movement of the knob of potentiometer creates a change in resistance across the pot that affects the resultant voltage supplied to the controller Hence, on the motion of the potentiometers produce the electrical pulses, which are in route for the Arduino board. The board then processes the signals received from the potentiometers and finally, converts them into requisite digital pulses that are then sent to the servomotors. This servo will respond with regards to the pulses which results in the moment of the arm.

A.Robotic Arm

A robot arm is designed with five degrees of freedom. Serial and parallel manipulator systems are used to position an end- effector with five degrees of freedom, consisting of three in translation and two in orientation. This provides a direct relationship between actuator positions and the configuration of the manipulator.

The robotic arm will be controlled via the designed controller and it will be able to grab, pick up and move objects according to their weights and shape. The manipulator design is mostly expected to pick up cubes and geometric shapes like a box. Depending on the numbers of joints, DOF differs, but generally robotic arms operate using 4 or 5 servo motors.

The servo motors are popular for their desirable characteristics for robotic application [3].

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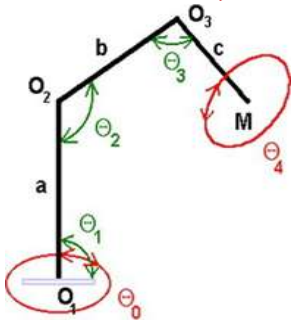

Fig. 3 Robotic arm degrees of rotation

Fig. 3 shows 5 DOF of robot arm. This number typically refers to the number of single-axis rotational joints in the arm, where higher number indicates an increased flexibility in positioning a tool. This is a practical metric, which measures the aggregate positioning capability of a system.

B.Arduino:

Arduino Nano is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

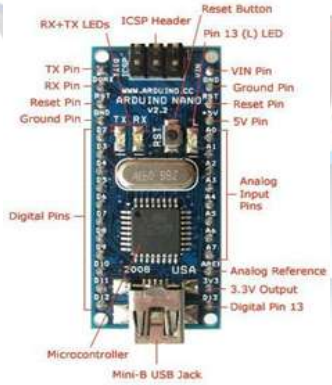

Fig. 4.Arduino Nano Microcontroller board

Fig. 4 shows the arduino nano micro controller board ." The Nano board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Nano board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform;

C.Programming

The Arduino Nano can be programmed with the (Arduino Software (IDE)).The ATmega328 on the Arduino Uno comes preprogrammed with a bootloader that allows to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

D.Power

The Arduino Nano board can be powered via the USB connection or with an external power supply. The power source is selected automatically.

The power supply of arduino nano board.External (non-USB) power can come either from an AC-to-DC adapter (wall- wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

E.Memory:

The ATmega328 has 32 KBmemory (with 0.5 KB occupied by the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM.

F.Servo motor

The servo motors used in this system operate with DC and are suitable for PWM control. The motor has series of gears attached to it and the potentiometer which does the feedback process. This feedback indicates the position of the servo which is derived from the corresponding servo potentiometer voltage. A typical servo motor's shaft is limited to rotate from 0 to 180° but it is possible to modify the motor for a continuous rotation. In the robotic arm assembled in this study, the servo motor which is used in the base is modified for 180 degree rotation. The PWM signals are generated with the microcontroller. A pulse duration of 2ms rotates the servo clockwise at its full speed and 1ms pulse rotates the servo counter-clockwise with full speed. Giving the servo motor a pulse with 1.5ms width

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stops the motor or can be set to return to its initial position via a feedback control.

It consists of a motor which is coupled to a sensor, used for position feedback, through a reduction gearbox. It also accompanies a relatively sophisticated controller, usually a dedicated module designed specifically for use with servo motors

IV. IMPLEMENTATION

The proposed system operation is defined in two steps.
1. Record mode
2. Play mode.

The record mode is used to train the slave robot. The potentiometer acts as a master robot. If we rotate the pot, the slave robot also rotates in the same direction. This happens because of the control voltage generated using the pot (master) is sent to the processor and processor generates control signal (PWM). This control voltage actuates the servomotor which is connected in the robot arm. Here, we have used three servo motors. One is for Upper protion of the arm rotation and another one is for middle portion of the arm and third one is used to move the limp rotation. So using record mode the potentiometer positions are adjusted to make the robot arm to do pick and place operation of an object.

Once it was done, then play mode is actuated manually and the slave Robot performs the recorded operation for an infinite duration or until it is programmed to do next operation.

Fig.5 shows the interfacing of Arduino nano board with potentiometers and servomotors in the slave arm. The training is done my manually adjusting the pot positions in such a way that the slave robot operation is defined .The arm movements are freely movable upto 180 degree.The proposed robot system, robot base is fixed. Shoulder, Elbow and Gripper are in rotating nature.

V. RESULT

In this robot system, the master arm is made with potentiometers and the slave arm is made with servo motors with arm. The potentiometer arm is connected to the analog pins of the arduino nano and the servo motor arm is connected to digital pins of arduino Nano. The master robot arm controls the slave robotic arm by varying resistance through potentiometer. From this the entire system will be controlled.

According to the code, when the potentiometer is varied the corresponding resistance value is stored and passed to the microcontroller. According to the voltage microcontroller generates the control signal. Based on the control signal the servomotor interfaced with microcontroller rotates and it is sent to the servomotor with arm (slave robot). According to the input, the servomotor with arm rotates with an angle upto 180 degrees.

Fig. 5 shows the servo arm and Arduino nano board with potentiometers. The servo motor has some control circuit and a potentiometer (a variable resistor) that is connected to the central axis of the servo motor. In the figure it can be seen on the right side of the circuit. This potentiometer allows the control circuitry to monitor the current angle of the servo motor. If the shaft is at the correct angle, then the engine is off. If the circuit checks that the angle is not correct, the motor will turn in the right direction until the correct angle.

The shaft of the servo is capable of reaching around 180 degrees. Normally, in some reaches 210 degrees, but it varies by manufacturer. A normal servo is used to control an angular motion of between 0 and 180.Figure 6 shows driver circuits for motor.

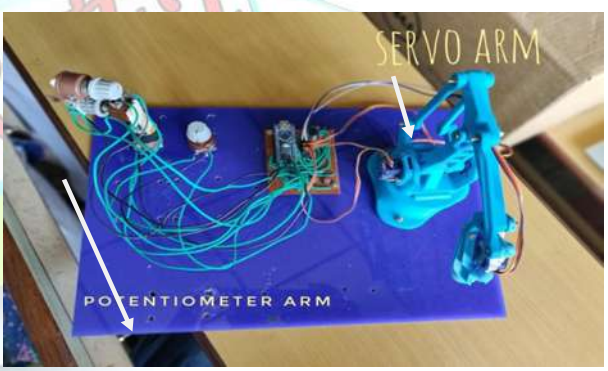

Fig. 5. Servo arm and Arduino Nano board with potentio meter

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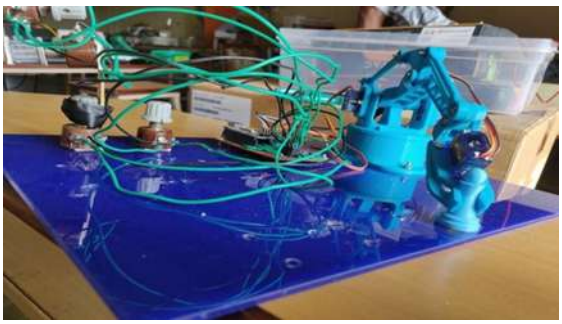

Fig. 6. Driver circuits

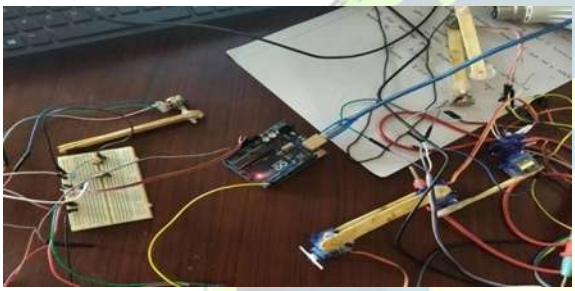

Fig 7. Complete system

Fig.7 shows the complete system .after assembling the components. Fig. 8 shows the picking an object process of the proposed system and Fig. 9 shows the placing the object.

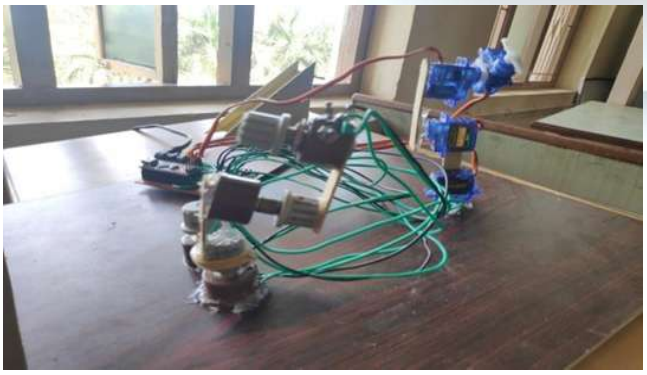

Fig. 8: Picking the object operation

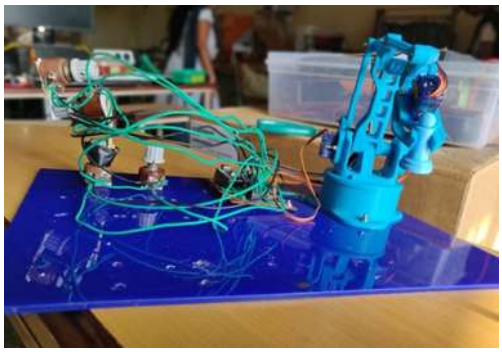

Fig 9: Placing the object.

VI. CONCLUSION

The master slave robot arm was designed with five degrees of freedom and talented to accomplish accurately simple tasks, such as light material handling. The robot arm is equipped with several servo motors which do links between arms and perform arm movements. A microcontroller that drives the servo motors with the capability of modifying position. The programming is done on ATMEGA-328p Microcontroller using Arduino programming. The proposed robotic arm system is more useful in industry applications. The proposed system can train more than one slave robots for different operations. In future, the proposed system can be controlled using android device.

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