ISSN 2395-1621

Development of Robotic Arm with 3 Degrees of Freedom for Interchanging of Tools in HMC Machine

Sohan Chikhalkar[1], Sushant Joshi[2], Tejas Kulkarni[3], Nilesh Kulkarni[4]

sohan.c555@gmail.com, sushant.joshi.1998@gmail.com, tejaskulkarni958@gmail.com, nileshkulkarni992@gmail.com

[1,2,3]Student, Dept. of E & TC, SKNCOE, Pune - 41
[4]Assistant Professor, Dept. of E & TC, SKNCOE, Pune - 41

ABSTRACT

To increase the number of operations of the HMC machine, the tool capacity of the machine needs to be enhanced. This paper states, the development of a Man to Machine interface to help overcome the flaws of picking and placing of the objects which may or may not be hazardous to be placed at a considerable distance. The machine helps to ease such operations and perform desired tasks at required time intervals. Developed system is a 3-axis Robotic Arm using ARM microcontroller. The microcontroller accepts inputs from the Wi-Fi module and provides commands to the respective 3 different servo motors, yielding 3-axis of freedom to the arm. This action can be provided remotely through the MMI interface for real time accurate operations. The arm can be used for exchange of tools of the HMC machine in turn increasing the tool capacity. The microcontroller is used for the efficient control of the Arm.

Keywords— ARM LPC2148, Node-MCU, 3-Axis Degree of Freedom, Servo Motors, HMC machine, Tool Exchange.

ARTICLE INFO

Article History

Received: 8th March 2020

Received in revised form :

8th March 2020

Accepted: 10th March 2020

Published online :

11th March 2020

I. INTRODUCTION

The need of autonomous systems has become the need of an hour. Rapidly increasing flow of work and the shortage of labour has lead to tremendous delay in manufacturing of good quality products within affordable prices. Due to the standardised systems employed before, to attain a better productivity and quality well trained and expert labourers were required for ensuring correct operation of the machines .This not only reduces the productivity but also increases the work force required and in turn the total cost of the product. Autonomous systems need to realise this in order to increase the productivity and quality of the manufactured goods in the desired time frame. The suitable solution for enhancing the ability of the machines is using Robotic systems. They are a perfect combination of various aspects of Engineering Sciences such as; Mechanical and Mechatronics Engineering, Electrical and Electronics Engineering as well as Computer and Informatics Engineering. The interdisciplinary approach of these systems helps in improvising the existing machines. The most commonly used HMC machine has a tool capacity of 60 tools. And the next enhanced variant has a tool capacity directly of 120 tools. So considering the fact that it is possible to expand the tool capacity of the existing 60 tool capacity HMC machine with the help of Robotic Arm System, the concept of this project is proposed. The Robotic Arm is a microcontroller based setup which demonstrates 3 degrees of freedom and provides efficient picking and placing of tools from palette to gear box of the machine. The high amounts of repetitive tasks are also achieved competently using the Arm which is quite unlikely to be observed in case of humans.

Paper [1] outlines process to develop a human-machine interface in between the 6-DOF Jaco's robotic arm and Leap Motion controller. An algorithm was defined and formulated to allow an optimal portray of the user hand movements. These movements were noted by the Leap Motion controller. The system should permit for further natural human-machine interaction with a smooth handling of the robotic arm. The implementation of the human-robot inter-communication is discussed in link with atmosphere assisted living and some practical cases were introduced.

Authors in [2] proposed the development of the robotic-arm based on ATmega32 and ATmega640. Signal processing was done using a personal computer. Lastly, a prototype was developed which expected to overcome the flaws like picking and placing of objects whether hazardous or not at a significant definite distance.

In [3] design and development of robotic arm based on ATmega microcontroller is discussed. The system responds to gestures as well as can be programmed for performing a specific task at some definite intervals or distance. Gesture control is achieved by inputting user's arm movements. The potentiometers sense the movements and accordingly provide relative motion through the servo motors connected, driving the arm to the desired position.

In [4] presented a new natural interface for robotic-arm remote directing. The interface was based on inertial motion trackers. The system uses two types of sensors to track inertial motion. Xsens Xbus Kit tracker is First tracker and Razer Hydra Controller is the another one. Hydra controller is implemented for localizing the robotic arm in 3D. The most important aspect discussed here is to approximate linear motion of the arm according to the user's movement.

In [5] proposed an industrial robot on an accelerometer-based system. The accelerometers were connected to the operator's arms. They sensed and captured gestures and postures of the operator's arms. An Artificial Neural Network (ANN) with back propagation algorithm senses and processes these behaviors. The arm begins its movement almost at the same time of the arm providing good accuracy and a low response mechanism. The results achieved recognition rate of (92%).

[6] proposes a design and developed a robotic arm which has traits similar to humans. The communication is via LAN or IP. Operator is given the freedom of controlling the arm remotely and accesses the sensor's feedback signals. The arm has a camera mounted onto it which processes the images and simultaneously transmits it to the user. This terminology is termed as Master-Slave terminology.

[7] describes the development of a cheap and user friendly controller of a 6-DOF Jaco's arm having traits similar to humans. Diction of the robotic arm is obtained around 6 single-axis revolute joint points. It uses the Man to Machine Interface (MMI) to operate in real-time the robotic arm. The MMI captures simple motion and which translates motion into analog voltage feedback signals which gives corresponding signals in the robotic arm in turn leading to actuating motions.

In [8] it describes a joystick controlled robotic arm which can be further used for healthcare applications. The entire arm is constructed of plastic elements like amphibious links, air bag actuators and acrylonitrile butadiene styrene (ABS) joints. The elements used in the manufacturing of the robotic arm make it lighter and softer as compared to those made with heavier materials like metal. The control method for the arm is by using a joystick having Four Degrees of freedom (4 DOF).

In [9] they proposed an algorithm for position signal interface (PSI), which contributes to the initial position feedback in the RACS. It helps in keeping track of every joint positions, allowing real time access to position, movement and error data. The PSI is developed on one single DIP plug-board and fitted into rack of controller. Feedback from the 6 optical encoders is used by the PSI for determining error detection. VAL communication interface of RACS receives joint position data for operation in a 'VAL-dependent' mode.

[10] defined a new concept of force feedback. The system can surmount the disadvantages of other feedback system in a user friendly way. Information of the gripper's position is communicated between Force sensors and laser distance sensors using force feedback module placed on a glove. A Magneto Rheological Fluid (MR-Fluid) actuates the gripper's force and pneumatic pressure gives the information regarding distance of the operator. This defines a robotic arm which uses a force feedback glove.

SUMMARY: Thus, this section describes the overall survey of the project. A set of servo motors and feedback sensors are curated to provide relative motion to the arm resulting in perfect positioning of the tool holder at defined location. The system has been modified to a standard servo motor and two servo motor to control the movement of the arm. Hence we can conclude by stating this system is designed to reduce manual labour, reducing the chances of injuries during work making it beneficial for industries.

II. METHODS AND MATERIALS

The system consists of the following components:

- ARM LPC 2148 microcontroller
- Arduino Node-MCU
- Servo Motors
- Material for Arm manufacturing
- DC power supply

Microcontroller (ARM 7 LPC2148):

The microcontroller used has the following specifications:

- 32-bit microcontroller ARM7 Family.
- Real-time immitation and embedded trace support.
- High speed flash memory from 32kB to 512kB.
- 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution permits 60 MHz high speed operation.
- Minimum performance issues (around 30%) can be obtained using alternative 16-bit Thumb mode.
- Serial communications interfaces with USB 2.0 Full-speed device.
- On-chip SRAM of 8kB to 40kB.

- Two 16C550 UARTs and Two I2C buses with 400 Kb/sec speed.
- Two 32-bit timers with PWM units and Watchdog.
- 45 fast GPIO lines with up to nine level sensitive external interrupt pins.
- Single or dual 10-bit ADC(s) with 6/14 Analog channels and a conversion rate of 2.44us per channel.
- Single 10-bit DAC with variable output facility.
- Built-in low power Real Time Clock (RTC) with 32kHz of clock input.

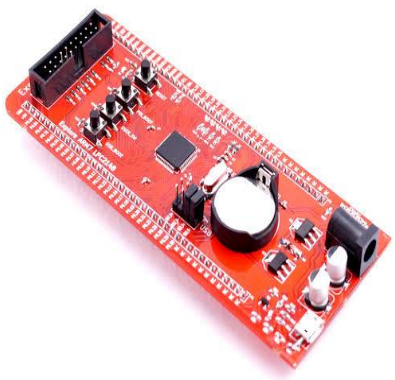

Fig. ARM7 LPC2148 stick

(Image Courtesy:- exploreembedded.com)

Servo Motor:

Servomotors can be stated as geared down dc motors with a control signal using an error amplification mechanism, allowing exact positioning of the tool holder, with a rotation range 90 degrees, which can be modified to achieve desired operable turns. The servo motor is operated by three wired signals: ground line (black), power line (red), and command line (typically white). Operable voltage is ranged from 4V to 6V DC which must be away from system power to avoid inducing electrical noise. Servos are able to be driven at higher voltages in turn improving speed and torque characteristics. The motor is controlled by regulating a variable resistor which is connected at the output side. The variable resistor checks whether the shaft is at the right angle, then the motor shuts off. If the circuit detects that the angle is not correct then it will turn the servo in the appropriate direction until the angle is right. Once the servo has acquired the desired direction with the help of Pulse Width Modulated signal then servo attempts to match the desired positions. By turning with a small angle to the motor's left or right. For example, if the required position is negative as compared to the actual position, the servo motor will turn to the left. And vice-versa for the positive motion.

Fig. Servo Motor
(Image Courtesy :- ipcsautomation.com)

In this prospect, the servo sets its "initial point" on the appropriate position. When a load forces the servo motor horn to the right or left, the motor will accordingly compensate.
Servos are commanded through "Pulse Width Modulation, " or PWM technique, signals are sent through wired commands. This signal is a variable-width
pulse, which can be varied from 1 to 2ms, known as "Control Signal". The pulse width controls the position of the tool holder. A 1.0ms pulse turns the head of the arm all the way counter-clockwise. A 1.5ms pulse puts the rotor at neutral (0 degrees), and a 2.0ms pulse will place the shaft all the way clockwise. 50 Hz of pulse frequency is sent to the motor.

Material for robotic arm:

The most applicable material used to manufacture the arm must be light in weight and strong enough to carry the tool heads. Or else, the motor will not push the arm in desired directions and eventually will not get the desired turning degree. Amongst the materials that can be used to fabricate the structure are Aluminium, Perspex, Plastic Polymer and Carbon Fibre. In deciding the materials required for production, the criteria of selection that should be taken into consideration are availability, overall cost and the flexibility of the material. Among the materials discussed above, Aluminium is the best to be chosen as manufacturing material.

DC Power Supply:

Biasing voltage of 5V DC required for the components like Arduino, shift registers. Line voltage available for usage is 230V AC. Conversion of 230V AC to 5V DC consists of a bridge rectifier, a capacitor filter and a 3-terminal non-programmable regulator. This circuitry is used to produce the biasing supply termed as DC regulated power supply.

III. SYSTEM METHODOLOGY

This chapter is all about discussing the block diagram of Pick and Place Robotic Arm with three degrees of axis freedom. It shows the interfacing of Servo Motor with the microcontroller LPC2148. It also depicts about the description of all the blocks in the block diagram, features of LPC2148. Three axis Pick and Place Robotic Arm is built using software PROTEUS, EAGLE, KEIL, FLASH MAGIC and many more.

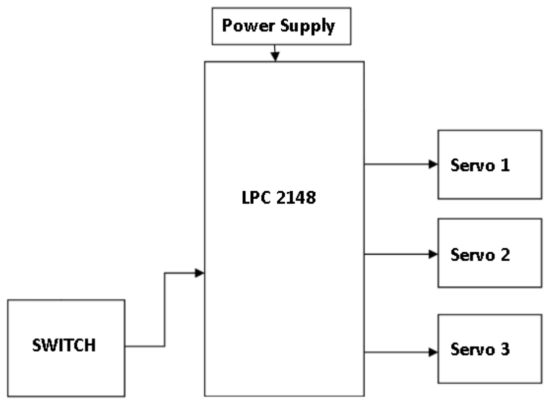

Fig. Block Diagram of System

A 12V lead acid battery is used to power the microcontroller and 3 servo motors used for the project. The power will be stepped down to 5V using 7805 IC. The microcontroller used is the LPC2148 of the ARM7 family. When the switch is turned, the servo motors will be actuated as per it is programmed to move. Servos are actuated by PWM pins from the microcontroller directly. No external Servo driver has been used.

Precision and high performance can be achieved with automation of the robot. It can be reprogrammed again for different tasks. Human efforts are reduced. Highly time efficient as they can work continuously without a delay for a long period of time.

Future Scope: Our attempt to develop a economical integrated system for manufacturing of pick and place robotic arm has thus resulted in the development of a tested, proven arm system. The software program has been developed for simplification and organisation of work.

Results

Motor	**Angle**	**Time**
Servo (4.8v)	90 Deg	1.20 s
Servo (7v)	90 Deg	0.98 s

IV. CONCLUSION & RESEARCH CHALLENGES

This robotic arm system would make it easier for human beings to lesser the risk of handling suspicious objects, which could be haphazard in its present environment and workplace. Complex and complicated duties can be obtained faster and more precisely with this arm. The robotic arm used here contains a tool holder, which safely handles the tools required for transfer. With the use of our system, the industrial processes and hazardous and precarious operations can be done easily, efficiently and cautiously in a small amount of time.

To conclude this project, it involved two phases which is the design of hardware and programming the controller. The report has covered both the aspects in brief. The design uses quite a simple mechanism to give 3 degrees of freedom with servo motor control.

This project helps in effective and fast exchange of tools of the HMC machine which will further help in increasing the tool capacity of the machine.

APPENDIX

The Servo controlled robotic arm is simulated and its CAD layout is designed. The design specifications of this model are displayed. Its future scope is also discussed below.

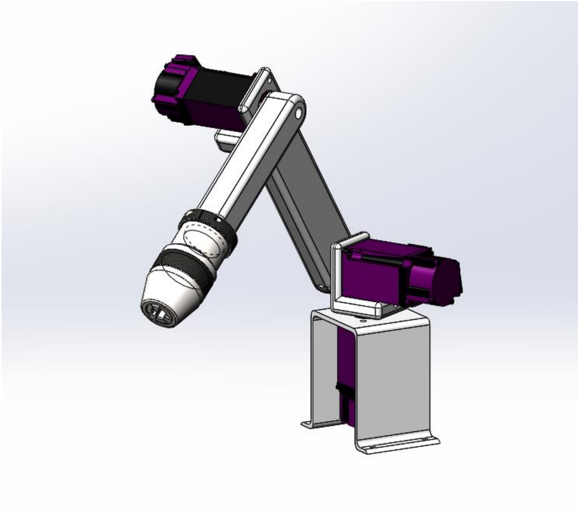

Fig. Rendered image of 3-axis Robotic Arm

ACKNOWLEDGMENT

We want to thank Mr. N. N. Kulkarni, staff member who coordinated the project. His guidance and combined efforts in preparing and presenting this paper has brought a good result. We also sincerely thanks to all other faculty members of Electronics and Telecommunication Department and our well-wishers for their support and encouragement received by us.

REFERENCES

[1] D. Bassily, C. Georgoulas, J. Güttler, T. Linner, T. Bock, TU Munchen and Germany, "*Intuitive and Adaptive Robotic Arm Manipulation Using the Leap Motion Controller*", Conference ISR ROBOTIK, 2014,Pages: 1 – 7.

[2] P.Adeeb Ahammed and K.Edison Prabhu, "*Robotic Arm Control Through Human Arm Movement Using Accelerometers*", International Journal of Engineering Science and Computing, 2016, ISSN 2321 3361.

[3] Mohammad Javed Ansari, Ali Amir and Md. Ahsanul Hoque, "*Microcontroller Based Robotic Arm Operational to Gesture and Automated Mode*", IEEE Conference Publications, 2014,Pages: 1 – 5.

[4] Piotr Kopniak and Marek Kaminski, "*Natural interface for robotic arm controlling based on inertial motion capture*", IEEE Conference Publications, 2016,Pages: 110 – 116.

[5] Pedro Neto, J. Norberto Pires and A. Paulo Moreira, "*Accelerometerbased control of an industrial robotic arm*", IEEE Conference Publications, 2009,Pages: 1192 – 1197.

[6] Gourab Sen Gupta,S. C. Mukhopadhyay and Matthew Finnie, "*WiFi based control of a robotic arm with remote vision*", IEEE Conference Publications, 2009,Pages: 557 – 562.

[7] Sulabh Kumra,Rajat Saxena and Shilpa Mehta, "*Design and development of 6-DOF robotic arm controlled by Man Machine Interface*", IEEE Conference Publications, 2012,Pages: 1 – 5.

[8] Hye-Jong Kim,Yuto Tanaka,Akihiro Kawamura,Sadao Kawamura and Yasutaka Nishioka, "*Development of an inflatable robotic arm system controlled by a joystick*", IEEE Conference Publications, 2015,Pages: 664 – 669

[9] S.P. Praturu and J.N. Anderson, "*Position signal interface for the robotic arm control system*", IEEE Conference Publications, 1991,Pages: 168 – 172.

[10] Tae Mun Park,Seung Yeon Won,Sang Ryong Lee and Gabor Sziebig "*Force feedback based gripper control on a robotic arm*", IEEE Conference Publications, 2016,Pages: 107 – 112.

