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DESIGN AND DEVELOPMENT OF MULTIFUNCTIONAL ROBOT USING RIGID AND FLEXI-BODY CONCEPT

Randesh Ramanath Kochrekar* & Dr. Ramachandra C G**

* PG Scholar, Department of Mechanical Engineering, Srinivas Institute of Technology, Valachil, Mangaluru, Karnataka, India

** Professor & Head, Department of Mechanical Engineering, Srinivas Institute of Technology, Valachil, Mangaluru, Karnataka, India

Abstract:

There will be some inconvenience linked to structuring of Computer Controlled Robot Vehicle (CCRV) with an appropriate robot arm which is capable of lifting a payload of 500gm. Initially, trouble of combining the entire unit to shape for working piece of machine later, the trouble in making use of right hardware and software equipments such as DC motor, sensors and also the fabrication materials etc. In the end, the difficulty of proper communication channels or protocols to execute along with besides the selection of resources such as mild steel, aluminium, nylon, plastic etc. Most significant component for CCRV would be mainly power of the robotic arm. Its variety relies in its highest payload which an arm able to bear, reaction time for its robotic arm, simplicity to employ as well as cost [4]. With this project, a CCRV having 5 DOF is considered as well as it is built. Main purpose of this project defines erecting an essential robotic unit which has 3 tires (wheels), sensors along with an arm amid base of the robot with attached tires acts like support to the entire unit of the robot. Construction of robot is planned in such a way that there has to be a separate space in order to attach some more devices or equipments once the construction of robot is done. In this model, foundation section is planned to affix circuitry lodging along with tires (wheels), LCD display, Renesas microcontroller which includes interfacing electronic devices, in addition to the topmost section meant for the horizontal arm, jaws with the peripheral devices.

Index Terms: Personal Computer (PC), CCRV, Sensors, Renesas microcontroller, Zigbee technology & Cubesuite

1. Introduction:

Robotic vehicles are currently larger than a piece of machine, because robotic technology has turned out to be the answer for the investments for labour income along with consumers demand. For speedy advance and an extremely more throughput, labours would not be competent for those expectations. Research and Development for upcoming robotic technology is under progress for attaining speedy rate since frequently upgrading with advancement and superiority. Robotic technology with computerization has evolved so as to substitute labour for carrying out odd jobs which were regular, hazardous, tedious, as well as risky places [4]. For a superior technology, robotic technology significantly yields higher manufacturing capacity. Quality of the product will be better and lesser manufacturing expenditure. Only very less people needed to plan and examine computer and provide regular repairs. In order to handle the payload (500gm) safely the robotic arm is developed which is much similar to the human arm [3]. Fixed to the base will be vertical boom that is attached to horizontal arm in order to move the arm up and down. The vertical boom make use of three DC geared motor, functioning collectively to supply the torque required to pick up several object with the help of jaw [5]. Fixed to the Arm will be a jaw in order to lift the payload. In this project robotic movement can be controlled with PC and embedded programming language is been used for the various operation to perform.

The related work carried out by some of the authors is **George Devol** received the first patents for robotics in 1954**.** According to the author Unimation robots transfer objects from one point to another, less than a dozen feet or so apart. They used hydraulic actuators and were programmed in joint coordinates, i.e. the angles of the various joints were stored during a teaching phase and replayed in operation. For Sometime Unimation's only competitor was Cincinnati Milacron Inc. of Ohio. This changed radically in the late **1970s** when several big Japanese conglomerates began producing similar industrial robots. Unimation had obtained patents in the United States but not in Japan who refused to abide by international patent laws, so their designs were copied.

Karl Williams suggested that the rotary joints and the sliding of prismatic joints allow the links to move in the robot work space. In robot system, the number of degrees-of-freedom is determined by the number of independent joint variables. "CRS Robotics", the automation laboratory robot has 3 DOF. It's inexpensive, easy to program and limited load capacity, it is primarily used in industrial areas such as pick & place and automated palletizing "Teleoperate Anthropomorphic Robotic Arms" has 5 DOF and the concept is similar to the industrial robotic arm in the factory. It is suitable for pick and place object with limited load capacity. After going through the literature I have chosen 5 DOF for my robotic arm because 5 DOF has the similar movement and features like human arm. But the more number of DOF the more complex the robotic arm. The DC geared motors are used in order to provide the proper movement for the robotic arm.

2. Objective, Methodology and Scope of the Project:

2.1 Objectives:

The main objective of the project is to design and develop a computer controlled multifunctional robot with 5 DOF which is capable of lifting a payload of 500gm and place it in a desired position. Since all the survey on pick and place robot has been done it is been designed and developed with a latest technology with more sensory systems on it in. The main concern of this project is to implement the robot in a hazardous working environment where labours cannot operate. To avoid the accidents in a hazardous work environment this robotic model is been designed.

This project also has sensory devices placed on it in objective is to detect the water/moisture content in the workplace in order to avoid deterioration of robotic unit. Also the room temperature of the work environment is detected with the help of temperature sensor. The usage of the temperature sensor is to detect fire hazard in the work environment so that the operation won't interrupted. Addition to it obstacle detection or line tracking operation is also done with the help of IR sensor which keeps robot on a proper track. The online temperature detection, water/ moisture detection, line tracking operation is performed and all the results are gathered in PC.

2.2 Methodology:

This project is industrialized for the loading and unloading of hazardous materials in a hazardous environment where human being finds it difficult. Also it detects if there are any unwanted sources in the work environment from which a operation of a robot could halt. The main constituents in this project are Commands given to the robot, Microcontroller unit, sensors and LCD display and along with personal computer (PC) and Robot. Here from the personal computer the robot gets the command as an input which is sent aerially through Zigbee technology. The arms of the robots are actuated with these commands which in turn interfaced with the DC geared motors. The robot movement is designed in such a way that the commands sent from

the PC are declared in program which are written in embedded C language. The model is designed in such a way that if the operator presses "FM" the robot moves forward direction making the robot tire to move one revolution forward. These are some of the commands are sent in terms of strings such as FM="Forward Motion", BM="Backward Motion", UM="Upward Motion", DM="Downward Motion", AU="Arm Up", AR="Arm Right", AD="Arm Down", AL="Arm Left", JO="Jaw Open", JC="Jaw Closed". With the help of Zigbee transmitter these commands will be transferred to microcontroller and hence the necessary action is performed through which DC motors actuate. After receiving the signal the MC controller will stimulate the Robot to move in a appropriate direction based on key pressed like the Robot will move Front, Back, Forward and Backward.

2.3 Scope of the Project:

The main purpose is to reduce the labor cost for pick and place operation which is a repeated task. Now a day's for every repeated operation industries are adopting robotic technology which not only increases productivity but also the cycle time will be reduced [1]. With the help of CCRV industries can perform many operations with the advancements in the model regularly. The CCRV performs pick and place operation, line tracking operation, online temperature detection and also online moisture/ Rain sensing operation which a human being cannot perform these many operations simultaneously. The CCRV model not only requires less time to perform these operations but also it needs less time to fetch the results on the personal computer. In future most of the pick and place operation can be performed with these models. Also advancement in robotic model can be done when required and performance can be compared. Since the commands can be sent to the CCRV aerially extra connection channels can be avoided. Handling of hazardous materials now day's is a big concern hence labor cost to perform this operation would cost more so CCRV reduces labor cost and also make sure that the handling of hazardous materials will be safer and easier.

3. Design and Fabrication:

The two dimensional drawings, three dimensional CAD models of multifunctional robot shown in figures 3.1 are created using CAD. All dimensions are in mm. Assembly of robotic model is also shown in the figure.

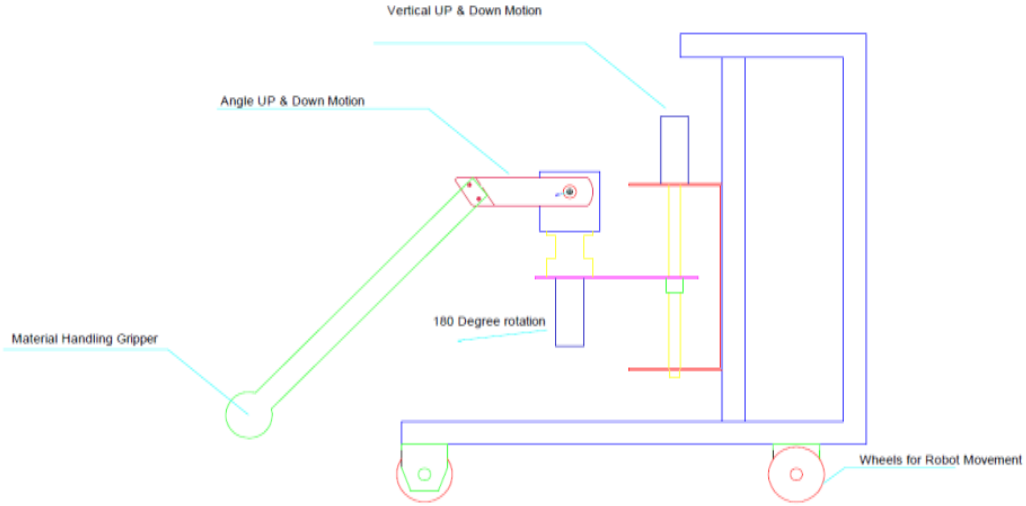

Figure 3.1 CCRV model

3.1 Base Structure:

The main supporting part and withstands the force and weight of vertical boom, Arm, Jaw and also the payload. The robot Base structure is constructed with mild steel which has light weight, high stiffness, and good load carrying capacity.

3.2 Vertical Boom:

The vertical boom is the one which supports Arm and also the gripper. On the top of the vertical boom a gear drive mechanisms is made by welding a gear DC motor to the shaft of the motor which acts as driver and the motor is fixed to vertical column which acts as a follower.

3.3 Horizontal Arm:

Horizontal arm one end is connected with vertical boom and other end is connected to the gripper which is used to hold the payload. The provision is made for arm to move up and down and also left and right. When the arm is made to lift a payload of desired quantity there has to be also a provision made for the arm not to free fall. In order to maintain the operation flexible it one end of the arm is fixed with rack and pinion technique which catch holds the arm hence making the arm not to free fall when desired load is lifted.

3.4 Construction of Jaw:

Jaw is constructed using nylon material. Since Jaw plays an important role in lifting the payload and placing it in the desired position it has to be flexible as well as rigid. In this project we have used rack and pinion type mechanism in order to hold the Jaw tightly so that the payload must not free fall when it is been lifted [6]. The rack and pinion mechanism is again actuated by DC geared motor which drives both rack and pinion assembly to be moved so that the Jaw opens and closes. Since the entire Jaw stiffness is dependent on the rack and pinion mechanism it will not let Jaw to fall hence continuing the pick and place operation with the desired payload capacity. Jaw is connected to the spacer so that it should not deflect while picking up the payload and also in the resting mode.

3.5 Assembly of CCRV:

The assembly of the CCRV as per the design is very much important to work as a unit. Each and every part of the robots is assembled with suitable screws, threading, soldering and fabricating process. Once the unit is matched with actual design of the robot, further wirings and programming procedure comes into existence. All the motors are pinned to the suitable places of the robots and also the wires are connected at the suitable places in order to develop communication network between the robot and the computer. All the sensors and all the communication ports are interfaced with the robotic model and the proper communication is checked and further operations are carried out.

Figure 3.2 Assembly of CCRV

4. Sensors:

Here in this project I have used three sensors namely, temperature sensor (LM35), moisture/rain sensor (LM393) and IR sensor (LM324). In order to perform the pick and place operation safely the sensors play an important role in this project.

4.1 Temperature Sensor:

This temperature sensor would not need any outside trimming to supply accuracy of ±1/4˚C (room temperature) also ±3/4˚C about a full −55 to +150˚C temperature range. The LM35 is used for single power supplies since it uses barely 60 μA as of its supply. The LM35 has exceptionally moderate self-heating (<0.1˚C in still air). It is also been rated to operate between −55˚ to +150˚C temperature range. The LM 35 could be fixed to a peripheral moreover its temperature is within about 0.01˚C of the surface temperature. This indicates that the ambient air temperature is about similar as the surface temperature; also if the air temperature be greater or lower than the surface temperature, the definite temperature of the LM35 die would be at an intermediary temperature between the surface temperature and the air temperature. Hence it is been noted that LM 35 temperature sensor is suitable for carrying out heat from the device.

4.2 Moisture Sensor:

The comparator uses LM393 chip for stability and moisture/Rain sensor can be utilized for detecting the water/moisture content on the robotic unit since the presence of moisture content on it would lead to deteriorating the structure of robotic unit. With the help of moisture sensor if the presence of moisture contents on the unit gives the output level high and can be read the detection message in the LCD panel. Mostly this sensor is been used by farmers in order to detect the water content on the plants in the fields.

4.3 IR Sensor:

To monitor the density of the traffic, we will be keeping a few sets of IR transmitter & receiver sensors on the side of the roads. On side IR transmitter will be placed & right opposite to the IR transmitter, an IR receiver will be kept. This set of IR transmitter & receiver will be kept on roads at different intervals. The IR transmitters are linked to supply, so that they will pass on high signal all the time. The IR receivers are connected to the comparator circuit, to get digital signals. A low power operational amplifier LM324 IC has been used to develop a comparator circuit. Two set of LM324 IC has been used in this project.

4.4 Motors:

Here for this project a good quality with less price motor is used (DC geared 12v, 60rpm). In order to have longer life and to sustain the work load it includes brass gears with pinions (made up of steel) [2]. Gears of motors are stiff on steel with its spindles are well polished in order to get the mirror like finishing. The rotation of spindle does not make noise since it rotates in between plates made up of bronze. Assemblage of the motor is roofed by means of rings which are made of plastic. No further maintenance is required since the bearings are well lubricated. From indoor the gear box is pinned to the motor.

4.5 Renesas Microcontroller:

The General-purpose register: 8 bits × 32 registers (8 bits × 8 registers × 4 banks) ROM: 512 KB, RAM: 32 KB, Data flash memory: 8 KB, On-chip high-speed on-chip oscillator, On-chip single-power-supply flash memory (with prohibition of block erase/writing function) ,On-chip debug function. On-chip power-on-reset (POR) circuit and voltage detector (LVD) ,On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator), I/O ports: 16 to 120 (N-ch open drain: 0 to 4), Timer → 16-bit timer: 8 to 16 channels, Watchdog timer: 1 channel, Different potential interface: Can connect to a 1.8/2.5/3 V device 8/10-bit resolution A/D converter (VDD = EVDD =1.6 to 5.5 V): 6 to 26 channels Power supply voltage: VDD = 1.6 to 5.5 V

5. Software Required for CCRV:

Once the fabrication of robotic parts are completed it is assembled and interfaced with the computer with the help of a software called as 'ZIGBEE' from which the commands can be sent to robotic vehicle to conduct the various operations. In order to pass commands to the robotic vehicle we need to create a new project with the help of 'CUBE SUITE+'. We can give the commands once we are done with the creating projects in this and later in the flash magic window we can pass the commands for various operations. Once the project is created it will be easier for a robotic engineer to perform the various operations of the robots using 'CUBE SUITE+' and 'FLASH MAGIC' as well. All the commands which are sent to the CCRV go via Renesas microcontroller which stores all the information within. The robotic engineer can certainly change the commands of the inputs given to the robots and also sitting at a far distance engineer can control the entire unit of the robot. Here in this project only thing the robotic engineer has to do it keep on entering the pick and place operations inputs one after another. The commands can also be modified in "CUBESUITE+' by editing the statements which has earlier given to the specific operations that has to be performed.

5.1 Zigbee Technology:

Zigbee is a latest evolved technology with the commonly effort of Zigbee alliance and IEEE 802.5.11 based on the demand of less requirement of power, less price, less difficult technology of wireless connection for about 30mtrs. Zigbee is ordinarily used in wireless sensor a network and control system that is able to communicate between number of minute sensors, these sensors need very small amount of power in order to transmit the data from one sensor to a different sensor with the help of radio waves into a relay way, hence the efficiency of communication will be exceptionally high. Zigbee software is a standard that defines a set of communications, set of rules for low data preferable range wireless technique for networking and also it has got many features such as consumption of power will be less, sensitivity is higher of type -105dBm, output power is programmable within the range of -22dBm to1dBm, temperature range is between -40to +85 deg C, voltage needed for operation is in between 1.6 to 3.8 Volts, frequency availability is in between 2.2 to 2.32 GHz.

The commands can be edited and it can be saved in the library as for convenience of the engineers. The following commands from the flash magic do the operations of pick and place;

FM='Forward Motion': The robotic vehicle moves forward making the rear tire to complete one revolution in a forward direction and stop. Again this operation is repeated as per the delay is given in the program. In this project the delay is given to repeat the Forward Motion operation as 5secs.

BM='Backward motion': The robotic vehicle moves backward making the rear tire to complete one revolution in a backward direction and stop. Again this operation is repeated as per the delay is given in the program. In this project the delay is given to repeat the Backward Motion operation as 5secs.

UM='Up motion': The vertical arm moves upward when this command is given through flash magic. The operation can be repeated as per the vertical arm has to be in exact position as required.

DM='Downward motion': The vertical arm moves downward when this command is given through flash magic. The operation can be repeated as per the vertical arm has to be in required position.

AU=' Arm up': The robotic vehicle horizontal arm moves upward when this command is given through flash magic. The operation can be repeated as per the horizontal arm has to be in required position.

AR='Arm right': The robotic vehicle horizontal arm moves right when this command is given through flash magic. The operation can be repeated as per the horizontal arm has to be in required position.

AD='Arm down': The robotic vehicle horizontal arm moves down when this command is given through flash magic. The operation can be repeated as per the horizontal arm has to be in required position.

AL='Arm left': The robotic vehicle horizontal arm moves left when this command is given through flash magic. The operation can be repeated as per the horizontal arm has to be in required position.

JO='Jaw open': The main components of the robotic vehicle are JAW. In order to pick a payload and place it in a required position the JAW plays an important role to hold it gradually not letting it down. When this command is given through flash magic the jaw gets open widely and it can be further widened as per the payload is considered. With the repeated 'JO' command the jaw can be widened.

JC='Jaw close': Once the jaw gets open widely then it has to be picked from the place in order to perform this operation the jaw has to be closed. With this command the jaw gets closed and the payload gets picked from the jaw since the jaw gets intact.

6. Results and Discussions:

1. The CCRV is capable of carrying out the pick and place operation with the payload of minimum 500gm. The jaws are suitable to pick the payload and hold it until the entire operation is completed.
2. The vertical boom is moved up and down which is used to reach to the desired location of the payload load to perform the pick and place operation and the horizontal arm is moved up, down, right and left to pick the payload and place it as per the desired location.
3. The Jaw which is the main component of the robotic vehicle is suitable to pick up a payload and also to release the load as per the desired location.
4. The online temperature detection, moisture/rain detection is also carried out and the results can be seen on the LCD as well as on the flash magic terminal.
5. Line tracking operation of the robotic vehicle is also carried out and the robot succeeded tracking the line.
6. Overall all the operations are carried out with the help of command input to the robotic vehicle and the results are noted down.
7. Since all the operations are carried out with the help of command input from the flash magic terminal through the personal computer the robotic engineer able to perform any operation easily and continuously.
8. The commands from the computer can be edited and suitable strings can be given so that the robotic engineer gets to know the command prompt very easily.
9. Overall productivity of the operation will increase since the CCRV capable of performing operations repeatedly and also the time taken to perform the operation by a human being can be minimized with the help of CCRV.
10. Overall cost of the operations can be minimized since only CCRV can perform all the operations by itself.
11. Handling of hardware units and electronic units will be safer.
12. The materials used to construct the CCRV are very much cheaper and are available in the market easily.

13. The DC geared motors are much suitable to drive the vertical boom and horizontal arm as for the convenience of the robotic engineer.
14. Rack and pinion technique is most suitable for the CCRV to catch hold the payload until the operation is executed.

7. Conclusions:

The construction of a CCRV for various task are taken into consideration from this project. Also suitable operations are conducted with the help of robotic unit which yields the performance is acceptable. The robotic unit is capable of lifting 500gm of payload and also it was able to place the payload as in required place. While lifting the payload it has been found that no wear and tear motion has happened with the horizontal arm of the robotic unit. Mainly the Rack and Pinion technique used for maintaining the balance of horizontal arm is found to be satisfactory. Also the object which weighs for about 500gm is handled safely without affecting the object. The moisture contents on the floor and also on the robotic unit is determined and found that moisture sensor works precisely and gives exact results. The temperature sensor normally displays the value of room temperature in a standby stage. It is also found that when the temperature increases around the robotic unit the temperature sensor reads the proper increase in it and displays the results on the LCD display as well as in the FLASH MAGIC output window.

The main purpose of the CCRV is also line tracking, which is carried out by toggle switch. The CCRV was able to track the black strip line and also the deviations in tracking of line are determined with the help of IR sensor and the results can be read on LCD display. The commands which are given from the PC are well read by microcontroller and appropriate actions are performed. The usage of Zigbee technique in order to communicate robotic unit with PC is aerial is found to be suitable hence reducing the usage of power cables. On the other hand moisture/rain sensor which is mounted on the base of the robotic vehicle can be replaced and mounted near to the front tire so that that the sensor should make a contact with the floor hence sensing the water content on the floor so that necessary actions can be carried out to stop the robotic vehicle right there. Adding up, image processing technique can be used for detecting the object which weighs for about 500gm which could avoid input of commands from the PC. Hence, for construction of horizontal arm, vertical arm and jaw in a précised manner more and more computer aided designing and fabrication technique are incorporated. CCRV would be easier to a mankind to avoid the hazardous material handling. Complicated operations can be carried out more rapidly, precisely by means of CCRV.

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