Design and Analysis of six DOF Robotic Manipulator

Article *in* IOP Conference Series Materials Science and Engineering · February 2021

DOI: 10.1088/1757-899X/1055/1/012005

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To cite this article: V G Pratheep *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1057** 012034

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Design and fabrication of multitasking transit robot`

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Abstract. Technology has blended itself with the everyday life of humans. People aren't finding greater efficiency despite the field of science and technology has progressed well. Traditionally goods are moved and distributed in and around an industry manually by humans. By using an automated material handling system this problem was reduced to a certain percentage. Even though there is no efficient method to deliver the products directly to the end-user like the patients in the hospitals. So,a robotic system that transports materials all over the workplace has been designed. The serviceability of the system is based on themaster-slave concept. This system can be used in mining operations to carry materials on a rail.To make the design economical, low-cost parts are used which makes it ideal for production on an industrial scale which will aid in many applications like drug delivery systems in hospitals and also material carrying robots in mine.

1. Introduction

Transportation of goods or people between places is commonly referred to as 'Transit'. Traditionally goods are moved and distributed in and around an organization manually by human beings. Later,people started to use machines to help in the process. The folk lifts, mini trucks, etc. were used, but the usage of these aids did not improve the performance of the organization to the excepted level. Currently,automation plays an inseparable role in many parts of society. Automated warehouse management robotic systems like the Amazon Kiva robot system and Swisslog carry pick system are also included in the list.

Warehouses weredeveloped to store commodities and goods. Warehouse management systems were deployed and models were developed with examples by Van den Berg, Jeroen P, and Willem HM Zijm, [1] and the core concept of stock control, monitoring, and measurement is explained by R L Ballard [2]. Advancements in Technology lead to the development of Ground terrain vehicles that used sensors, vision system, and navigation systems designed as a Ground Surveillance Robot (GSR) by Harmon S [3] and practical mechatronic setup such as Housing module, Drive module, Docking module, Elevating shaft and a Rotation module were incorporated to develop an apparatus for handling inventory items by Richard R. Fontana and Cape Elizabeth [4]. Later Noguchi and Noboru developed two algorithms namely GOTO and FOLLOW which were used in tractors to test their efficiency [5].

Liu, Wensheng Yu, and Yu Liu [6] proposed a resource management system that used RFID to process real-time information, and a practical application testing using forklifts was done by Harry KH Chow [7]. Vidyasagar, M. Sumalatha, K. Swathi, and M. Rambabu [8] developed a smart guided robot to collect waste material from restaurants using RFID (Radio-frequency identification), RF Transmitter and Receiver and microcontroller ARM7 producing output commands to the robot. Ya-Chuan Chen and Jung-Hua Chou [9] developed an autonomous robotic material handling system to extend the functionalities of traditional AGVs to operate in highly dynamic environments. Kornienko [10] used an IR-based system for navigation, object recognition, directional, and unidirectional communication.

Chuan, Loh Poh [11] developed an RFID robot to perform simple pick and place operations using MPLab 7.3. Jørgen Nordmoen, Sondre Engebråten, Thomas Thoresen, Espen Skjervold, Lars Landmark, Erlend Larsen, and Jonas Moen [12] developed a UAV to locate a hidden Radio Frequency (RF) transmitter. Kelly, B. Nagy, D. Stager, and R. Unnikrishnan [13] developed an infrastructure-free AGV that worked to an extended period more reliably. Jamu [14] designed low-cost automatic ground vehicles to support e-commerce businesses. Li, Jun-tao, and Hong-Jian Liu [15] proposed a system that uses the Amazon Kiva system for picking operations and demonstrated design optimization.

Ding [16] proposed an intelligent warehouse management system that uses IoT as a major resource for operations. Rahul Kumar [17] conceptualized a Local Positioning system of the robots by using cameras and beacons. Usage of PLCs and CAN for stacker cranes to control them was designed by Dorner [18] that depicted real-time warehouse systems. Real-time studies by Mavaji, Arun Seetharam, Sudhakar Kantipudi, and G. Somu [19] confirmed positive results in effective hospital healthcare systems. Dallal, Ahmed H., Ahmed S. Derbala, and Mona F. Taher [20] designed a mobile robot that works on WLAN to handle hospital wastes and other materials.

In Kiva robotic system [21] by Dev Bahadur, portable storage units are used to store products or items. When an order is entered into the Kiva system, the software tracks down the closest bot to the item and directs it to retrieve it. The Swisslog system is similar to the Kiva system. Carry Pick is a disruptive automated system for multi-channel intralogistics for storage and picking purposes.These robotic systems are only for warehouse management systems. When it comes to delivery, there are no standard systems to deliver materials throughout the workplace. The above-discussed systems will operate only in warehouse environments. A robotic system is designed in which the robots will work in the real world delivering the products and materials to the consumers directly and can also be used for continuous loading operations in mining applications. The primary objective is to design a multitasking transit robot that can be used in any areas like the medical field, mining, etc., to transport objects from one place to another safely and effectively by saving time. Final fabrication is done [22-24].

2. Methodology

2.1. Existing System

Existing robotic systems workin the warehouse environment only. Even in mines there are only automated robots to drill and other mining operations. There is no robotic system to collect and carry the mined ore automatically from the mine. This shows that there is no effective transit system to carry products around the workplace effectively. This also costs high labor costs. The drawbacks of the existing system are:

- Human effort required for the whole process
- Time consumption is high
- Safety issues
- Increases the operating cost

2.2. Proposed Methodology

In this proposed model, two robots are designed, master and slave. Where DC motor with encoder is used for moving the robots at the desired place and the ultrasonic sensor is used to avoid the obstacles and servo motor is used for rotating ultrasonic in 180 degrees and RF transmitter and receiver is used for communication between Master and Slave. The Node MCU is used to operate the robot from anywhere. This robotic system is a collaborative one. This can be used to deliver drugs to the patients in the hospital. It can also be used in mines to carry the ore. The advantages of the proposed system:

- Compact design
- Reduces the time for material transportation
- Reduce manpower in the workplace
- Minimal cost
- Decreases accident rate

3. Feasibility Study

3.1. Economic Feasibility

Implementing this model is more possible in an economic way. The model is made of DC Motor with encoder, Servo motor, Ultrasonic Sensors which are readily available in the market at cheaper rates. For a large scale, the project is economically feasible and it can be followed by the design and fabrication process.

3.2. Operational Feasibility

The robot is a fully automated one that is capable to work autonomously. DC Motor with Encoder is used for the rotation of the wheel and calculate the traveling distance. Servo Motor is used to rotate an ultrasonic sensor atan angle of 180 degrees and avoidobstacles. RF transmitter and receiver are used for communication between the robots.

3.3. Technical Feasibility

The components required and the technologies adapted for the design are easily availableto carry out theprototype. Globally available software packages fulfill the requirements adapted for developing the prototype into a product. The design which has to be implemented can be simulated through the available software and the prototype can be developed according to the concept. The developed prototype represents the concept and the processesthat are going to be implemented. The proposed system is technically feasible and makes the existing system incompetent.

4. Mechanical Modelling

4.1. CAD Modelling

Designing is indispensable. The model is designed using SolidWorks software. Initially, the parts are drawn to the specified dimensions and assembled as shown in figure1.

4.2. Mechanical Hardware

The CAD model is fabricated into hardware using metallic frame and wheels upon which the electrical and electronic components that includes Arduino, Battery, Node MCU, Ultrasonic sensor, and driver circuit are fixed. Fabricated model is shown in figure 2.

4.3. Circuit modelling

The Electrical and Electronic components are virtually interfaced using Proteus software and is then simulated. Proteus model of the circuit is shown in figure 3.

4.4. Electrical Setup

The electrical section consists of a simple Arduino programming circuit. All the circuits are simulated and tested using proteus 8 professional software. The Electrical circuit is shown in figure 4.

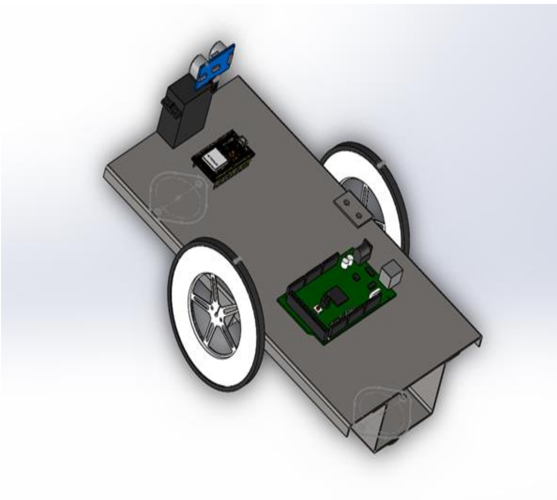

Figure 1. Solidworks model of robot

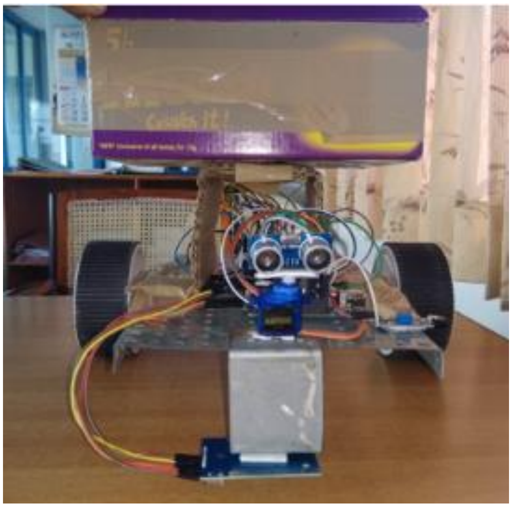

Figure 2. Fabrication Model

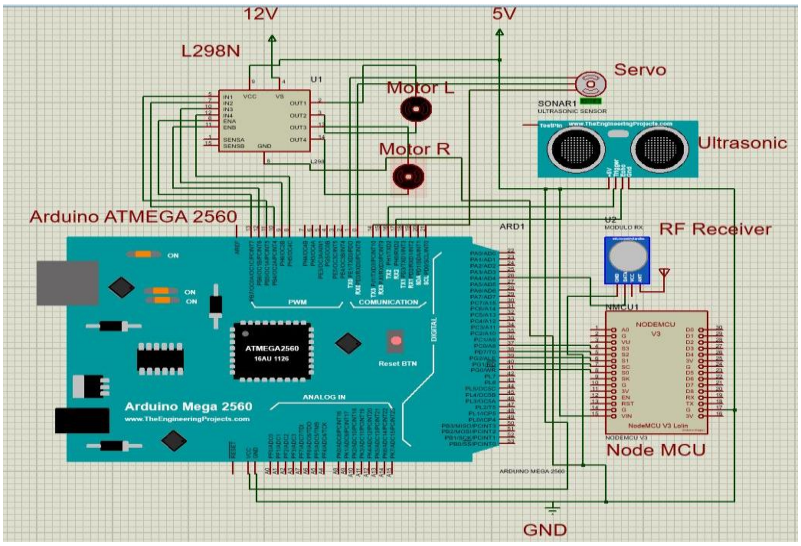

Figure 3. Circuit model using Proteus

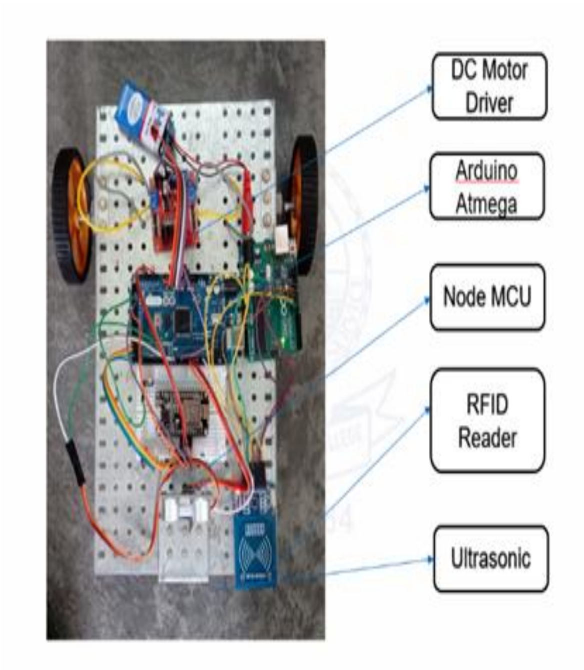

Figure 4. Electrical setup

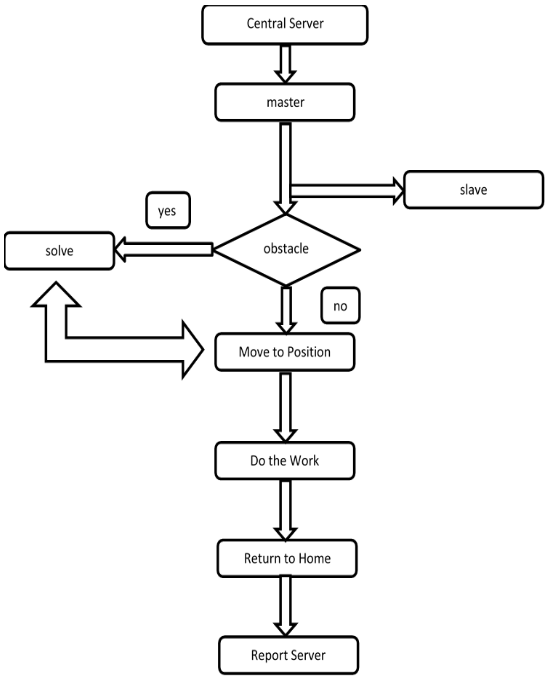

Figure 5. Flow diagram of process

5. Design specifications

5.1. Design Calculation

Power (P) = Voltage * Current (1)

Torque (T) = (Power*60) / (2*3.14 * Speed) (2)

5.2. Mass of the Component

Material used = Mild steel (MS)

Density of MS = $7.85*10^{-6}$Kg/mm^3

Chassis = 1.10 Kg

Wheel = 0.25 Kg

DC Motor mass = 0.75 Kg

Total mass (m) = 2.1 Kg

5.3. Dc Motor Calculation

Voltage Rating = 12 V

Current Rating = 60 mA

Speed = 300 rpm

Substituting these values in Equation (1)

Power (P) = 12*0.6

Power (P) = 7.2 W

Substituting these values in Equation (2)

Torque (T) = (7.2*60) / (2*3.14 * 300)

Torque (T) = 0.229 Nm

6. Working principle

The robot is controlled by an IoT based app called Node MCU car. The command will be given through the central server. The robot will be commanded to go to the specific room number. Then it will scan its current position and gives a command to the slave to come to the specified room number. Then the slave will be scanning its position and makes a route map to the room and acknowledge its position to the master. Then the master will go to the room as per the route map. If there are any obstacles in the path, it will be detected by the ultrasonic and it'll be avoided by the robot. Finally, after reaching the position the robot will scan for the position and confirm whether the specified room is correct. It will command the slave and finishes the job. Then it returns to its home position automatically. Figure 5 shows the flow of operation.

7. Conclusion

The multitasking transit robot was successfully developed. The Proposed model is a prototype. This concept is a standalone system and shows how a transit robotic system can reduce the workload in the hospital for transporting materials. This also shows how a robotic system can be used in carrying ore in mines. This model will move at high speed with position accuracy to any place within the floor map. Every robot will communicate with each other at any movement for any information. This system has more advantages like compact design, portability, low cost and working time can be reduced nearly to 20% to 30% compared to existing systems. Thus the efficiency in economical and operations is comparatively high. This also saves labor costs.

8. Future scope

This system can be further improved by incorporating high powered gear motors, shock absorbers, and interlocking mechanism to lift and move various objects in the workplace. Two or more bots can also be used to lift the objects depending upon the weight.

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