Development of Unmanned Guided Vehicle for Material Handling Automation for Industry 4.0

C. Maheswari, E.B.Priyanka, S.Thangavel, P. Parameswari

Abstract: ***In the current scenario, the industries are implementing automation in every field works. Industries are trying to reduce the labor cost and processing time which is taken by the human. This proposed work will be helpful for handling the materials efficiently. That is, for picking the raw materials from the storehouse and carrying it on the vehicle and transporting to the workshop where it is being machined. To replace the labor cost and to reduce the processing time, this type of vehicle can be used. The UGV picks the raw materials that had to be machined from the storehouse to the workshop where the machining processes are done. ARDUINO UNO R3 ATMEGA 328P controller is the heart of the system which controls the vehicle movement and arm actuation. The robotic arm consists of 5 servo motors with the gripper at its end. The vehicle with three wheels is helpful for carrying the materials from one place to another place. Three IR sensors are used for detecting the black line on which the vehicle has to move. Sensor 1 and 2 are used for sensing the black line. Whenever it is sensed the vehicle has to move forward or left or right. The third sensor indicates the storehouse or the workshop. When the robot reaches the storehouse, which is indicated by the third IR sensor, the vehicle stops and ARDUINO UNO R3 actuates the arm and simulates it to carry the goods. The vehicle automatically starts and carries it to the workshop without any human interruptions. Hence, the proposed project is useful for carrying and transporting the raw materials and finished goods efficiently with the less consumption of time. This research includes the robotic arm with a gripper, an Autonomous vehicle with three wheels, ARDUINO UNO R3 controller, Motor driver, three InfraRed sensors (IR) and Single-Mode Power Supply (SMPS).***

Keywords: Unmanned guided vehicle, Robotic arm, ARDUINO UNO R3 ATMEGA 328P, Material Handling+

I. INTRODUCTION

In general, allthe products are produced for the specific applications that have to be useful. All the products are created by the fundamental material. That material is known as ‘Raw material’. Without raw materials, there are no products [1, 8]. These raw materials maybe different kinds based on applications. These raw materials are converted into useful products by the industries. There are lots of labors or workers for machining these raw materials. Also, there are many workers used for transporting these materials [10, 11, and 12]. There are many rooms such as storehouse or warehouse, different workshops, and also some inventories for holding or carrying the finished or partly finished goods [5]. A lot of workers cause the high labor cost for the owner of the industry. Some workers have to work there for machining these raw materials that are inevitable [2, 4].

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But many workers used for transporting should be avoided because it reduces the labor cost. The proposed project may be useful for transporting materials from one place to another place without human intervention [3, 6].

The proposed project is made simple and efficient one by introducing Automation there. The traditional process of transporting the raw materials as well as finished products involves at least 2 or 3 workers in that field. Because one person should take the materials from the storehouse and then another person should load this material to the vehicle which carries that materials and another person should drive the vehicle to the appropriate places such as Lathe section, Cutting section, Drilling section, Milling section, Painting section, Assembly section, Cleaning section etc. So the manual method of having many processes involving human and takes large time and also sometimes accident occurs due to carelessness and distractions in the human mind [13, 14]. This is not a cup of cake for everyone. Hence new entrepreneurs will not take up this business. Henceforth, the primary intention of this research work is to automate the material handling process using low-cost automation techniques.To design and fabricate a low-cost Unmanned Guided Vehicle (UGV) for material handling in industries for handling both the raw materials and the finished goods with the help of Robotic Arm with Gripper at its ends by using Arduino UNO R3 controller.

II. EXISTING METHODS UTILISED FOR INDUSTRIAL MATERIAL HANDLING

A. Manual Handling Technique

In manual handling technique, all the materials are carried and transported solemnly by the workers and not using any vehicle for carrying those materials. This method is the very ancient method for material handling in the world. This method prevails still in the small industries such as fireworks, match boxes industries etc. and also this method costs high due to lots of humans are required for handling those materials are heavy and a lot if any.

Figure1. Manually Handling Technique

B. Manual cart (Transporter) Technique

Manual cart technique possesses an approach in which materials are taken out from the storehouse with the help of humans and then they place these materials in the vehicle which carries and transports it to the destination such as workshops etc. One transporter who drives the vehicle which carries the materials that has to be machined. If he loses his control, it leads to an accident.

Figure 2.Manual cart (Transporter) technique

C. Fork Lift & Conveyor Technique

These techniques involve some lift or crane type mechanism for lifting the products which are bigger in sizes and does not carry the human. This method is mostly used in Automotive and automobile industries such Audi, Ferrari, Lamborghini industries, particularly in the lifting of the engine components such as engine head, the whole crankcase, flywheel and hood of the vehicle and more are lifted by implementing this way of procedure.

Figure 3.Fork Lift & Conveyor Technique

And also this technique not only lifts the materials but also transports it to its next section. But this forklift method used in the only vast area in industries and also it is an expensive one. By analyzing the existing methods instigated in material handling, the following drawbacks have been identified as follows:

- The existing system takes more time to lift the materials that have to be machined.
- It involves many human labors which in turn results that high labor cost.
- It causes an accident and broken materials sometimes due to the carelessness of humans and results infewer production rates.

III. ENACTMENT OF PROPOSED METHOD

The proposed system entirely focused on, to reduce the humans for materials handling. The primary motto is to automate the entire material handling process. The process is automated by using sensors and actuator connected to Arduino UNO R3 controller. This proposed work is not only picking or lifts the raw materials from the storehouse but also transports to the other sections and drops there and also again picks the finished or semi-finished good from the workshop to other painting section or any. This research is mainly concentrated on the requirement of small and medium scale enterprises, to offer them with high reliability, high efficiency and the most important efficiency and less time consumption.

A. Advantage of proposed system:

The advantages of the UGV for material handling in industries project are

- Low cost of manufacturing and easy to maintain.
- It is well-suited for picking the materials and dropping it easily with help of Arm with the Gripper mechanism.
- The machine consumes less power.
- Not only picks up the raw materials and also carries them on the vehicle and transports it to its destination easily by the Line follower concept.
- It is compact and occupies less floor space.
- It is easily programmable and controllable by using the servo mechanism.

IV. FEASIBILITY STUDY

A. Economic Feasibility

The UGV for material handling machine will be economically feasible one to produce.The mechanical setup consists of the metal vehicle with 3 wheels; its base is made up of aluminum material, and metal welding, bolt,and nuts. Then, the automation is done by Arduino so as to be very flexible and easy to program. The use of controller will reduce the cost of automation since other controllers also we can use such as PLC [8, 9] (Programmable Logical Controller) but the cost is higher than Arduino controller. Then, the IR sensor module and the L298 Motor driver IC is easily available one and cheap in cost. But, the Robotic Arm is not available easily and also cost is around Rs.10000. Thus the overall system is cost effective. Cost of the system is given in table1.

B. Technical Feasibility

Technical success of the research work relies upon the work expected from the different section of the planned approach. Technically, the above-mentioned process is so simple and thus feasible to produce. The Arduino is programmed with the help of ARDUINO software.

The language used to program the controller is very easy. Then it is dumped into the Arduino with the help of a serial cable. Thus, the controller is ready to be used. The SMPS (Single Mode Power Supply) supplies the power to all the components such as Robotic arm for the 5 servo motors andthe motor driver IC and also for the Arduino UNO R3 board. The IR sensors sensitivity is too good for this project for detecting black lines. The controller gets the inputs from the IR sensor modules and controls vehicle motors and then Robotic arm formed by the servo motors. Thus it is simple and easy to build with the help of Arduino UNO R3.

C. Design Calculation:

TORQUE CALCULATION FOR DC MOTOR:

Voltage = 12V; Speed = 60rpm;
Torque = Force * Radius (F*R)

IV. FABRICATION PROCESS

A Table 2.elaborates the components involved in fabricating the proposed approach design as follows

Table 1.Cost feasibility study of total project

S.No	Items	Specification
1	Robotic arm with a gripper	5V
2	Arduino UNO R3 with ATMEGA328P	5V
3	DC motor	12V,60rpm
4	SMPS	I/P:230V AC – O/P: 12V, 5V
5	IR sensor	5V
6	Motor Driver IC	L298 IC 12V
7	Voltage regulator IC	7805 5V
8	Battery	12V,7A

Table 2.Components involved in model

S. No	Items	Specification and numbers	The costisRs.
1	Robotic arm with a gripper	5V-1	11260
2	Arduino UNO R3 with ATMEGA328P	5V-1	600
3	DC motor	12V,60rpm-2	1600
4	SMPS	12V,5V-1	1000
5	IR sensor	5V-3	240
6	Motor Driver IC	L298 IC 12V-1	300
7	Voltage regulator IC	7805 5V-1	20
8	Battery	12V,7A-1	800
		TOTAL	**Rs.15820/-**

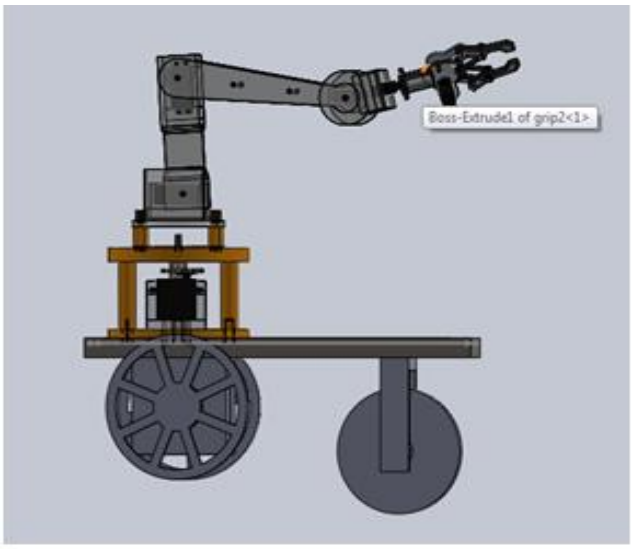

Figure 4. Solid Works Model

Radius = 5mm = 0.005m; Mass = 4.4kg;
Force = 4.4*9.81= 43.16N
Torque = 0.005*43.5 = 0.21582Nm
Power = $(2 * \pi * N * T)/60$
Power = (2*π*60*0.21582)/60 = 1.36 watts
Current = Power/voltage
Current= 1.36/12 = 0.113 A = 113mA.

A. Cad Modelling

Product design is the most important stage in the project. Mechanical setup of the project is modeled in SOLID WORKS software. Parts are designed and assembled in SOLID WORKS with the required dimensions. Design calculations are used for the accurate dimensioning. Sequence or working of the mechanical setup is simulated in software. If the simulation meets the requirements then it will be carried out for the real time implementation of the setup. The Solid works model of this research work is shown in Figure 4.

B. Mechanical setup of the Proposed Design

This machine is designed using Solid works software. Initially, the part drawings are made to the dimension specified and then the parts are assembled. Once the design meets the requirement, the real time setup is fabricated.Most of the components are connected by using bolts and nuts to reduce the weight, cost of the project and to improve the flexibility of the project. Mechanical setup of the project is shown in Figure 5.

V. SIMULATION

A. Simulation of the program in PROTEUS software

A software implementation of the electrical section is carried out using ARDUINO software for programming and PROTEUS software for simulation. The Arduino program in ARDUINO software is dumped in the PROTEUS software to simulate the electrical setup. A softwareimplementation of the electrical section is shown in Figure 6.

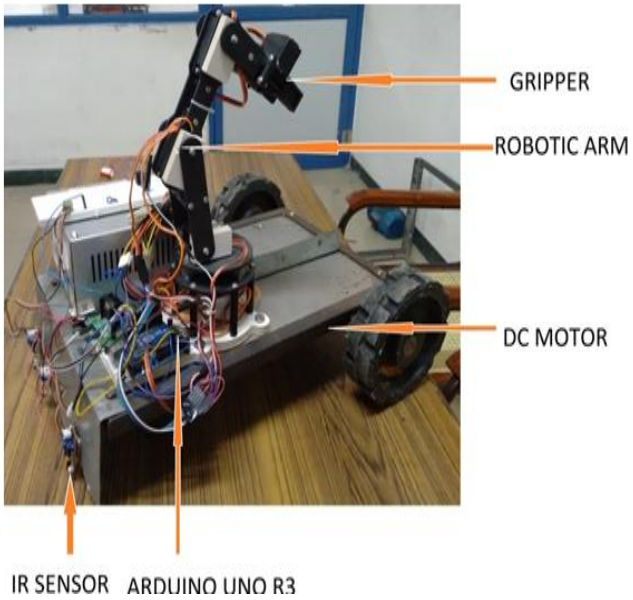

Figure 5.Mechanical setup

B. Interfacing electrical circuits using ARDUINO UNO R3

The voltage source is given to the elements through the breadboard. The controller is connected with IR sensors, L298 motor driver, and then the Robotic arm with the help of male and female connecting wires. The SMPS is connected to the L298 motor driver IC and to the Robotic Arm. And the battery is connected to the 3 IR sensor modules. The real time the electrical circuit is shown in Figure 7**.**

VI. WORKING OF PROPOSED SYSTEM FOR MATERIAL HANDLING AUTOMATION

The robot is placed over a wide sheet with black lines. The bot actually moves in the track of black lines. For this operation, three INFRARED sensors were used. The first two sensors were used to track the black line. The robot changes its direction with the help of these two sensors. The third sensor is used to detect the separate line on the sheet which indicates the workshop and storehouse. When the third sensor senses, the robotic arm gets actuated by

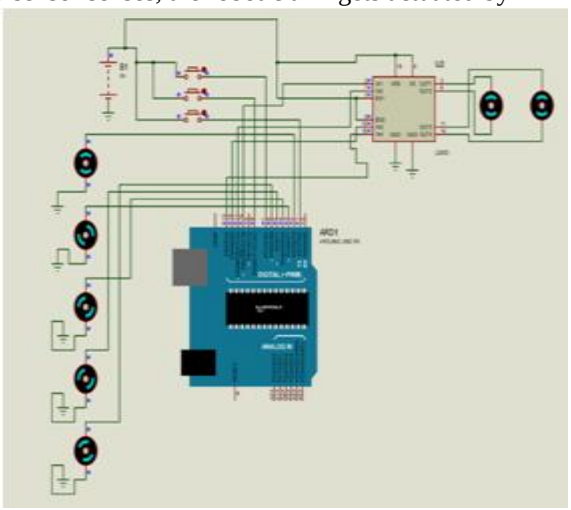

Figure. 6. Proteus model-material transport control system

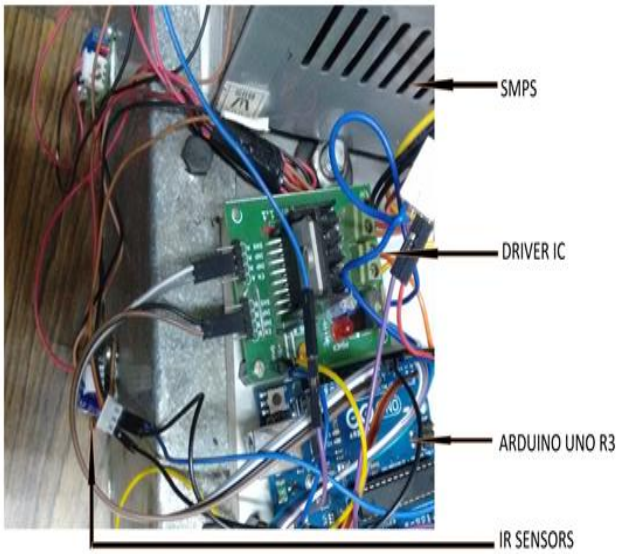

Figure 7.Electrical setup

Means of ARDUINO UNO R3. The ARDUINO UNO R3 gets 5V supply from the SMPS. The function of the robotic arm is already programmed. The robotic arm helps to pick the raw materials from the storehouse with the help of grippers. After picking the raw materials were placed in the container of the robot. The Wheel motor gets started when the arm finished its work. The motor gets 12v supply from the SMPS and is actuated with the help of L298 motor driver IC. When the robot reaches the workshop the third sensor gets sensed and so that the robotic arm gets actuated by ARDUINO UNO R3. This time the robotic arm picks the raw materials from its container and places it in the workshop andpicks the finished goods from the workshop and places it in the container.

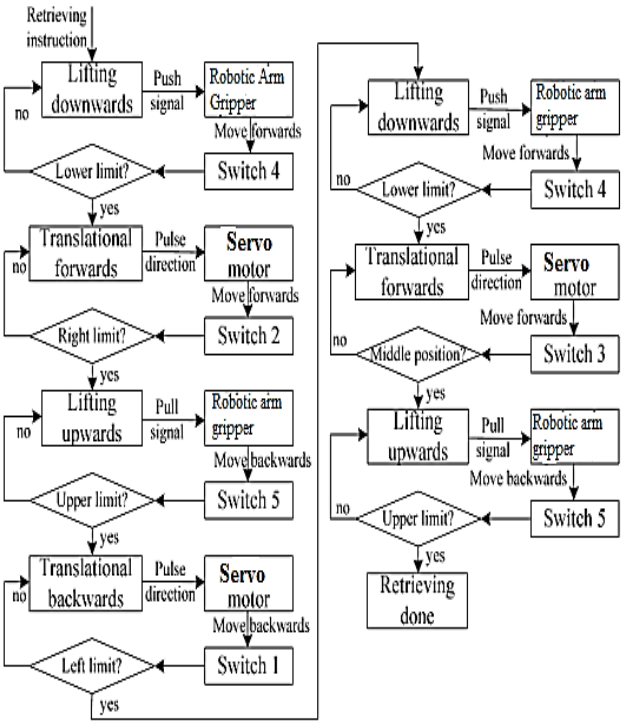

Figure 8. Retrieving control diagram

After this picking and dropping material is done, again the motor gets started and follows the black line and the finished goods were picked from the container and placed in the storehouse. Thus the process is repeated. The 230-volt ac supply is converted to dc by means of SMPS and it gets converted to 5v for Arduino supply and 12v for servomotors and DC wheel motors.After AGV arrives at the accurate docking spot and checks its pallet target, AGV controller [7, 9] sends a retrieving instruction to the Arduino that starts the entire control process, as shown in Figure 8. Firstly, the Arduino gives a push signal to the robotic arm gripper, and it pushes sliders forwards to lower lifting module. When switch 4 sends a lower limit signal back to the Arduino, it stops the gripper, and the convex blocks have moved below the sockets. Secondly, the Arduino gives a forward pulse sequence to the stepper motor. The motor drives plane 2 and 3 towards the load stand. When switch 2 sends a right limit signal back to theArduino, it stops the stepper motor, and convex block 2 has aligned with socket 1. When the Arduino gives a forward pulse sequence to the stepper motor until switch 3 feeds back a middle position signal to the gripper when the UGA moving on its path by carrying its load towards its destination.

VII. LOAD TRANSFER EXPERIMENTS

In order to test the material transport system of AGV, the load transfer experiments are conceded out in our laboratory. A ring closed path is laid out in the floor by using black lines. One load stand is located on a selected spot exactly beside the path, which serves as both load pickup workstation and delivery workstation. Firstly, AGV flinches at an arbitrary point of the track and passages towards the load stand. After it attains at the accurate docking spot, it picks up the pallet from the load stand robotically. Then it continues to run on the ring path and comes back to the load stand when it completes the black line of path. After it checks the load stand is free, it delivers the pallet to the load stand routinely. In the load transfer experiments, retrieving and depositing processes of AGV are performed uninterruptedly in a episodic way up to 8 hours. This adequate experiment result can only be attained when the material transport system already has two control capacities at the same time. Usually, the longitudinal position error is less than±15mm, and the lateral position error is less than ±10mm. The other is that the load-transfer mechanism can reach at the exact position to hold the platform, push the platform to the precise position of the load stand, and pull the platform back to itself perfectly. The experiment confirms that the translational module has a position error less than ±1mm, and the lifting module has a position error less than ±3mm.

VIII. CONCLUSION

A new system for material handling is designed and developed. The complete automation of the system is achieved and the system proves to be cost effective as well. Also, the objective of this system is to pick, to carry and to transport the materials with the help of UGV without any human intervention and reducing processing time which is taken by the human is successfully accomplished. The present UGV carries the load with the capacity of upto 3.5 kgs since the capacity of the gripper lifts up to 200 gram per lift. Depends on the requirement, the capacity of the gripper and DC motor can be changed. Thus the model can be used for handling heavy weight materials also.

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