International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

Material Handling Robot with Obstacle Detection

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***Abstract*— The Material Handling Robot refers a type of system that can be used in production as well as in other industries etc. This system includes a battery operated remote sensing locomotive (carrier) on which a small lift is provided, specific path over which it moves, sensors for sensing the the obstructions on the path of the carrier. Also sensors for sensing exact positions from where load wants to carry and to where. The Material Handling Robot moves using the electric power from the battery. It moves with a low and constant speed on the prescribed path. The path has a specific colour (black). The bottom of the carrier have sensor which is always coupled with the path. The steering is done by the path. The front side of carrier vehicle contains sensors for sensing the obstructions on the path. As it reaches the unloading station, it is stopped and unloading of the material is done at that station. And move to collecting stations again. Continues working cycles for making this project a reality. By this the there is ease in transporting materials or finished products from one work station to the other.**

***Keywords*— AGV, Microcontroller.**

1. INTRODUCTION

In manufacturing industries, the key motive is to achieve productivity with the help of efficient and effective use of methods and workers. Especially in non automated industries wherein the workers have to do the material handling activity manually there is an issue of fatigue arising which is one of microcosmic factors contributing to inefficiency. Transporting material, to illustrate, from raw material storage to the operation centre and forthwith after completion of process to the storage room is a strenuous task and certainly its essential to elucidate this issue.

This material handling robot which is built in with a obstacle detection system will help not only to transfer material from one place to an area of interest but also to avoid objects that may inadvertently be in its path. But what is of critical relevance is that it will eventually reduce fatigue of workers and in some cases may also eliminate the need for workers for this activity thereby reducing labour cost.

A material handling robot (MHR) is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. They are most often used in industrial applications to move materials around a manufacturing facility or a warehouse

Automated material handling robots increase efficiency and reduce costs by helping to automate a manufacturing facility or warehouse. The MHR can tow objects behind them in trailers to which they can autonomously attach. The trailers can be used to move raw materials or finished product. The MHR can also store objects on a bed. The objects can be placed on a set of conveyor and then pushed off by reversing them. Some MHRs use forklifts to lift objects for storage. MHRs are employed in nearly every industry, including, pulp, paper, metals, newspaper, and general manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done.

A MHR can also be called a laser guided vehicle (LGV) or self-guided vehicle (SGV). Lower cost versions of MHRs are often called Automated Guided Carts (AGCs) and are usually guided by specific lines magnetic tape. AGCs are available in a variety of models and can be used to move products on an assembly line, transport goods throughout a plant or warehouse, and deliver loads to and from stretch wrappers and roller conveyors. MHR applications are seemingly endless as capacities can range from just a few kg to hundreds of tons. The Aim of the project is to design and fabricate such a MHR

2. LITERATURE REVIEW

The survey of existing products and other technical and journal papers in which the information or mechanism of present technologies are studied.

2.1 Robot obstacle detection system with storage.

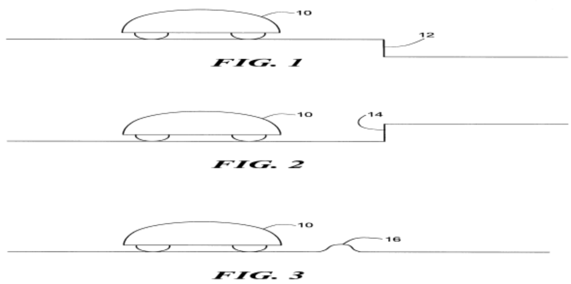

Figure 1: Robot obstacle detection system

- Patent:US6594844 B2
- A robot obstacle detection system including a robot housing and some storage space to keep an object, which navigates with respect to a surface and a sensor subsystem having a defined relationship with respect to the housing and aimed at the surface for detecting the surface.
- The sensor subsystem includes an optical emitter which emits a directed beam having a defined field of emission and a photon detector having a defined field of view which intersects the field of emission of the emitter at a region. A circuit in communication with a detector redirects the robot when the surface does not occupy the region to avoid obstacles.

2.2 Obstacle detection system

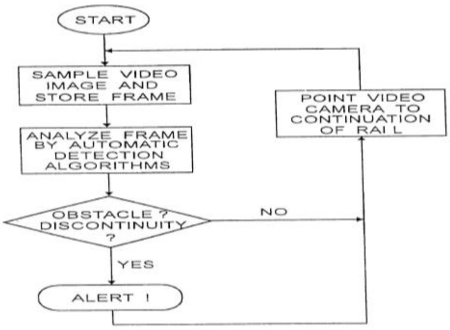

Figure 2: Obstacle detection system

- Patent:US6163755 A
- An obstacle avoidance device is mounted in the vehicle and coupled to the obstacle detection device and is responsive to the obstacle detect signal for producing an obstacle avoidance signal.
- According to a preferred embodiment, the track is a rail track, the vehicle is a railway engine and the sensor includes a video camera for imaging the track. The resulting image is processed so as to detect a potential obstacle on the tracks allowing the brakes to be applied either manually or automatically.

2.1.3 Obstacle avoiding system

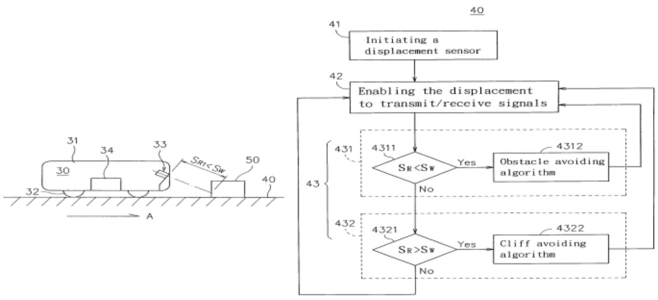

Figure 3: Obstacle avoiding system

- Patent:US7643906 B2
- An obstacle and cliff avoiding system is disclosed, which is substantially a movable chassis having at least a displacement sensor arranged thereon
- The paths of signal emission and reception of each sensor are defined by the specific angle, whereas the reflected working signal received by the sensor is sent to a control unit to be compared with the working signal so that the control unit is able to evaluate whether there is an obstacle or a drop in front of the moving direction of the movable chassis and thus control the chassis to maneuver around the obstacle or the drop.

3. METHODOLOGY

Work plan is the systematic, theoretical analysis of the methods applied to a field study, or the theoretical analysis of the body of methods and principles as associated with a branch of knowledge.

There are many reasons which yield to the creation of Material Handling Robot(MHR) around the world. Mostly the reason is to overcome the logistic problems that often occurred in the workplaces and to make improvement to the facilities provided in the workplaces. Usually the MHRs are implemented in factories, hospitals, offices, houses, and even can be found anywhere outdoors without the people surround realized it. In the industries or factories, the MHRs can ease the physical strain on human workers by performing tiring tasks, such as lifting and carrying heavy materials, more efficiently with no signs of fatigue creeping in. They can carry far more than human workers, and their movements can be tracked electronically at all times. Their movements can be timed to feed or collect products or materials from the work cells in the factories

PATH DECISION

MHRs have to make decisions on path selection. This is done through different methods: frequency select mode (wired navigation only), and path select mode (wireless navigation only) or via a magnetic tape on the floor not only to guide the MHR but also to issue steering commands and speed commands.

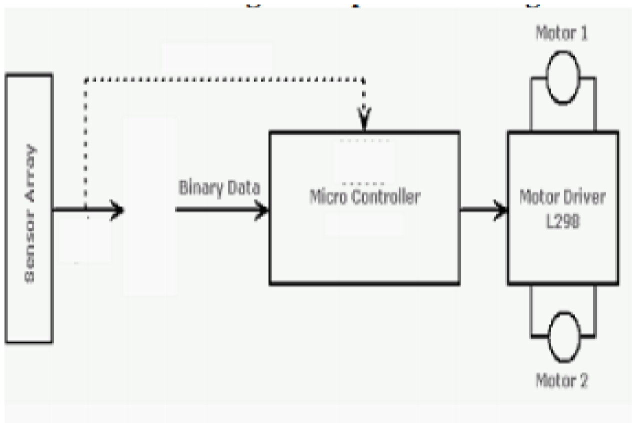

Figure 4: Block diagram of MHR

The Basic Block Diagram of the MHR consists of 3 blocks as showing in the figure, namely,

1. Photo Logic Optical Sensor Module.
2. Microcontroller Module.
3. Motor Control Module.

PATH FOLLOWING BY SENSOR SIGNALS

The sensors are aligned so that if the MHR is centered on the track, then all the three sensors can see track – the output from all detectors will be high and the robot will continue in the previous direction.

Table 1
Indicating which sensor sensing the path and average direction of movement

LEFT SENSOR	CENTER SENSOR	RIGHT SENSOR	AVERAGE MOTION
0	0	0	Previous value
0	0	1	Turn Right
0	1	0	Forward
0	1	1	Turn Right
1	0	0	Turn left
1	0	1	Turn Right
1	1	0	Turn left
1	1	1	Previous value

1. When right sensor senses the path MHR turns to right
2. When left sensor senses the path MHR turns to left
3. When centre sensor senses the path MHR goes forward
4. When all three sensors sense the path MHR goes in previous direction

3.1 Functional analysis
The functional analysis method offers such a means of considering essential functions and the level at which the problem is to be addressed. The essential functions are those that the device, product or system to be designed must satisfy, no matter what physical components might be used. The problem level is decided by establishing a boundary around coherent subset of functions. [8]

Functions
- Transporting the material into the trolley.
- Movement of the (robot) trolley once it's triggered.
- Sensing the presence of any object in the path by the proximity sensor and restricting the movement of the trolley.
- Recognizing the path to be followed.
- Delivering the material to the area of interest.

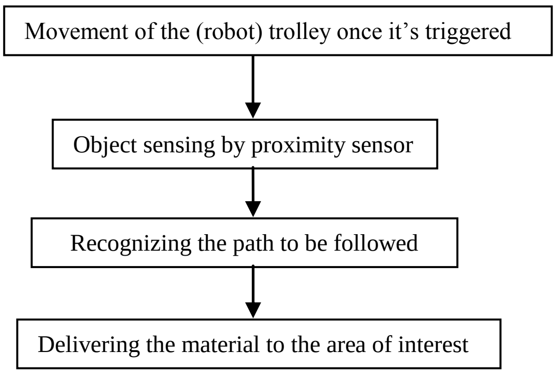

Figure 5: Flow diagram of functions

3.2 Design

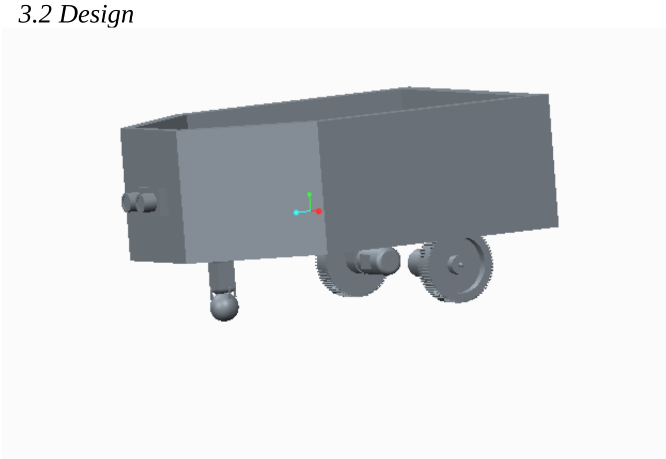

Figure 6: Final Design

There are many reasons which yield to the creation of Material Handling Robot (MHR) around the world. Mostly the reason is to overcome the logistic problems that often occurred in the workplaces and to make improvement to the facilities provided in the workplaces. Usually the MHRs are implemented in factories, hospitals, offices, houses, and even can be found anywhere outdoors without the people surround realized it. In the industries or factories, the MHRs can ease the physical strain on human workers by performing tiring tasks, such as lifting and carrying heavy materials, more efficiently with no signs of fatigue creeping in. They can carry far more than human workers, and their movements can be tracked electronically at all times. Their movements can be timed to feed or collect products or materials from the work cells in the factories

3.3 Detailed design
FABRICATION DETAILS AND DRAWINGS
- The dimensions of each designed part are shown in detail in the 2D view.
- The sensing element is an ultrasonic sensor which has a detection range of half a meter.
- It has two rear wheels and one front Castrol wheel which makes the movement of the trolley easier.
- The rear wheels are motor driven which are sensor based.

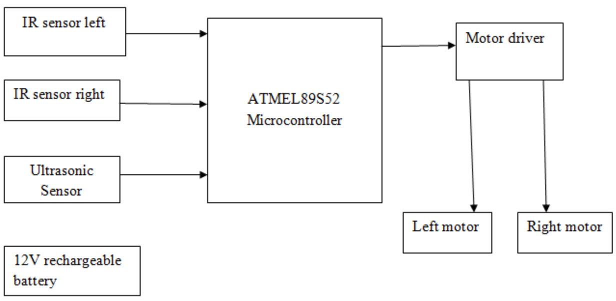

Figure 7 Block diagram

COMPONENTS OF MATERIAL HANDLING ROBOT

1. MECHANICAL PARTS

The Mechanical components includes,

1. Chassis
2. Steering system
3. Ultrasonic sensor for obstacle detection

Chassis:

- Act as a frame for attaching other components
- Carry the load of other components and the payload.
- Act as sacrificial component to prevent damage of expensive payload in case of accidents

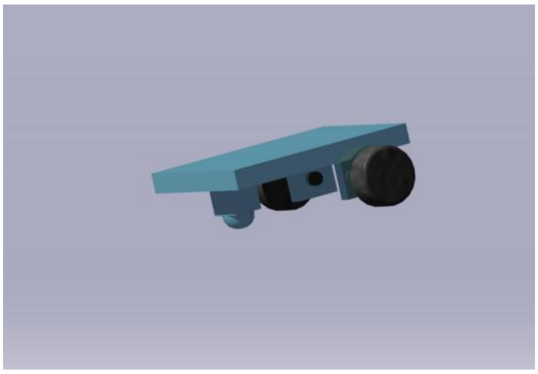

Fig 8 Chassis of Material Handling Robot

Tàble 2 Technical Data of Chassis

Features	Data
Length	300mm
Breadth	160mm
Height	62mm
Material	Colored Acrylic sheet, Aluminum
Maximum load	
Mounting Holes	14×3mm ø Holes for general mounts 2×8mm ø Holes for motor 1×10mm ø Hole for switch

Steering System:

Steering system is for steering the Material Handling Robot. The two individual motors are directly attached with the rear wheel for steering and a single Castrol wheel is at the front.

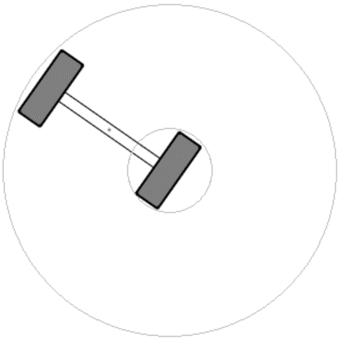

Fig 9 Small radius turning

If one of the wheels is stopped, while the other continues to rotate, the robot will pivot around a point centred approximately at the mid-point of the stopped wheel.

Table 3 Steering Specifications

Feature	Data
Wheel Base	180mm
Wheel Diameter	70mm
Track Distance	170mm
Material	Rubber and plastic
Turning radius	190mm

Ultrasonic sensor for obstacle detection:

In controlling and designing Material Handling Robot (MHR) systems the problem of prevention of MHR collisions and deadlocks should be addressed. By attaching ultrasonic sensors on MHRs, physical collisions can be avoided. An MHR should have the ability to avoid obstacles and the ability to return to its original path without any collisions.

2. ELECTRICAL COMPONENTS

Electrical components include the motor and the power supply unit for the motor, sensing unit

DC MOTOR

100 RPM DC Motor with Gearbox generally used for robotic application are used for the driving mechanism, steering mechanism and lifting mechanism. We can adjust it to desired RPM using gear box. Very easy to use. It is excellent for line tracking robotic application.

Fig 10 DC Motor with Gear box

Table 4 Motor Specifications

Feature	Data
Supply voltage	12V DC
Speed	100 RPM with gear box
Shaft Diameter	6mm
Weight	125gm
Torque	12Kgcm
No-load current	60mA(Max)
Load current	250ma(Max)

BATTERY

The power required for the entire working process is given by a Rechargeable valve regulated Lead-Acid battery. The power from the battery is split it into two and one part is given to microcontroller, display unit, driving unit and other part is given to lifting motor.

Figure 11 Battery

Table 5 Battery Specification

Features	Data
Speed	100rpm
Voltage	12V DC
Torque	12Kg-cm
No load current	60Ma
Load current	250Ma

3. ELECTRONIC COMPONENTS

Electronic components provide sensing, logical decision and control of the vehicle. It includes microcontroller, which is the brain of the vehicle for the decision logic, the motor driver as both sensing and control of motor, regulator ICs, sensors for sensing the path, position of loading and unloading stations, detect object in the path etc.

MICROCONTROLLER

FEATURES

- Compatible with MCS-51™ Products
- 4 Kbytes of In-System Reprogrammable Flash Memory Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 128 x 8-Bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low Power Idle and Power Down Modes

Table 6 Specification of AT89C51

Type:	32Pin DIP Package
Flash	4K Bytes
I/O pins	32 Pins
Minimum/Maximum Voltage:	5
Maximum current:	20Ma
Number of PORTS	4
No of channels	6
Bus width	10Bit
Oscillation Speed	20Mhz
PWM	6

Motor driver

It is an electronic circuit which enables a voltage to be applied across a load in either direction. It allows a circuit full control over a standard electric DC motor. That is, with an H-bridge, a microcontroller, logic chip, or remote control can electronically command the motor to go forward, reverse, brake, and coast.

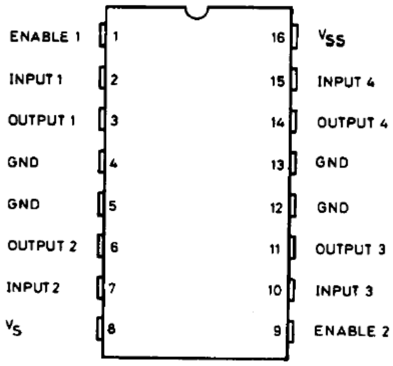

Figure 12 Motor Driver (L293D)

The following figure shows the connection of the driving mechanism.

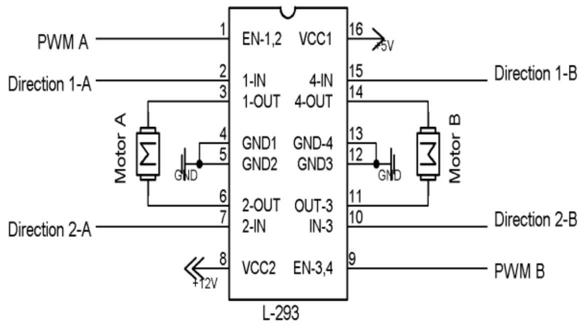

Figure 13 L293D connected with two motors

4. SOFTWARE COMPONENTS

Computer is used for making and implementing program for the microcontroller, using embedded computer programming language. For this project we use ATMEL89C51 microcontroller. The ATMEL89C51 can be programmed with the Kiel-µvision software.

MICROCONTROLLER PROGRAMMING

```
#include<reg51.h>
Sbit p10=P1^0;
Sbit p11=P1^1;

sbit p20=P2^0; // forward movement of Motor 1
sbit p21=P2^1;
sbit p22=P2^2;
sbit p23=P2^3; // Forward movement of Motor 2

void main(void)
{
 p10=1;
 p11=1;
 p12=1;
 p13=1;

 p20=0;
 p21=0;
 p22=0;
 p23=0;
 while(1)
```

```
{
 if((p10==1) && ()p11==0) Forward
{
   p20=1;
   p21=0;
   p22=0;
   p23=1;
}
else if ((p10==0)) // Right
{
   p20=1;
   p21=0;
   p22=0;
   p23=0;
}
else if ((p11==0)) // Left
 {
  p20=0;
  p21=0;
  p22=0;
  p23=1;
}
)
}
```

CALCULATIONS

Torque of DC motor used, T = 12Kg-cm
= 1.1772 N-m

Speed of motor, N = 100 RPM

Angular Velocity, ω = $2\Pi N/60$
= $(2*\Pi*100)/60$
= 10.47 rad/sec

Physically Power is the rate of doing work. For linear motion, power is the product of force multiplied by the distance per unit time. In the case rotational motion, the analogous calculation for power is the product of Torque multiplied by the rotational distance per unit time

Rotational Power, P = $T * \omega$
= 1.1772*10.42
=12.33 W

No. of motors available for driving mechanism = 2 motors
So total power available for driving = 2* 12.33
= 24.66 W

While the range of obstacle detection is good enough as it is able to detect obstacles within a range of 1m and as result it turns out to be a convenient to be used when something barges in.

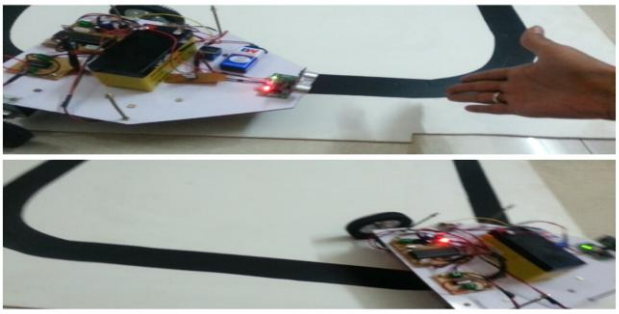

Figure 14 Material handling robot testing

4. Conclusions

The Material Handling Robot (MHR) is a productivity increasing feature in a factory. During the manufacturing of this MHR it was found many of intelligence that can be given to it. It provides the basic functions like line following and collision avoiding. And the main function, transportation of goods from station to station. The followings are the main features of the prototype which has been fabricated.

1. Speed of delivery
2. Adaptive to changes in factory layouts
3. Avoid collision with other objects
4. Reduction in labor cost
5. Reduction in running cost compared to conveyer systems
6. Ability to add sensors to detect the payload conditions
7. Ability to adjust the lifting time
8. Continues cycle of working
9. Conditions for line following can be changed easily

Automatic Guided Vehicle can be used in a wide variety of applications to transport many different types of material including pallets, rolls, racks, carts, and containers. AGVs excel in applications with the following characteristics:

- Repetitive movement of material over a distance
- Regular delivery of stable loads
- Medium throughput/volume
- When on time delivery is critical and late deliveries are causing inefficiencies
- Operation with at least two shifts
- Archive Systems
- Cross Docking
- Distribution
- High Density Storage
- High Speed Sortation
- Material Flow and Transport
- Production and Manufacturing Delivery Systems
- Production and Manufacturing Support Systems
- Warehouse Management and Control
- Work-In-Process Buffers

The fabricated models have following advantages while comparing with the existing models of this kind. The analysing of advantages helps to motivate the fabrication of MHR in the manufacturing industries. The important advantages of the prototype are given below

- ✓ Reduce manpower
- ✓ Increase productivity
- ✓ Eliminate unwanted fork trucks
- ✓ Reduce product damages
- ✓ Maintain better control of material management
- ✓ Traffic control is not needed in this system because of single carrier
- ✓ Suitable to transfer frames

- Each of the machines have their own merits and demerits. The
- followings are the limitations of the prototype fabricated:
- Installation cost is very high.
- MHR are fragile and should be handled with care.
- Regular care, inspection and maintenance needed
- Should be recharged periodically
- MHR will stop delivery when it is forced off the path.

Battery should be recharged during intervals.
Sun light affects the movement.

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