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A Light Tracking Automated Guided Vehicle for Oil Pipeline Leakage Detection

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Abstract— Leakages occur in oil pipelines due to several causes, e.g, weathering of the pipeline material, pipeline vandalism, etc. Tracking a leakage in an oil pipeline can be very cumbersome and unfruitful if carried out manually. An Automated Guided Vehicle (AGV) is a set of cooperative driverless vehicle, used on manufacturing floor and coordinated by a centralized or distributed computer-based control system. AGVs-based Material Handling Systems (MHSs) are widely used in several Flexible Manufacturing Systems (FMS) installations. In this research work, an AGV with the ability to sense light and track it, then convey the GPS location of the light (which represents a leakage in the pipeline) as a Google maps link to a registered mobile number was designed and consttructed. The microcontroller that is being employed to attain this objective is the Arduino Uno, which houses the Atmega328 microprocessor as its brain box. The AGV is able to avoid obstacles by using the principle of sonar location, i.e. using ultrasonic (sound which cannot be heard by the human ears) to determine the distance of an object or obstacle near it. The AGV is made to sense light using Light Dependent Resistors (LDRs) mounted at the left, right and in front of it. Low cost Global PositioningSystem, GPS and Global System for mobile communication, GSM modules have been used to get the location and send text messages.

Index Terms— Automated guided vehicle, pipeline, leakage, detection, automation, material handling systems, GPS.

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1 Introduction

THE creations of Automated Guided Vehicle (AGV) have been around since the 1950's and the technology was first developed by Barret Electronics from Grand Rapids, Michigan. It was then developed by the Europeans in the 1970's and nowadays AGVs can be found in any countries. One of the first AGVs was a towing vehicle that pulled a series of trailers between two points, and today's there are many task given to AGVs and they also have their own name and potentials.

Considering the full potentials and advantages of the Automated Guided Vehicle (AGV) in our livings, it is valuable to do this project, as it also will be the first step towards the creation of more intelligent technology or system. The simplest AGV model may use just a sensor to provide its navigation and can be the complex one with more sensors and advance systems to do the task. They can work or do the task everywhere needed but the safety for the AGV as well as the people and environment surround it must be provided.

The AGVs is just the same as mobile robot, which can move from one place to another to do their task, which in this project is to sense light and report its gps coordinates through gsm; but mostly the mobile robot is used for difficult task with dangerous environment such as bomb defusing. Furthermore, the mobile robot can be categorized into wheeled, tracked, or legged robot. Although the AGVs may not be glamorous of robots, but their work, which usually menial, are often be essential to the smooth running of factories, offices, hospitals, and even houses. They can work without any complaint around many workplaces all over the world.

An automated guided vehicle or automatic guided vehicle (AGV) is a mobile robot that follows markers or wires in the floor, or uses vision or lasers, or LDRs as a means of vision. They are most often used in industrial applications to move materials around a manufacturing facility or a warehouse or in pipelines for detecting leakages.

Automated guided vehicles increase efficiency and reduce costs by helping to automate a manufacturing facility, warehouse, or surveillance and tracking applications. The AGV 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 AGV 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 AGVs use fork lifts to lift objects for storage. AGVs 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.

An AGV can also be called a laser guided vehicle (LGV) or self-guided vehicle (SGV). Lower cost versions of AGVs are often called Automated Guided Carts (AGCs) and are usually guided by 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.

AGV applications are seemingly endless. The Aim of the project is to design and fabricate such an AGV which tracks light which are present in pipeline that have leakages, and report the gps coordinates of the exact location which the light was detected to a mobile number through GSM..

2 Literature Review

The first big development for the AGV industry was the introduction of a unit load vehicle in the mid-1970s. This unit load AGVs gained widespread acceptance in the material handling marketplace because of their ability to serve several functions; a work platform, a transportation device and a link in the control and information system for the factory.

Since then, AGVs have evolved into complex material handling transport vehicles ranging from mail handling AGVs to highly automated automatic trailer loading AGVs using laser and natural target navigation technologies. Since then, AGVs have evolved into complex material handling transport vehicles ranging from mail handling AGVs to highly automated automatic trailer loading AGVs using laser and natural target navigation technologies.

In fact, the improvement of AGVs over the last decade is deeply indebted to development of Scheduling, Algorithm and Steering methods [1]. The work in [2] showed how the additional consideration of the material handling system and limited buffers degrades the system performance. The work [3] developed a real-time algorithm in which material handling transporters are considered.

The authors [4] highlighted the importance of material handling and they compared several AGV dispatching rules. They also showed how the buffer capacity can affect the performance of the system

3 Methodology / System Design

The project consists of LDRs, Ultrasonic Sensors, GPS receiver and GSM modem with an Arduino microcontroller. The whole system is attached to the vehicle. The LDR Sensors are configured to sense light intensity and report when the light intensity is beyond a threshold pre-programmed value. So, the GPS system will get the longitudinal and altitude values corresponding to the position of vehicle when the light intensity is beyond a certain threshold value, embed it into a Google maps link and send it to the user via GSM Modem.

The block diagram in fig.1 shows the overall view of the system.The blocks that are connected here are Microcontroller, GSM Module, GPS Module, Motors, Power supply, Light sensors (LDR), and Ultrasonic Sensors. The Power supply used is lithium ion batteries. These were chosen because of their very high current storage capacity at lower voltages

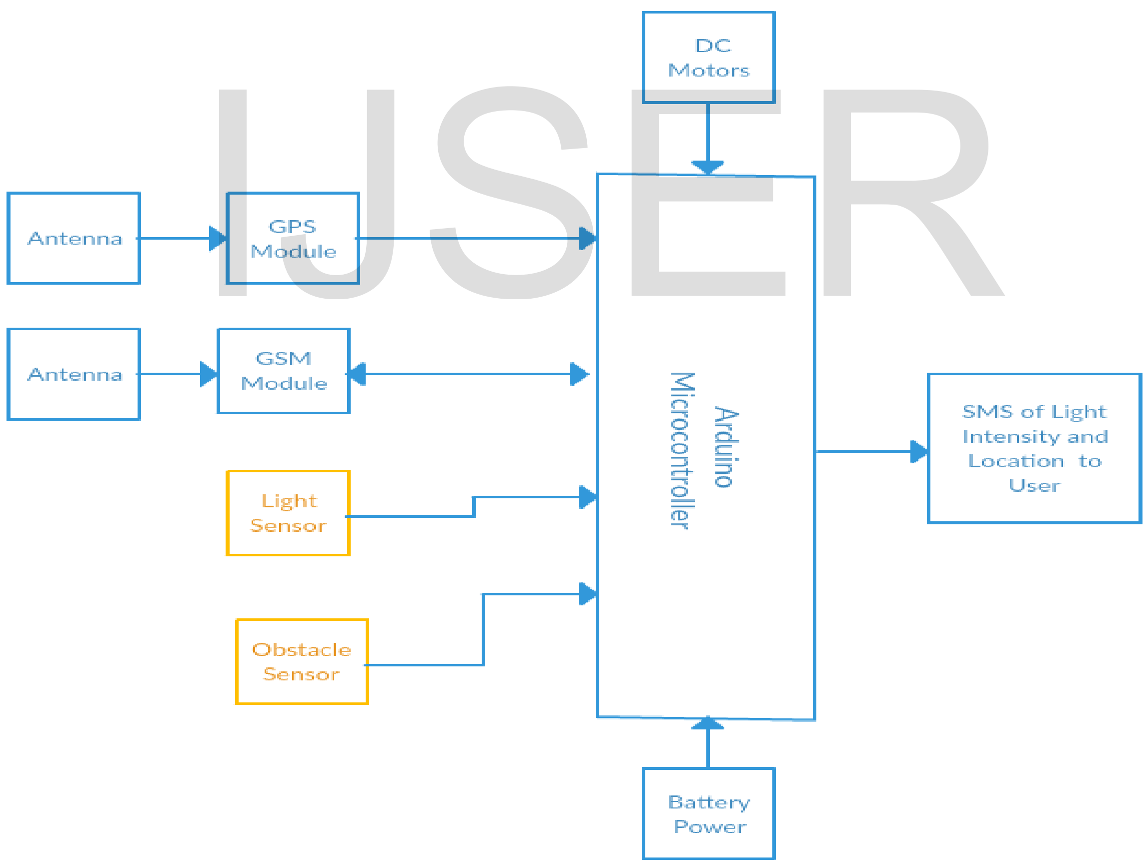

Figure 1: Block Diagram of Light Tracking Robot

The project uses Arduino as the controlling element. It uses Light Dependent Resistor (LDR). When light comes in the path of sensor then sensor gives +5V to Arduino board. This +5v is

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detected then Arduino board decides to run the robot by taking left or right turn. If the sensor gives 0v to Arduino board, that means there is no light present in its path so it would keep moving until any light is detected.

One light detector resistor is fitted on front of robot while two are fitted on the left and right side. The connection can be given from main circuit to sensor using simple connecting wires.

Two motors namely right motors and left motors are connected to driver IC (L293D). L293D is interfaced with the Arduino board. Arduino board sends logic 0& logic1 as per the programming to driver IC which moves motor left, right and forward direction.

The GPS module works hand in hand with the GSM module and they both function to send the coordinates of the current location where the light intensity is beyond the threshold value.

One Ultrasonic sensor is placed at the front of the vehicle. This helps the vehicle to be able to avoid obstacles. The ultrasonic sensors measure the distance between the vehicle and the object right in front of it and uses this value to compare with a fixed threshold value which has been coded in the program, it then uses this value to determine if there's an obstacle in front of it or not.

The solar panels used today are mostly stationary and do not have the ability to grasp all the energy of the sun because of its inability to shift its position according to the movement of the sun. Because of the still stature of the harnessing methods used today it may not be able to receive the best part of the energy which is hitting the surface of the earth. The machine which has been designed (Photo-vore) for this particular job has the ability of detecting the presence of light in an area and following the path illuminated by it. This is a really good application of an LDR (light dependent resistor) since it involves the detection of light with the help of the LDR and the intelligent independent behavior of the machine based on the reception of solar energy.

3.1 Light Sensor Analysis

The sensor that is being used in this project is Light Dependant Resistor (LDR). It is made up of Cadmium Selenide (CdS). CdS is mainly used as a pigment. CdS and Cadmium Sele-nide are used in manufacturing of photoresistor (light dependent resistors) sensitive to visible and near infrared light. CdS was also one of the first semiconductor materials to be used for thin film Transistors (TFTs). In thin-film form, CdS can be combined with other layers for use in certain types of solar cells.

A photo-resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

The LDR exhibits photoconductivity. It can also be referred as photo-conductor. Its resistance decreases with increasing light intensity and vice versa. In bright light its resistance can go down to few ohms. In the dark, its resistance goes in the range of mega ohms.

To use them as a sensor, we need to measure the voltage drop across the resistor with the analog port of Arduino board (because a change in resistance means a change in voltage).

To choose resistor values, solve this equation:

$$(R * V_{in}) / (R + R_{photo}) = V_{out} \text{ .... (1)}$$

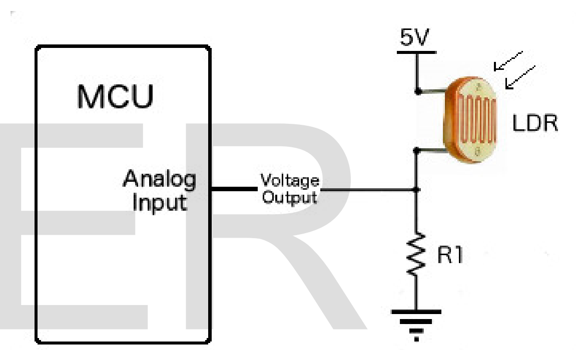

Figure 2: Voltage Divider Circuit with Light

There are three steps to determining what resistor we should use for R. To do this, it is necessary to use a multi-meter to measure the resistance across the photo-resistor in two situations. The first situation is the darkest situation the robot photo-resistor will experience.

The second situation is for the brightest light the robot will experience. For this, both resistance values are multiplied, then the square root of the product is found. This is the resistor to be used.

$$Resistor = \sqrt{R_{dark} \times R_{bright}} \text{ .... (3)}$$

The first photo-resistor that was used gave the following value:

$R_{photo} = 4\,K\Omega$

$R_{dark} = 0.8M\Omega$

$R_1 = \sqrt{4K\Omega} \times 0.8M\Omega$

$= 5.65K$

The second photo-resistor that was used gave the following value:

$R_{photo} = 18\ K\Omega$

$R_{dark} = 1.8M\Omega$

$R_1 = \sqrt{18K\Omega} \times 1.8M\Omega$

$= 5.692K\Omega$

3.3 Obstacle Avoidance

For obstacle avoidance, HC-SR04 Ultrasonic sensor modules have been employed. Ultrasonic sensors emit short but high-frequency sound pulses at regular intervals. These pulses travel through the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo. As the distance to an object is determined by measuring the time of flight and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background interference.

3.4 Steering Analysis

The steering system used by the vehicle is of differential type. A differential wheeled vehicle is a vehicle whose movement is based on two separately driven wheels placed on either side of the body. It can thus change its direction by varying the relative rate of rotation of its wheels and hence does not require an additional steering motion. It allows the turning center to be on the vehicle body thus the ability to rotate on the point.

If both wheels rotate at the same speed and in the same forward direction, the robot will move forward in a straight line. If both wheels rotate at the same speed and in the same backward direction, the robot will move backward in a straight line. If the left wheel moves forward while the right wheel moves backwards (or does not move at all), the vehicle steers to the right. If the right wheel moves forward while the left wheel moves backwards (or halts), the vehicle steers to the left. In order to achieve a halt, Logic 0 is sent to both motor

3.5 Software Requirements

3.5.1 Arduino Compiler

The Arduino IDE is a cross-platform application written in Java, and is derived from the IDE for processing programming language and the Wiring project.. There is typically no need to edit make files or run programs on a command-line interface. Although building on command-line is possible if required with some third-party tools such a Ino.

The Arduino IDE comes with a C/C++ library called "Wiring" (from the project of the same name), which makes many common input/output operations much easier. Arduino programs are written in C/C++.

3.5.2 TinyGPS Library

The TinyGPS library contains pre-written functions which makes it easy to interface the GPS module to the Arduino microcontroller and make sense of the raw GPS data being received from the Satellites.

3.5.3 NewPing Library

The NewPing library is used to control the Ultrasonic sensor without having to write codes from scratch. It makes available functions that enable the programmer to easily get the distance in centimeters from the module attached to the Arduino.

3.6 Description of the Working Principles of the Complete System

The light tracking AGV is made up with Arduino Uno R3, SIM808 module including GSM antenna, GPS module, LDRs, and Ultrasonic Sensors. The core part of tracking system is microcontroller Arduino Uno. The geo location of a vehicle can be captured through GPS receiver and that information will be transmitted to a registered mobile number through the GSM module. The information transmitted is embedded as a Google maps link and is sent as an SMS. This google maps link is only transmitted when the AGV reaches a region of high light intensity, representing a region where there is a leakage in the pipeline.

The SIM808 module is initialized and addressed using AT commands. These commands are used to send text message to the user informing him of an area of high light intensity, hence, a leakage in the pipeline. The module and Arduino have a common ground. We had uploaded the program into the Arduino microcontroller which program is written in C programming language. Uploading program into Arduino is done by using Arduino IDE software.

The ultrasonic sensor is attached to the servo. It constantly scans so the distance in order to know when it is approaching an obstacle. When it reaches an obstacle, it scans the left and right hand side in order to determine which side if more obstacle free, then relays the information to the microcontroller which commands the motors to respond according to the direction where there is no obstacle. The algorithm for this system is represented in the flowchart in fig. 3:

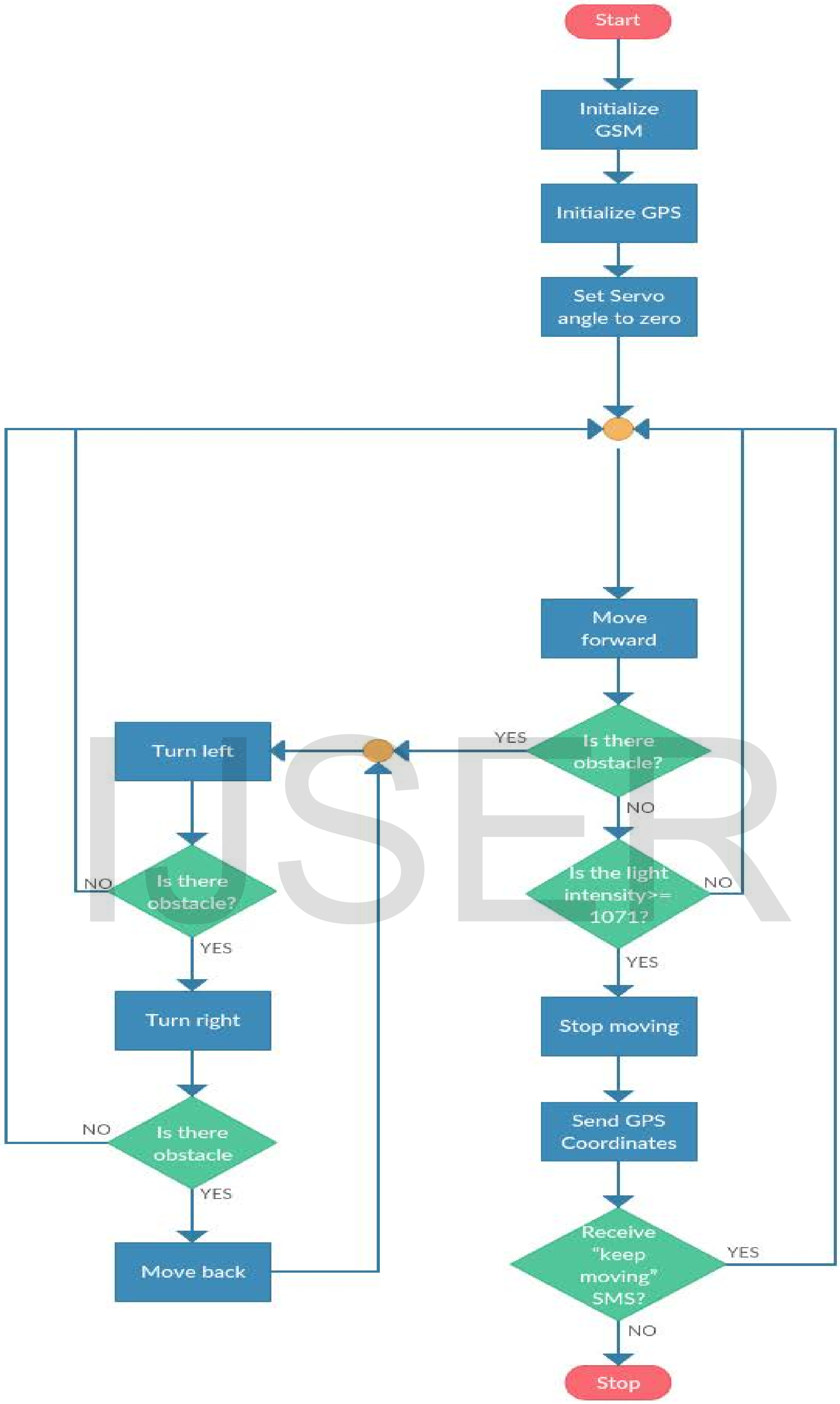

Figure 3: Flowchart of Entire System

4.0 Results And Discussion

The complete circuit diagram is as shown in fig. 4. The components were assembled as shown in the circuit diagram. The lithium ion batteries was fully charged and coupled to the circuit to provide the power necessary to drive the circuit.

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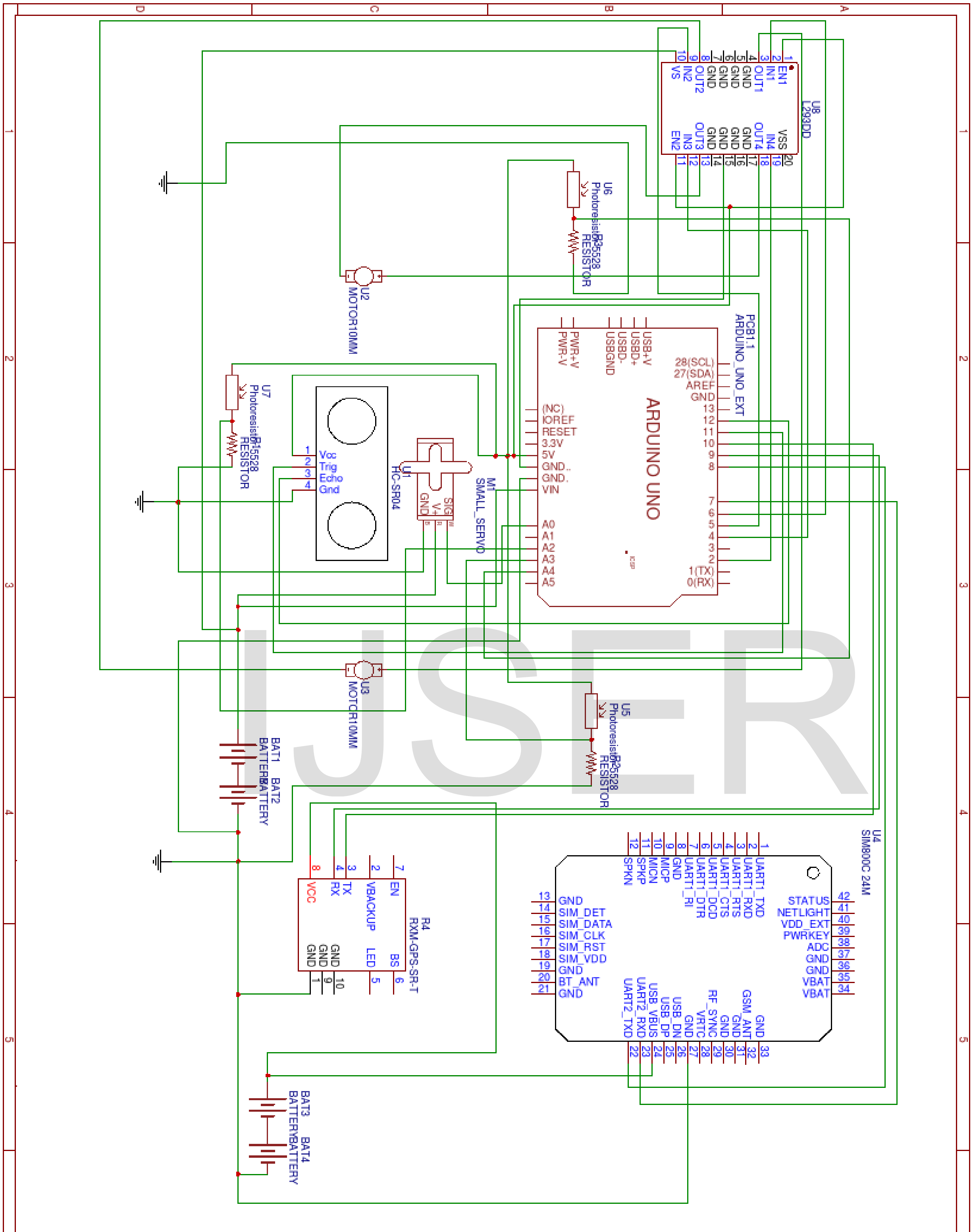

Figure 4: Circuit Diagram of the Complete Module

The prototype automated guided vehicle is as shown in fig.5.

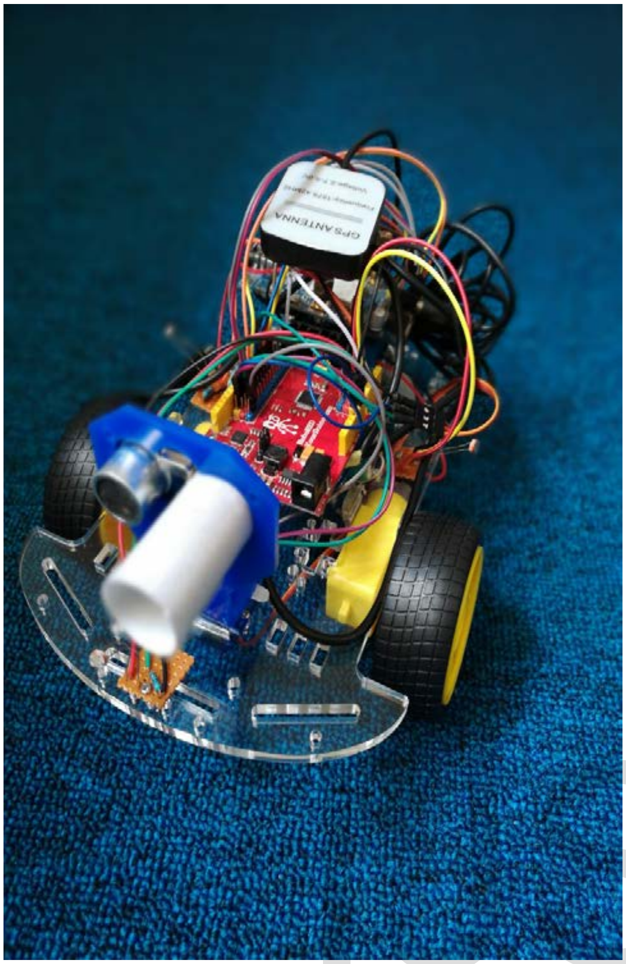

Figure 5: Fully Assembled Light Tracking AGV

A test program was written to communicate with the SIM808 module using the Software Serial library. This allows for sending of commands to the SIM808 through the Arduino. A suitable baud rate was selected for the UART communication. The baud rate chosen was 9600bps, as this is the baud rate in which the SIM808 module functions optimally. The GSM module consumes a lot of current hence, the lithium ion batteries have been employed due to their high current storage and supply capacities. The batteries used to power the module was about 3.7V 2.2Ah. two of them were paralleled to give the adequate voltage required by the module. The GPS module was connected as well to the Arduino and raw NMEA data was streamed to the Serial Monitor of the Arduino IDE. This raw data was made sense of by the Tiny GPS library which provided the longitude and latitude from the raw NMEA data.

The longitude and latitude gotten from the GPS module using the Tiny GPS library is being concatenated with a predefined Google maps link. Google maps link have a specific format in which the longitude and latitude are encoded in a URL (link).

5 CONTRIBUTION

A prototype Light tracking AGV which was able to track light and report the longitude and latitude of the location of the light i.e. leakage in the pipe to a mobile number by SMS as a direct google maps link was developed in this work. The vehicle is able to intelligently avoid obstacles that are in front of it.

A lot more can be done to improve the current state of this project. A compass module can be attached to the system to enable the AGV find its way back to its destination after it has surveyed the pipeline. Alternate Battery Pack and Battery Monitoring can be supplied to make room for situations where the battery provided does not carry enough charge for the pipeline surveillance trip. Also, the battery monitoring functionality should enable the AGV to switch power or return home in cases where the power will not successfully carry it through the trip. A video camera can also be incorporated for real time video streaming and for taking pictures of the areas where there is an assumed leakage in the pipeline to know the severity of the leakage. The AGV can also be programmed to auto-balance so it does not topple over.

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