Design and Construction of a Remotely Controlled Truck Robot for Detecting Harmful and Flammable Gases in Underground Mining

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Abstract:

Mining is one of the main sources of foreign currency in Peru, with over 50% of them in 2015, plus 20% of tax revenues, 11% of GDP and to attract the most foreign investment, among other macroeconomic factors; however, it is well known that the lifetime of most of its workers is reduced due to the high amount of contaminants found in their work area, plus occasional accidents due to flammable gases. Fortunately, the frequency of such accidents can be reduced by taking some precautions, one of which is the present project.
Keywords: Telecommand, minery, prevention, SUV, gas sensors.

I. INTRODUCTION

There are many situations in underground mining in which access for man to an area would put him on danger, or it is simply impossible because of their size; in these cases it would be convenient to send a wirelessly controlled unit, so that the controller is kept away from the area, but with clear sight of the area thanks to the camera in the device.
Another common danger within mining is the presence of substances harmful to man, sometimes being unnoticed by man. For this reason, our mining truck will perform a constant monitoring of air conditions, by analyzing the Air Quality in a certain period of time, then alerting staff if any polluting gases exceed the permissible limits or indicating that the entry to an area must be with the use of certain additional security measure.
With these functions we want to reduce the mortality rate in the mines by the explosion of flammable gases or inhalation of toxic compounds, keeping a better working environment and conserving workforce.

II. SUBJECT

A. GENERAL OBJETIVE

- It will be designed a vehicle capable of moving on uneven ground such as it is in the mines, being controlled via Bluetooth connection and a wireless camera by an operator, in order to collect data of the components that are in the air of a specific area .

B. SPECIFIC OBJETIVES

- Performing a real time image transmission using a wireless camera.
- Components of the air that could be dangerous in the mines, such as carbon monoxide (CO), carbon dioxide (CO2), methane (CH4) or nitrates (NOx), will be identified.
- Real time data will be provided to the operator about the composition of the air and environmental conditions.

C. MECHANICAL DESIGN

Mechanical properties of the mining truck

- Degrees of freedom: 2
- Weight: 4 Kg.
- Independent mechanical steering system using servo motors.
- Wheel dimension
  - ✓ Diameter: 15 cm.
  - ✓ Thickness: 3 cm.
  - ✓ Material: microporous
- Chassis dimensions:
  - ✓ Large: 40 cm
  - ✓ Width: 20 cm.
  - ✓ Height: 22 cm.

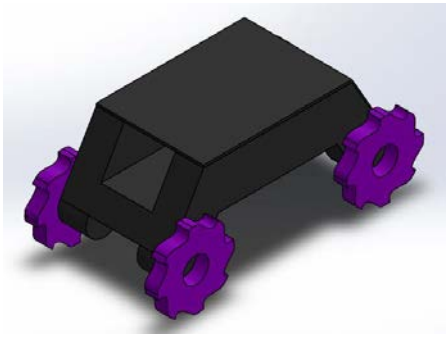

Fig.1. Model of the car made with SolidWorks

Wheel design

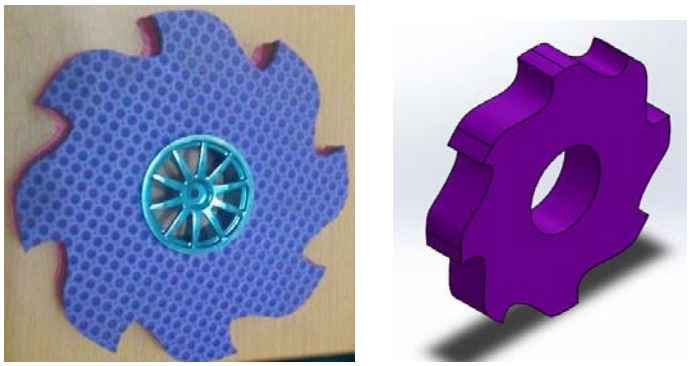

Fig. 2. Photograph taken from the wheel used in our mining truck and 3D model

With the wheel design, the vehicle stability, average speed reached, traction on the ground, fundamental characteristics can be calculated whenever the desired vehicle tries to overcome obstacles.

The geometry design is starry because their tensile properties are superior to conventional wheels. It allows advance and retreat more easily.

Mechanical and electrical characteristics of the servomotor

- Brand: Sayama engine Gear
- Torque : 6 kgf - cm
- Voltage : 24 VDC
- Power Value : 3.17 W
- Angular speed 11 RPM
- Transmission ratio 1: 500
- Operation mode: continuous.

Fig.3. Servo used for the mining car

Engine Plane:

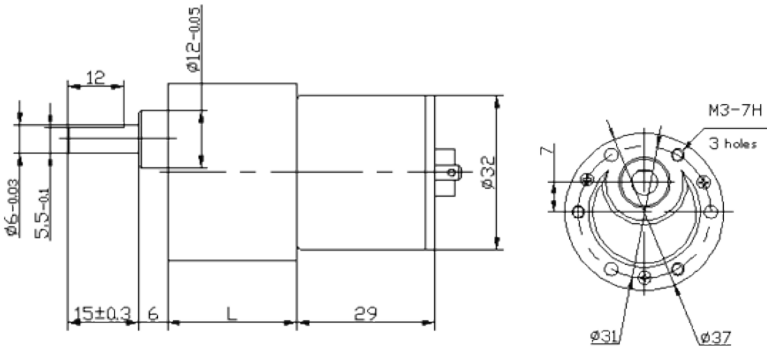

Fig. 4. Front and profile view of the motor

D. ELECTRONIC DESIGN

Electronic system

It controls the mechanical system. It consists of two voltage regulated sources, 2 of 5V and other 2 of 12V, each one with 4.4 A; an Arduino Mega , two L298N dual drivers , a bluetooth module HC-05 ZS- 040 ,MQ gas sensors and a wireless camera . Figure 5 shows the circuit diagram of the system.

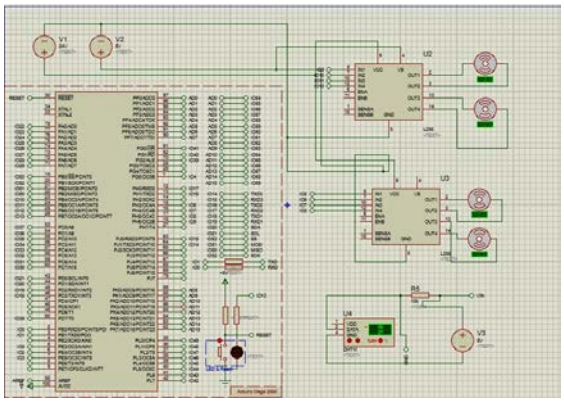

Fig. 5. Circuit diagram of the electronic system developed with Proteus

Next it will be explained each of its parts:

1. Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the AT mega2560. It has 54 digital pins of input/output (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a crystal oscillator of 16 MHz, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connecting it to a computer with a USB cable or power with an AC adapter or a DC battery to start. We use this board to control the 4 motors, receive the data supplied by the sensors and the wireless camera.

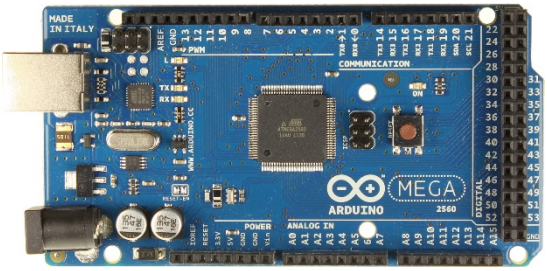

Fig. 6. Arduino Mega

1. L298N Dual Driver

The module has all the necessary components to run without additional elements, including protection diodes and LM7805 delivers 5V regulator to the logic part of the integrated L298N. In this project two of these drivers are used to control the four motors.

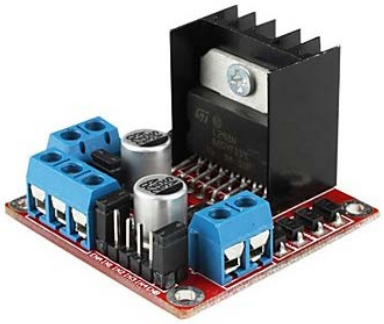

Fig. 7. L298N Driver

2. Bluetooth Module

The HC-05 Bluetooth module is factory configured to work as master or slave. In the master mode you can connect with other Bluetooth modules, while in the slave mode is listening to connection requests. Adding this module to a project can be controlled remotely from a cell phone or a laptop with all the functionality you want. The HC-05 Bluetooth module uses the RS 232 serial UART protocol. It is ideal for wireless, easy to implement with PC applications, or Arduino microcontroller modules. In this project will be used to link the mining truck with a tablet using Android interface.

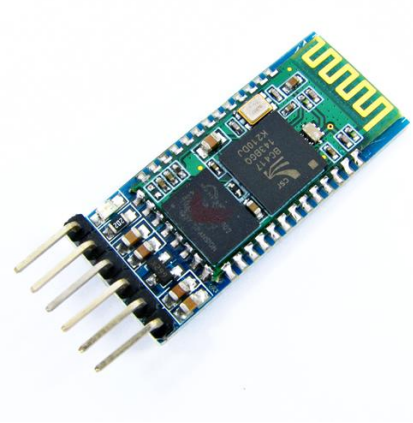

Fig. 8. Bluetooth module HC-05

3. Gas sensors MQ

This series of sensors use a small heater in the interior with an electrochemical sensor, which temperature varies the level of gas concentration. The present project will use MQ135 type, and data will be shown in the Android interface.

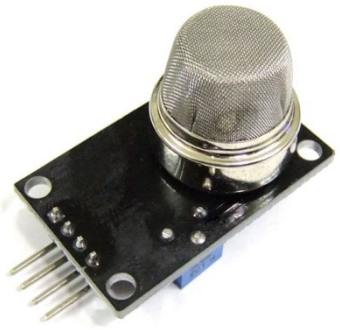

Fig.9. Shows a MQ type sensor, for detecting gases

4. Wireless Camera

Wireless Camera USB 2.0 Video Grabber, which can be also used via a direct connection to a laptop or a TV. The software used by the camera is Honestech TVR 2.5, the interface is shown in Figure 10.

Fig. 10. Camera on, the interface of the program Honestech TVR 2.5 is shown

E. ANDROID INTERFACE DESIGN

Fig.11. Android interface

Parts of the interface:

Real time images

The images, so as the data, will be transmitted to a laptop, while the controls will go from a tablet or phone.

Buttons:

Mobility: Consists of buttons to achieve adequate mobility robot.

Connectivity: Pressing this button, the different devices with which the tablet reaches connected by Bluetooth connectivity is sought; which will be chosen among the HC-05 module.

Data acquisition

The display data acquired by the various sensors such as the percentage of different gases and the temperature at which you are working is.

F. FLOW CHART MAKING PROCESS DATA SENSOR

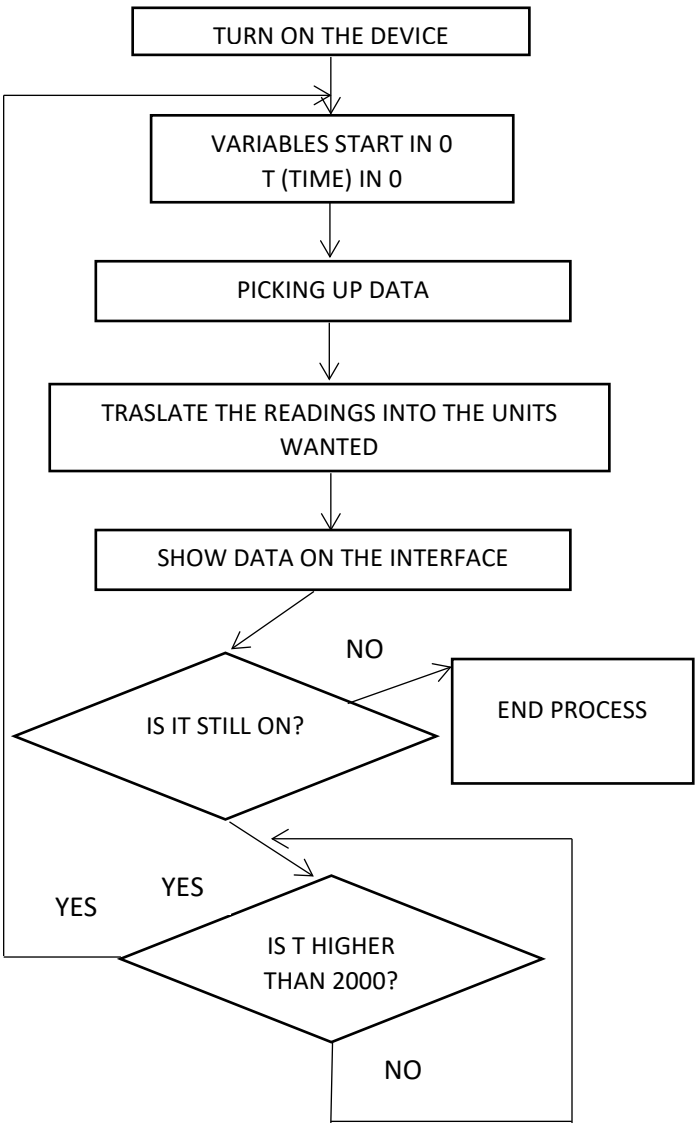

Fig . 12. Flowshart of the process of collecting data, t in milliseconds.

Arduino is used as a platform for taking sensor data for both the analysis of components of air and the temperature measurement; and Bluetooth module for wireless control.
Flowchart of the process of gas analysis was performed as this is the most interest in the project.
When the device is turned on, the variables start at 0, including the time, which gradually advance without the need of a counter. After this, the sensor signals will have to be transformed before being shown in the Android interface, the operation will be repeated every 2 seconds.
If the system is offline, the action is interrupted, shutting down until being turned on again.
For the carriage movement must be taken into account which engines should go on for move in which direction and how fast.

III. RESULTS

• For the sensors:
Tests were conducted to test the gas sensor MQ135, getting the tables below show:

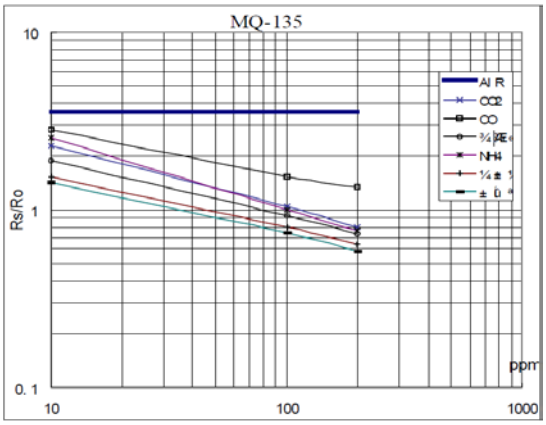

Fig.13. Graph showing the relationship between the sensor resistance against the gas concentration.

The concentration of the analyzed gas is shown in the abscissa of figure 13, in parts per million (ppm); while on the ordinate, the resistance ratio is shown, which is calculated as the quotient of the sensor resistance to other gases between the strength of the sensor to 100 ppm to the NH3. A decreasing linear trend is noted in the chart, which is corroborated by the MQ135 datasheet.

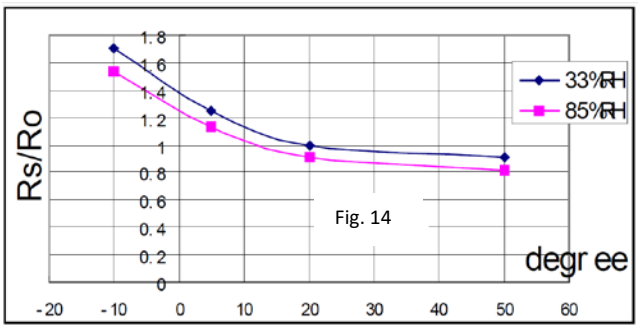

Fig. 14

Fig.14. Graph showing the relationship between the sensor resistance and temperature for different moisture contents.

Figure 14 helps to determine how the sensor resistance varies according to environmental variables, such as temperature and humidity. It can be noticed that, taking humidity as a constant, the resistance decreases by increasing temperature; if we maintain constant temperature, we noticed that the resistance increases with humidity. Again, this information is corroborated by the product datasheet
.
• For the camera:

We use a wireless camera New Pro Series USB 2.0 Video Grabber, using the HD DVR 2.5 Honestech program, achieving an image in real time up to 30 frames per second (fps) with a resolution of 720x480.

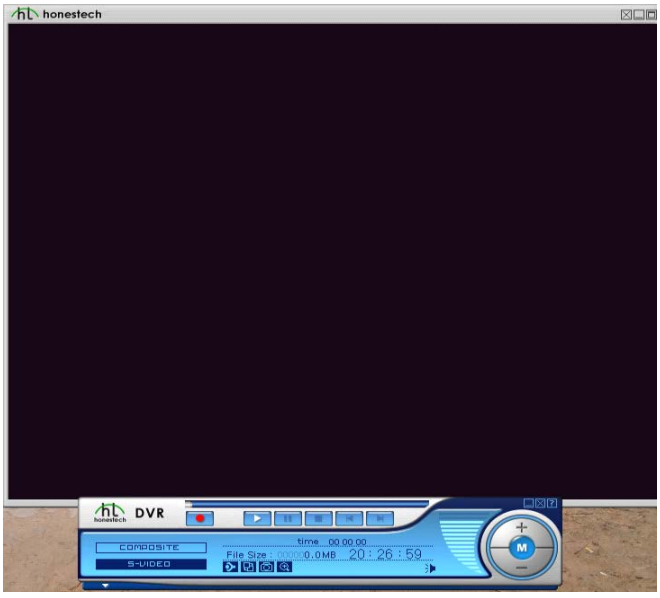

Fig. 15. Interface program Honestech HD DVR 2.5

Wireless control tests were performed with a range up to 10 meters with the mining car, value that can be easily surpassed by only the camera , but not broader performed for reasons of space and because of the limited range that gives the bluetooth .

IV. CONCLUSIONS

-The range of the mining truck may be increased if a wider module is used, such as the XBee compared to the bluetooth module, a goal that can be achieved to obtain better financing.

-The gas gamma detected by the project could be increased if there where sensors that work according to the requirements of the mines, it is worth noting that some of the existing have very high prices in comparison to the ones we use.

-It is necessary that the vehicle has the power to move on uneven ground as it is on the mine, and a traction system to help non-slip on the surface of the rocks, whatever the size, the said requirements are satisfied by our mechanical design.

-The Android interface allows us to share data in real time with the user, whether images, using the wireless camera; as information of the environment, using the sensors and Arduino; in addition, it can be supported by a large number of current mobile phones.

V. REFERENCES

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