PICAR : Pipe Inspection and Cleaning by Automatic Robot

Saransh Sharma (B17057)[S], Satyam Shukla (B17058)[SS], Nabeel Khan (B17130)[NK], Nitin Mittal (B17132)[NM], and Vikas Verma (B17030)[V]

[S]b17057@students.iitmandi.ac.in
[SS]b17058@students.iitmandi.ac.in
[NK]b17130@students.iitmandi.ac.in
[NM]b17132@students.iitmandi.ac.in
[V]b17030@students.iitmandi.ac.in

***Abstract*—In this project, we have made a robot which makes the tedious job of inspecting and cleaning the pipes easier. It can go inside pipes of different diameters(ranging from 25cm-35cm) using its three wheels. It is also installed with a motor in front of it where a drill can be attached to clean the blockages inside the pipe. You can control the bot wirelessly by your mobile phone. These days a lot of human labour is being used in industries for the purpose of inspecting and cleaning pipe, which can be saved by our robot.**

I. Introduction

PICAR uses linear actuator to expand and contract its 3 wheels according to diameter of pipe. It moves inside the pipe with the help of motors which are controlled by Arduino Nano. And all the commands are given to Arduino Nano from mobile phone via bluetooth.

A. Components

All the components used are mentioned below

1) Arduino: Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. It was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming.
Arduino Nano is a compact and breadboard-friendly version board based on ATmega328 processor. It consist of 6 analog inputs, 14 digitals output where 6 of them support PWM, and 16Mhz clock speed.

2) Bluetooth Module: A BlueTooth module is usually a hardware component that provides a wireless product to work with the product. The HC-05 Bluetooth Module has 6 pins -

1) ENABLE - to turn on the module
2) VCC - Supply Voltage
3) GND - Ground pin
4) TXD RXD - acts as an UART interface for communication

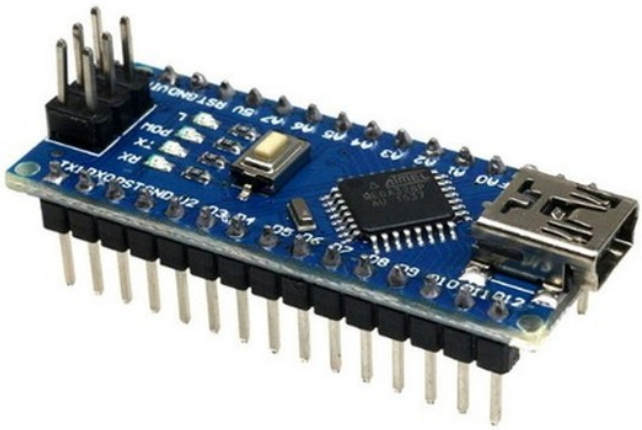

Fig. 1. Arduino

5) STATE - acts as a status indicator
6) BUTTON SWITCH - used to switch the module into AT command mode

3) DC Motor: A direct current or DC motor, converts electrical energy into mechanical energy. It is one of two basic types of motors: the other type is the alternating current or AC motor. Among DC motors, there are shunt-wound, series-wound, compound-wound and permanent magnet motors.
We used DC Motor(the one used for changing diameter) with following specifications
RPM: 100 at 12V
Voltage: 4V to 12V
Stall torque: 10Kg-cm at stall current of 1.3Amp.
Shaft diameter: 6mm
Shaft length: 22mm
Gear assembly: Spur
The reason for using high torque motor was to make the heavy assembly easily movable.

For wheels,we used 3 dc motors(geared) with following specifications.
Voltage : 3V to 9V

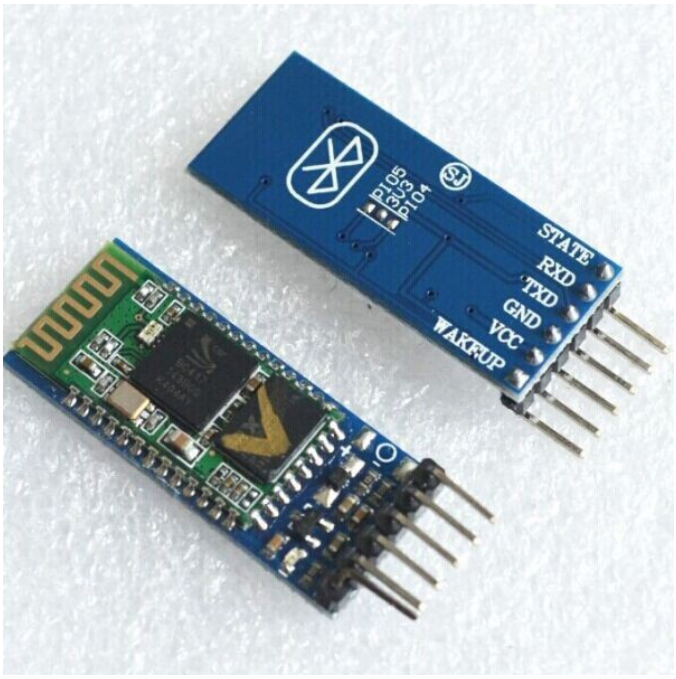

Fig. 2. Bluetooth Module

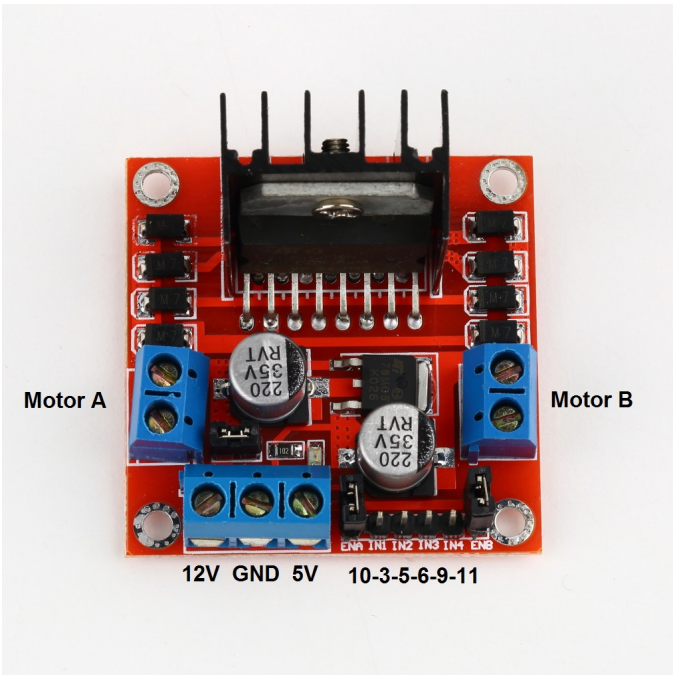

Fig. 3. Motor Driver

30gm weight
Ability to operate with minimum or no lubrication, due to inherent lubricity.
Stall torque: 1.9 Kgf.cm
Here we needed speed and not much torque ,so we used a low torque motor.

4) Motor Driver: The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. L298N is an integrated circuit multi watt 15 package and capable of giving high voltage. It is a high current dual full-bridge driver which is designed as to accept standard TTL logic levels. It can drive inductive loads e.g relays, solenoids, motors (DC and stepping motor) etc

5) Li-ion Battery: A Li-ion battery is a type of rechargable battery in which lithium-ions move from the negative electrode to the positive electrode during discharge and reverse in charging.

B. Motivation behind the idea

Our motivation was huge human labour employed in oil industries just to inspect the pipes used for transportation. There is no method to inspect and repair such pipes without employing huge cost and human labour. We made this robot to overcome this problem make this task cost efficient as well as fast and reliable.

C. Target Audience

Primary customer for our Project will be household pipe system which require regular maintenance. But our Project is

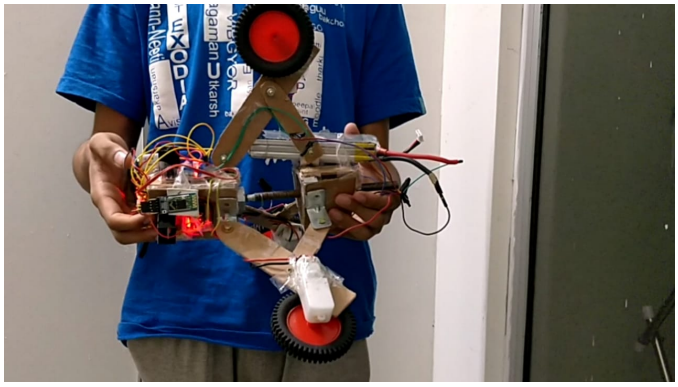

Fig. 4. Device

extremely versatile and after installing some extra components , it can be modified to be used in oil transportation pipes , sewage systems and in other industries which use pipes for transporting various materials. One suggestion that we got was , a miniature version of this robot can be made which can go inside human veins and can be used by doctors for medical purposes , although it is not possible using current technology we have but still is a good future prospect.

II. Implementation of PICAR

A. Making of Device

The task started with the mechanical parts of the device..

1) We built a linear actuator to be placed at the centre of the device to handle the contraction and expansion mechanism. The actuator was built out of a simple nut

Fig. 5. Linear Actuator

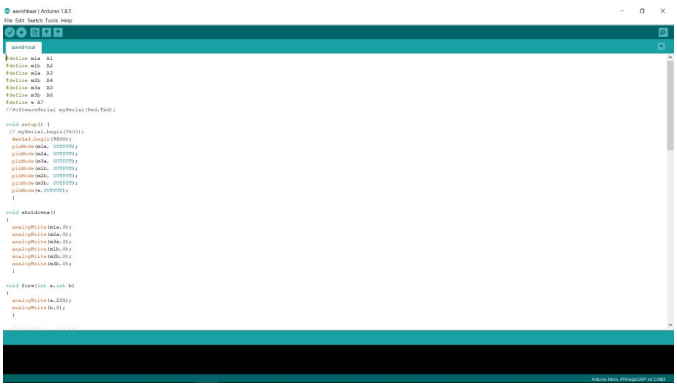

Fig. 6. Code snippet 1

bolt assembly with the bolt mounted on a 100 rpm high torque DC motor while the nut was kept unattached.

2) Next, an assembly to mount the wheels and motors was built which was to be attached to the actuator assembly. This assembly consisted of three simple hinges with one part of all hinges connected to the central motor and the other part connected to the nut. The motor was placed on the hinge which accounted for the outward motion. The task started with the mechanical parts of the device.
3) The following piece of code was hard coded into the Arduino Nano using Arduino IDE.
4) The Arduino Nano was connected to all the other components using the following connections.

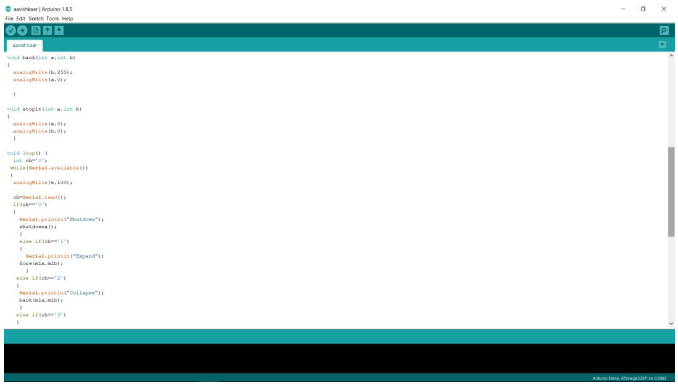

Fig. 7. Code snippet 2

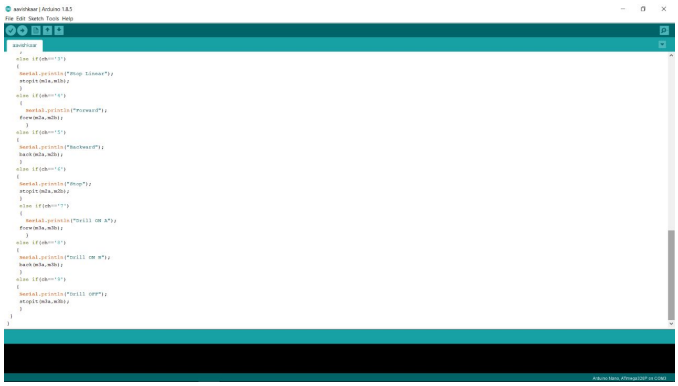

Fig. 8. Code snippet 3

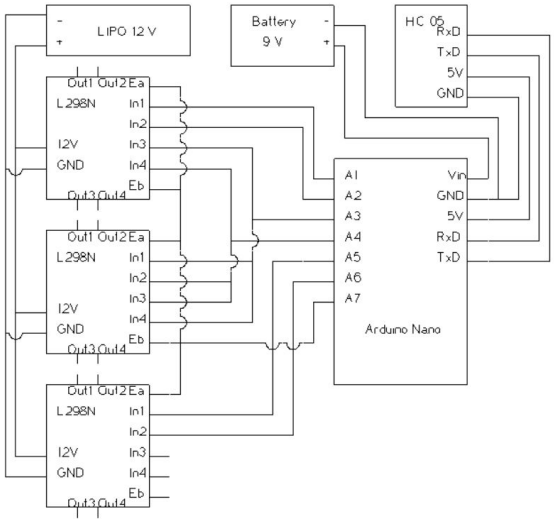

Fig. 9. circuit

B. Working of the Device

1) Changing the Diameter of the device
This depends on the linear actuator placed at the centre of the device. The linear actuator we created is known as a mechanical actuator known for its high durability

and low cost. A hinge assembly was attached to the sides of the actuator to give the diameter increasing and decreasing motion.

2) Forward and Backward Motion
The diameter increasing motion that we had provided to our device also gave it a reasonable normal reaction which helped the tires maintain a grip on the edges of the pipe holding the device in a position parallel to the pipe.
Moving all the three tires together then gave it a forward or backward motion as required while the actuator held the tires in place against the walls of the pipe.

3) Wireless Commands
Giving the device a reasonable power source and balancing it in structure was the first step towards making it wireless. A bluetooth module was installed in the electrical circuit for giving the commands via any other device that supported bluetooth. The bluetooth module contacted with the arduino using its RxD and TxD pins

4) Drill Assembly
A high rpm motor was installed at the front of the device which could be activated whenever the device faced any blockage in order to loosen or remove it. Any suitable drill head could be installed on the device as per the requirement.

C. How to Use

The commands were simple number based commands with the HC-05 module responding back with the command executed.
The commands are:
0 - Shutdown
1 - Expand Structure
2 - Collapse Structure
3 - Switch off the centre assembly
4 - Forward Motion
5 - Backward Motion
6 - Stop Moving
7 - Drill Active (Clockwise)
8 - Drill Active (Counter- Clockwise)
9 - Drill Off

There are a few steps to be taken to use the device inside any pipe.

a) Check that all the systems are working by giving the commands one by one.
b) Place PICAR at the centre of the pipe and increase its diameter until the wheels have a firm grip at the edges of the pipe.
c) Give the simple commands for the forward and backward motion until you reach the blockage or detect the blockage.

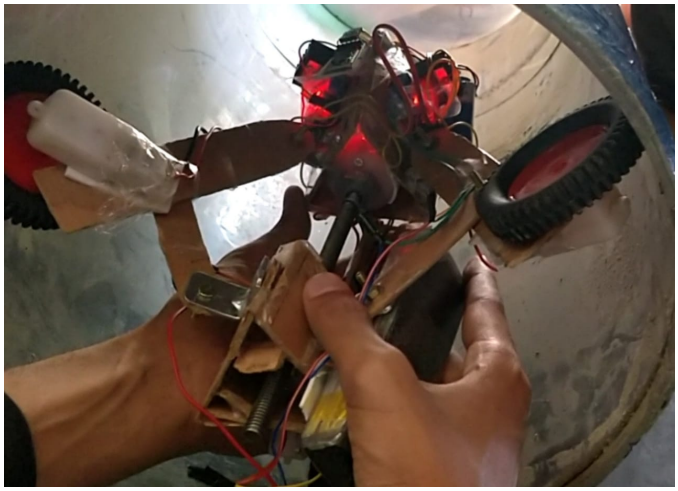

Fig. 10. Using the device

d) Then, take the appropriate action to ensure that the blockage is removed.
e) Bring PICAR back to its initial position and contract the structure completing the job.

III. Result and Discussions

TABLE 1: Table showing the component wise cost

Sr.	Component	Cost(for 1 device in INR)
1	Arduino Nano	400
2	Bluetooth Module	385
3	Motor Drivers	870
4	Li-ion battery	500
5	9v Battery	20
6	DC Motors (geared and non-geared)	715
7	Hardboard	100
8	Other Components	200
	Total	3310

The total cost of manufacturing one Robot is around 3310 INR . Since this is the prototype and it requires additional components like camera and SONAR sensors for full functionality , the final cost will increase upto 5000 inr but still it is very reasonable considering the purpose it serves.

IV. Conclusions

A. Advantages

1) EASY TO CONTROL: It is easily controllable wirelessly by mobile phone via bluetooth or wifi.
2) COMPATIBILITY: It can go through pipe of different diameter within 25cm to 35cm with ease.
3) RELIABILITY : It is reliable as it is electronically controlled and unlike humans, it doesnt get tired and can do same task again and again.
4) Visual inspection : After installing camera, It can live stream whole picture inside pipe for inspection

B. Future Implementations

Listed below are modification that can be made for improving our project and better functioning.

1) A camera can be fitted for visual inspection and sonar sensor to detect any fault, cracks and blockages.
2) Springs can be used to withstand small damping due to irregular diameter.
3) Tilted and guided wheels system can be used to go through traversing curves and bends
4) It can be made compact for improving adjustable range and it can be made waterproof.
5) Robotic arm can be used for various tasks like welding any cracks or to remove blockages and so on.

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