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# Water Pipeline Inspection Robot

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***Abstract:*** *Robots are widely used in many fields of industry nowadays. They have multiple applications and inspection is one of them. This inspection includes the monitoring of internals of pipes and channels, identifying and rectifying problems respectively. Thus such smart mobile robots help to acquire the relevant data of pipes automatically. Pipelines undergo corrosion, oxidation resulting in reduction in thickness of walls of the pipe because of being buried underground. Corrosion can also occur not only outside but also inside. This can reduce the strength and lifetime of the overall pipe section. Cracks can be formed in these sections due to fatigue and lead to leakages and in special cases can fail catastrophically. Thus various measures are taken into consideration to mitigate corrosion. Pipe inspection is essential to locate defects caused by the above aspects while the pipe is in operation.*
***Keywords:*** *Inspection, Pipeline, Robot, Water, Wireless.*

## I. Introduction

Pipelines are the important lifelines of human society which provide us with water supply, gas supply, sewage pipe, chemical plants, nuclear plants etc. which are essential to everyone's life. These pipeline also suffer aging, corrosion, cracks and mechanical damages from third parties. Defects caused by rust and natural calamity are difficult to spot if a pipe is laid underground. Blockages and leakages often occur in the pipelines due to unwanted impurities and reactions of materials. This disrupts the life of the inhabitants depending on these pipelines. Therefore, scheduled inspection and maintenance for pipeline are necessary. Manual inspection and maintenance consumes a large amount of time, effort. money and labor to grub up the pipes that are buried in the ground. Robots can assist to inspect these anomalies inside the pipes faster with accuracy at low cost. Inspection for pipelines is a special task, thus employing robots for complete inspection and maintenance appears to be one of the most attractive solutions today.

## II. Problem Definition & Objective

Robots are made to eliminate the human factor from labor exhaustive or hazardous work and also operate in unreachable environment. The usage of robots is very common today than ever before and it is no longer solely used by the heavy manufacture industries. The inspection of pipes can be relevant for refining security and effectiveness in industrial plants. The specific actions as inspection, preservation etc. are expensive, thus the use of the robots looks to be one of the best solution. For transporting drinkable and effluent water, gas oil and fuels pipelines are widely used. A lot of difficulties caused by piping systems aging, rust, flaws, and mechanical indemnities are likely. It is not possible every time to remove the whole pipe line system for the inspection of a particular area of the pipe line. Thus to overcome this disadvantages we use robots which is a very promising solution for pipe inspection.

**Common Pipe Anomalies Detected**
•Metal loss in ID (inner diameter)
•Localized and widespread corrosion
•External and internal pipe body defects like corrosion, cracking, laminations, pitting etc.
•Weld defects and misalignment.
•Blockages in pipes.

**These types of defects can be overcome by visual inspection and objective of the project.**
•To design the model using solid works.
•To fabricate the prototype.

## III. Working Of Robot And Result

This design of pipeline inspection robot is particularly for circular pipes only. It has the ability to move forward and backward in the varying range of diameter. It has the ability to get inside the pipe where no human can reach to detect the anomaly caused in the pipe.

**1.Mechanical Components of Robot**

The robot consists of a Body, Front and Rear leg system, Head and Spring. The robot components are made of ABS plastic material. The Front and Rear leg systems are symmetric, consisting of six legs, six rear motor drives each, twelve wheels, six telescopic suspension system. Each legs pivots are at 120° angle from each along the axis of the body. The legs act as a telescopic suspension. Each suspension system consists of a spring inside a tube, which helps to compress the spring during change in diameter of pipe and can bend up to 70° about the pivot.

**1.1 Suspension System**

The suspension system is one of the important part in the robot, it helps to propagate through various range of diameter of pipe internally during inspection. When the diameter of the pipe increases the spring expands thus allowing the robot to increase the length of the legs and move in the pipe as shown in Fig.1. As the diameter of the pipe decreases the spring gets compressed thus this allows the robot to move in the small diameter pipe as shown in Fig.2. Whereas when the diameter of the pipe decreases further the legs bend about the pivot point as shown in Fig.3.

**Fig.1** Robot in minimum and maximum pipe diameter

**Fig.2** Minimum Diameter Isometric View

**Fig. 3** Minimum Diameter Bending Isometric View

**1.2Body**

The Body provides the foundation both the fore leg and rear leg system. It is a plastic cylinder which is used to store different components which are related with the control of the entire system.

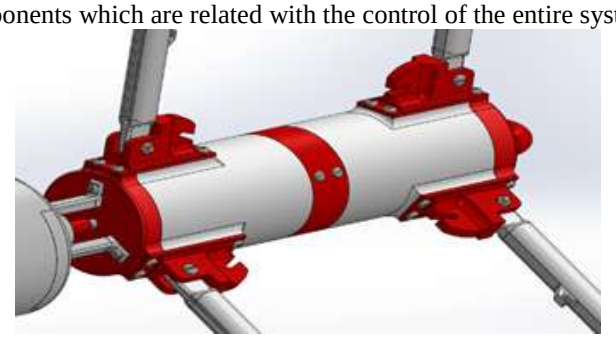

**Fig. 4** Body

**1.3 Head**

The head is hollow cylinder closed from both ends and its height is less than diameter of cylinder. Front side of cylinder has led lights and a camera while on the other side flange is connected. This head is connected with stepper motor (which is inside main body) with the help of flange and screw. On circumference of the cylinder i.e. Head; there are two holes where one hole is provided for second camera and another is for ultrasonic sensor. The inside hollow part of head is also used for the all connections and place for battery.

**Fig. 5** Head Assembly

**2. Electronic Components of Robot**

**2.1 System 1 Transmitter and Receiver**

System 1 transmitter identifies and transmits the positional data of the analog joystick to the receiver of system 1. It plots the coordinates of joystick and maps the value and transmit the data. This transmitted data is further processed by the receiver system using Arduino coding which controls the stepper motor and DC motors of the robot. It also helps to decide the speed and direction of the both stepper and DC motors. The following is the circuit diagram and pin connections of the System 1 Transmitter.

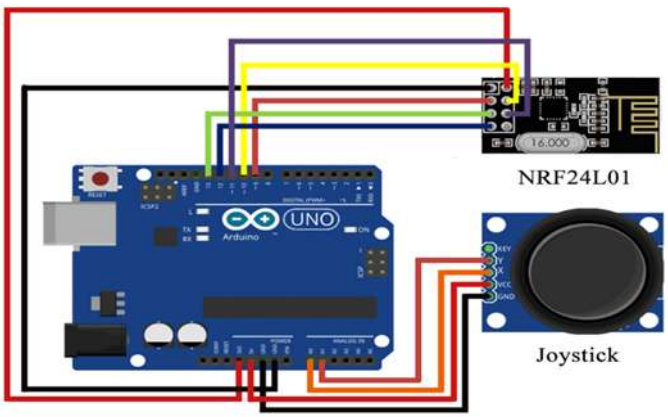


**Fig. 6** Circuit Diagram of System 1 Transmitter

**Table 1**
Pin connection of system 1 transmitter

| **Joystick Pin No.** | **Arduino Pin No.** |
|---|---|
| GND | GND |
| Vcc | 5V |
| X | A0 |
| Y | A1 |
| S/W--KEY | - |
| **NRF24L01 Pin No.** | **Arduino Pin No.** |
| GND | GND |
| Vcc | 3.3V |
| CE | 9 |
| CSN | 10 |
| SCK | 13 |
| MOSI | 11 |
| MISO | 12 |
| IRQ | - |

System 1 receiver receives and identifies the data and processes the signal. According to the data received the controller will execute the program as per the Arduino coding and respectively drive the stepper and DC motors. The received data consists of the direction and speed of motors. The following is the circuit diagram of System 1 Receiver.

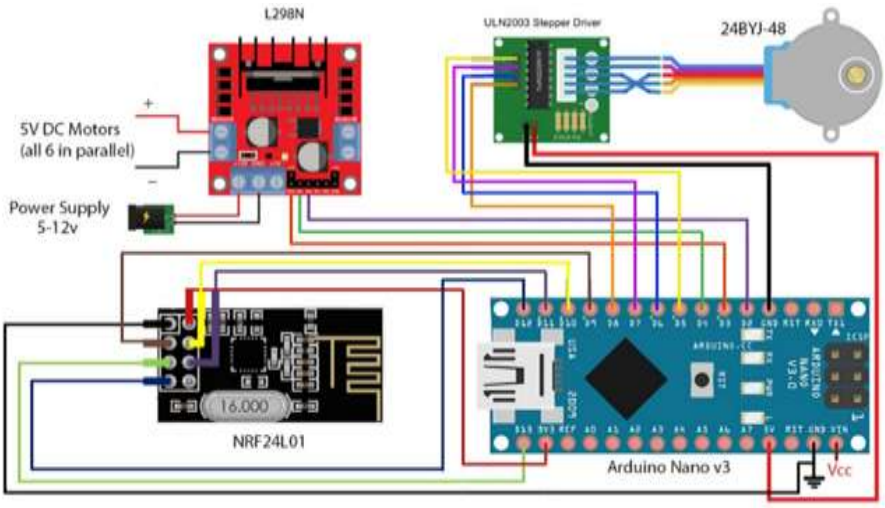


**Fig. 7** Circuit Diagram of System 1 Receiver

**Table 2**
Pin connection of system 1 receiver

| **L298N Pin No.** | **Arduino Nano Pin No.** |
|---|---|
| ENA | D3 |
| IN1 | D4 |
| IN2 | D2 |
| **ULN2003 Pin No.** | **Arduino Nano Pin No.** |
| IN1 | D5 |
| IN2 | D7 |
| IN3 | D6 |
| IN4 | D8 |
| GND | GND |
| 5V | 5V |
| **NRF24L01 Pin No.** | **Arduino Nano Pin No.** |
| GND | GND |
| Vcc | 3.3V |
| CE | D9 |
| CSN | D10 |
| SCK | D13 |
| MOSI | D11 |
| MISO | D12 |
| IRQ | - |

**2.2 System 2 Transmitter and Receiver**

System 2 transmitter calculates the distance between the ultrasonic sensor and pipe walls according to the Arduino coding in 'mm' using ultrasonic sound. Thus reading from the sensor is transmitted via system 2 transmitter to the system 2 receiver. This system continuously keeps transmitting the data till the power supply remains on. The following is the circuit diagram of the System 2 Transmitter.

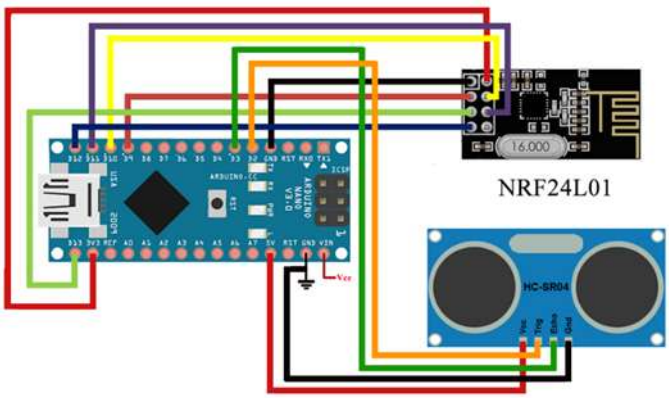


**Fig. 8** Circuit diagram of System 2 Transmitter

**Table 3**
Pin connection of system 2 transmitter

| **Ultrasonic Pin** | **Arduino Pin No.** |
|---|---|
| GND | GND |
| Vcc | 5V |
| Trigger | 2 |
| Echo | 3 |
| **NRF24L01 Pin No.** | **Arduino Pin No.** |
| GND | GND |
| Vcc | 3.3V |
| CE | 9 |
| CSN | 10 |
| SCK | 13 |
| MOSI | 11 |
| MISO | 12 |
| IRQ | - |

System 2 receiver receives the signals from system 2 transmitter and decodes the value according to the Arduino coding and display it in the 'Serial Monitor' of the 'Arduino Sketch Window'. The serial monitor displays the text as "Distance in mm = 'value' mm.". The following is the circuit diagram of System 2 Receiver. This controller is connected to computer via USB cable

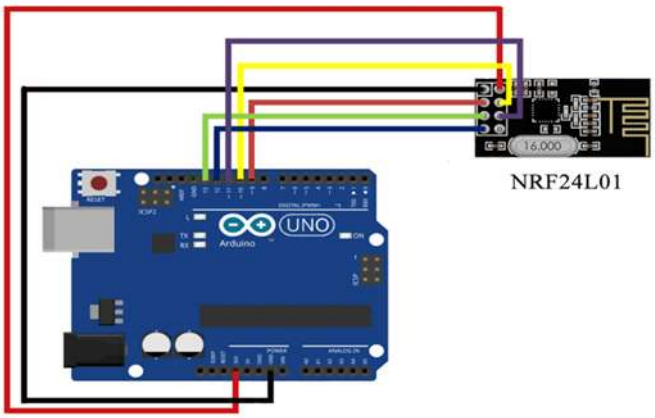


**Fig. 9** Circuit Diagram of System 2 Receiver.

**Table 4**
Pin connection of system 2 receiver

| **NRF24L01 Pin No.** | **Arduino Pin No.** |
|---|---|
| GND | GND |
| Vcc | 3.3V |
| CE | 9 |
| CSN | 10 |
| SCK | 13 |
| MOSI | 11 |
| MISO | 12 |
| IRQ | - |

## IV. Result

With the current system design we can propagate the robot inside the pipe. The Fig. 10 shows the robot in the pipe, Fig. 11 shows the images captured by the robot's cameras and Fig. 12 shows diameter profiling of the inner walls of the pipe using ultrasonic sensor readings.

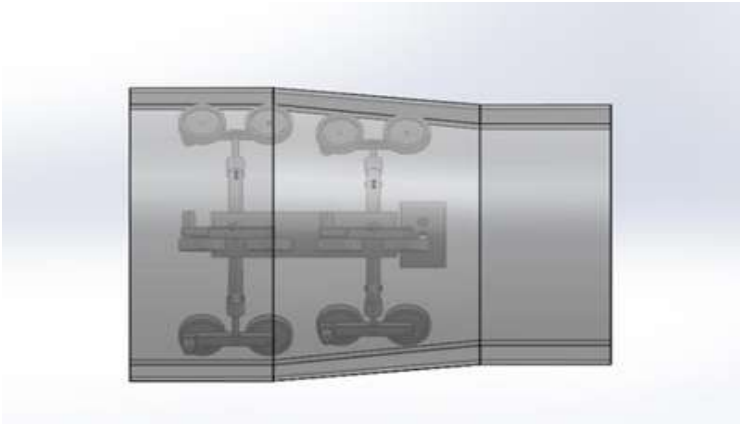

**Fig. 10** Movement of Robot in the pipe

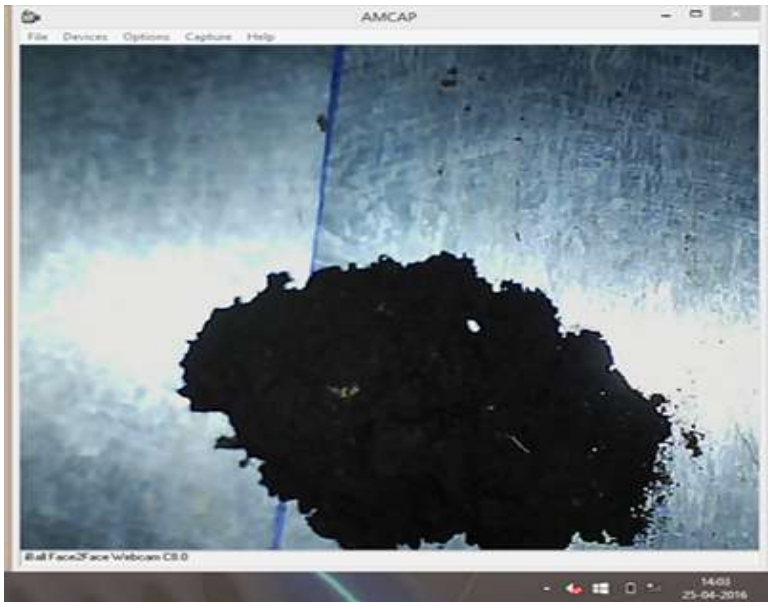


**Fig. 11** Images of Sludge in the pipe

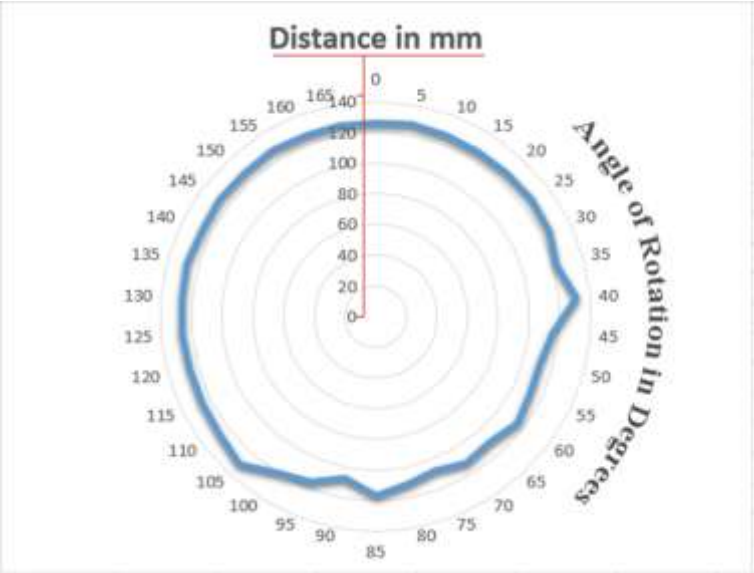


**Fig. 12** Pipeline Diameter Profiling

## V. Conclusions

Helps in safe operation and inspection of pipes internally. The detection of defects is done with the help of Cameras and Ultrasonic Sensor. The above robot can be used for diameter range of 430 mm to 730 mm. Camera with high resolution is used to detect major cracks and deformation by visual inspection. Ultrasonic sensors are used to measure depth of anomalies along diameter of pipe. Suspension system helps to keep the robot legs in contact with the wall of the pipe and compensate the change in diameter of pipe.

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