Inpipe Inspection Robot

Pooja G M
Affiliated to VTU:
Dept. Telecommunication Engineering
Ramaiah Institute of Technology, RIT
Bengaluru, India

Niharika S N
Affiliated to VTU:
Dept. Telecommunication Engineering
Ramaiah Institute of Technology, RIT
Bengaluru, India

Kavyashree M S
Affiliated to VTU:
Dept. Telecommunication Engineering
Ramaiah Institute of Technology, RIT
Bengaluru, India

Chandrashekhara G N
Affiliated to VTU:
Dept. Telecommunication Engineering
Ramaiah Institute of Technology, RIT
Bengaluru, India

***Abstract* --The purpose of the present study is to develop the inpipe inspection robot to remove human intervention from labor intensive and hazardous work environment; sometimes they are also used to explore inaccessible work places which are generally impossible to access by humans like repair and maintaining inside the pipeline. The inspection of pipe carry toxic chemicals, fluids and most of the time has small internal diameter or bends which become inaccessible to human. The complex internal geometry and hazard content constraints of pipes demand robots for inspection in order to check corrosion level and blockages of pipe. The proposed model is a wall press type inpipe inspection robot. The robot has outstanding mobility in horizontal pipes in forward and backward directions, it detects blockages using sensor and it clears the path through milling which we can observe in real time through camera while the inspection is taking place.**

Keywords — Arduino UNO, Inpipe robot, Infrared sensor, Motor driver, Wifi module, Milling Tool.

I. INTRODUCTION

In our introduction to inpipe inspection robot we have some background history of different classifications in robot and pipeline , and secondly the purpose of our project.

Background

*Robotics:*Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labor intensive or dangerous work and also to act in inaccessible environment.

A. Mechanical Classifications in robot

A pipeline exploration robot can be broadly classified into two types namely in-pipe and outpipe. We can clearly perceive that the out-pipe robots are a little less flexible than the inpipe robots. Also for the conditions which are being considered in the challenges mentioned above, an out-pipe robot would be an inappropriate choice, as the prime concentration of our robot agent is to deal with underground or inwall conditions. So, our robot agent can be classified as an inpipe robot. Having said that, let us see how the inpipe robots can be classified into different sub-categories.

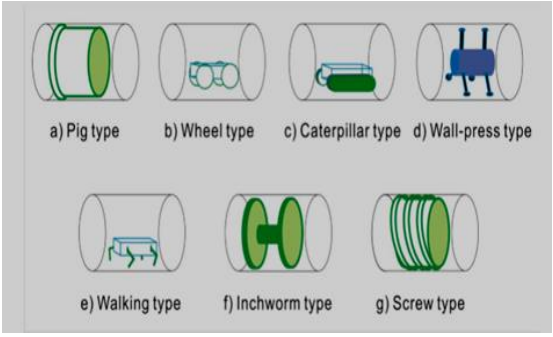

Figure 1 Mechanical classifications of pipeline robot

Robotic system

A. **Autonomous controlled robots**:used in industrial areas.
B. **Remote controlled robots**: used in environments that are restricted for human beings.
C. **Manually controlled robots**: used for handling goods and also for transportation.

Types of Autonomous Robotic System

- *Programmable Automatic Robot*

A programmable robot is a first generation robot with an actuator facility on each joint. The robots can be reprogrammable based on the kind of application they are commissioned to. The function and application of the robots can be changed by reprogramming after the robot is programmed once to perform a function in the given pattern and fixed sequence.

- *Non-Programmable Automatic Robot*

The mechanical arms used in industries are some of the examples of these types of robots wherein the robots are generally attached to the programmable devices used in industries for mass production. These types of robots find applications in some of the devices including path guiders

and medical products' carriers and also some line follower robots.

- *Adaptive Robot*

Adaptive robots are also industrial robots that can be adapted independently to various ranges in the process. However, these robots are more sophisticated than programmable robots. These can be adapted up to a certain extent, and after evaluation they can perform the action required in that adapted area. These robots are mostly equipped with sensors and control systems.

- *Intelligent Robot*

Intelligent robots, as the name suggests, are the most intelligent of all the other types of robots with sensors and microprocessors for storing and processing the data. These robots performance is highly efficient due to their situation-based analyzing and task performing abilities. Intelligent robots can sense the senses like pain, smell and taste and are also capable of vision and hearing, and – in accordance, perform the actions and expressions like emotions, thinking and learning. These robots find their applications in the fields like medical, military applications and home appliance control systems.

Pipelines :There are many areas where robots can be replaced for human; amongst them pipelines is one of the most challenging areas. Pipelines have been used in major utilities for along time. Over billions of places, from huge plants to an individual house, robots are employed by people.

Types of pipelines

A. Oil Pipelines

Oil pipelines are made from steel or plastic tubes which are usually buried. The oil is moved through the pipelines by pump stations along the pipelines.

B. Ethanol Pipelines

These pipelines are majorly used in Brazil and United States. There are several ethanol pipeline projects in Brazil and the United States. Main problems related to the shipment of ethanol by pipeline are its high oxygen content, which makes it corrosive, and absorption of water and impurities in pipelines.

C. Hydrogen Pipelines

The most cost-effective way to move gaseous hydrogen over a long distance is via pipeline. Hydrogen pipeline is used for transportation of hydrogen through a pipe as part of the hydrogen infrastructure. Hydrogen pipeline is used to connect the point of hydrogen production or delivery of hydrogen with the point of demand, with transport costs similar to compressed natural gas (CNG).

D. Water Pipeline

Pipelines are useful for transporting water for drinking or irrigation over long distances when it needs to move over hills, or where canals or channels are poor choices due to considerations of evaporation, pollution, or environmental impact.

Aim of project

Proactive monitoring and frequent inspections are critical to maintain pipeline health, as gas, oil, water pipelines have become an indispensable part of life. Hence, the continuous proactive monitoring and maintenance system for these pipelines is essential; however, deployment, monitoring, and maintenance of them should remain cost effective, scalable, and easily customizable. A number of technologies, which are proposed and available to monitor, control, and maintain diverse types of pipelines, have still remained in unsatisfying those requirements due to their limitations.

In this dissertation, we aim at designing a cost-effective pipeline maintenance and monitoring system. Such a system would allow frequent inspection, early detection of problems and planned recovery measures. To accomplish those goals, we believe that a monitoring system for pipelines should combine sensor technologies, which are well suited for event localization, and robotic techniques, which allow proactive and corrective monitoring. In addition, we argue that a more efficient technique for locating objects and incidents should be integrated in such systems.

Based on the above hypothesis, we have developed a new method, Inpipe Inspection Robot (IPIR)in which robot is able to move forward and backward directions which can get adjusted to various diameters of the pipe and move inside pipe.further, it detects blockages using infrared sensor(IR), and starts milling if found to clear the blockage.

II. METHODOLOGY

The principle of this project is to inspect various pipes and provide its actual footage to operator. IPIR works on wall pressed type mechanism and is designed in such a way that it reduce human efforts while inspecting the industrial pipes. IPIR inspects the pieline by moving in forward and backward direction and detects blockage through sensor. Further, it clears the path by milling which we can observe in real time through camera while the inspection is taking place. Various steps are carried out to make robot work efficiently.

III. STRUCTURE OF INPIPE INSPECTION ROBOT

Figure 2 Pipeline robot

Figure 3 Ipipe robot

IV. HARDWARE COMPONENTS

The major components required for building targeted robot are as follows:

1. Microcontroller:ATmega328P(Arduino UNO)
2. DC Motor Driver IC L29D3
3. DC Motors-4
4. Power and connecting cables.
5. WiFi module:ESP8266
6. Infrared sensor.

Auto CAD drawing for robot structure

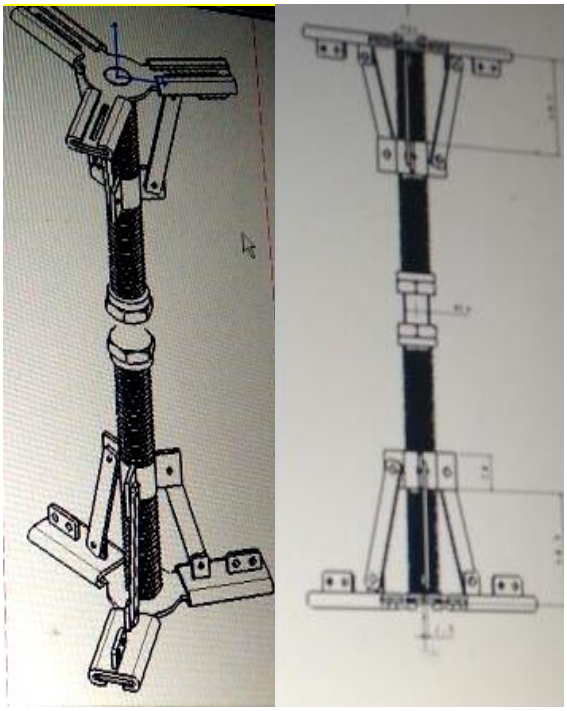

Figure 4 CAD design of pipeline robot

V. SPECIFICATION & DETAILS OF THE COMPONENT USED IN ROBOT STRUCTURE

Microcontroller –ATmega328(Arduino UNO)
Technical specifications:

- Operating Voltage:5V
- Analog Input Pins:6(A0-A5)
- Digital I/O Pins:14(out of which 6 provide PWM output)
- DC current on I/O pins:40mA
- DC current on 3.3V Pin:50mA
- Flash Memory:32KB
- SRAM:2KB
- EEPROM:1KB
- Frequency(Clock speed):16MHZ

Figure 5 Arduino UNO

D.C. Motor(12V,300rpm)
A **DC motor** is a mechanically commutated electric motor powered from direct current (DC). The stator is

stationary in space by definition and therefore so is its current. The current in the rotor is switched by the commutator to also be stationary in space.
DC motors have a rotating armature winding but nonrotating armature magnetic field and a static field winding or permanent magnet. Different connections of the field and armature winding provide different inherent speed/torque regulation characteristics.

Types of Power Supply
There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable DC voltage supply for electronic circuits and other devices.

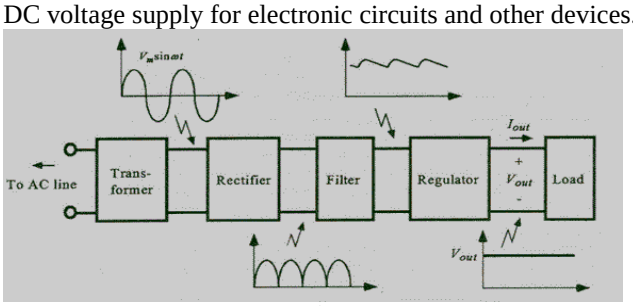

Figure 6 Components of regulated power supply

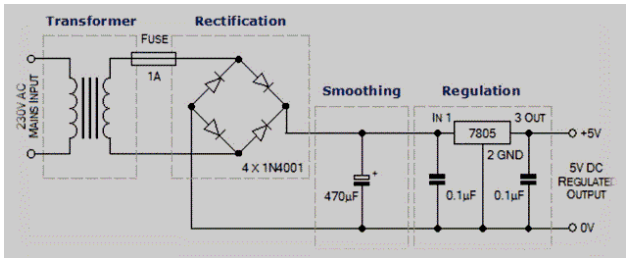

Figure 7 Circuit of a regulated +5V DC power supply

DC Motor Driver IC L29D3
L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC.It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction.

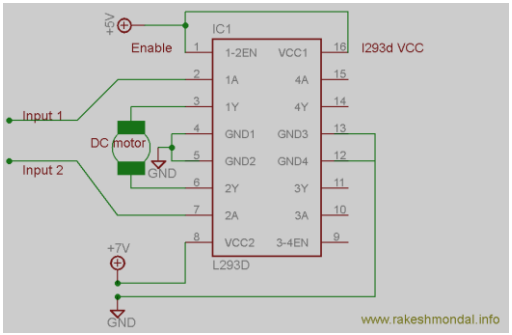

Figure 8 Circuit diagram

The circuit comprises following components:

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo ohms.
- Variable resistors.
- LED (Light Emitting Diode).

WIFI Module:ESP8266

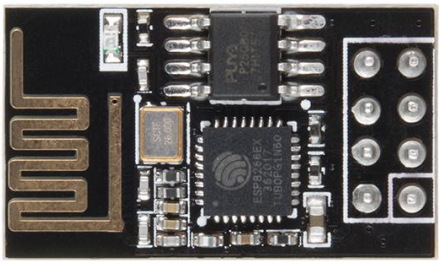
Figure 9 wifi module

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

Technical specifications

- 802.11 b/g/n
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLLs, regulators, DCXO and power management units
- +19.5dBm output power in 802.11b mode
- Power down leakage current of <10uA
- 1MB Flash Memory
- Integrated low power 32-bit CPU could be used as application processor
- SDIO 1.1 / 2.0, SPI, UART
- STBC, 1×1 MIMO, 2×1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4ms guard interval
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)

VI. IMPEMENTATION OF IP WEB CAMERA

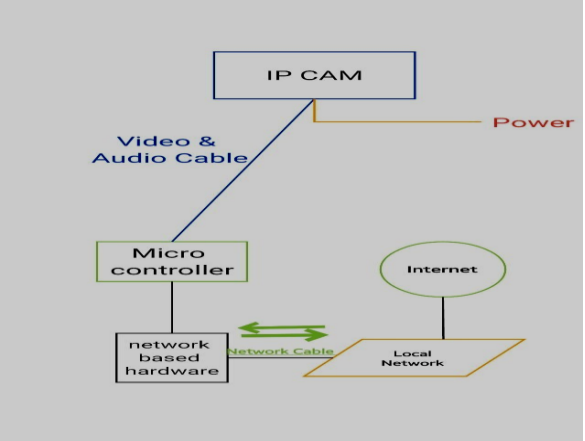

Figure 9 Implementation of IP web camera

An Internet protocol camera, or IP camera, is a type of digital video camera commonly employed for surveillance, and which, unlike analog closed circuit television (CCTV) cameras, can send and receive data via a computer network and the Internet. Although most cameras that do this are webcams, the term "IP camera" or "netcam" is usually applied only to those used for surveillance. An IP camera is typically either centralized (requiring a central network video recorder (NVR) to handle the recording, video and alarm management) or decentralized (no NVR needed, as camera can record to any local or remove storage media).

The protocol(s) that IP cams use for communicate with softwares is TCP/IP through network; like other devices on the networks, same as your phone and etc. but we have bunch of protocols for broadcasting in the world but the better and easiest way is TCP/IP and the base is also the TCP/IP. the ip cam just record or stream Video (& audio) then convert it from analogue to digital to the microchip then the microchip make packets from the recorded or streaming files then send it over the network (Internet or local network). now a days the IPcams just have the one board with all of these hardwares in it, and just plug it to the network modem with LAN cable and record over network or broadcast it! also we have the LANpowered cable, it means you don't need the other power cable over the IP cam, you just have a cable with all of them (Power over ethernet or PoE).

VII. CONCLUSION

In this project, a modular robotic system based on wall pressed mechanism is proposed. An important design goal of this robotic system is the adaptability to the inner diameters of the pipes. This given prototype permits the usage of a ip-camera for visualization of in-pipe inspection and obstacles are detected using sensor. The major advantage is that it could be used in case of pipe diameter variation with the simple mechanism. We developed a in-pipe inspection robot that can be applied to 152mm- 254mm pipeline. A real prototype was developed to test the feasibility of this robot for inspection of industrial pipelines. The types of inspection tasks are very different. A modular design was considered for easily adapted to new environments with small changes. Presence of obstacles within the pipeline is a difficult issue. In the proposed mechanism the problem is solved by a using springs which can get adjusted to various diameters manually. The robot is designed to be able to travel in forward and backward direction. Several types of modules for in-pipe inspection robot have been presented. Many of the design goals of the Pipe inspection robot have been completely fulfilled.

VI. FUTURE SCOPE

The future scope of the project is limited in several ways and can be worked upon to broaden its features and applications. A few of the improvements that can be implemented are mentioned below.

- Use of tilted and guide wheels for traversing curves and bends in pipes.
- Use of lighter material for the links to reduce the weight.
- Implementation of long range sensors.
- Implementation as a bore well rescue robot.
- Alternate design without links to facilitate better motion.

VII. RESULT AND DISCSSIONS

The following results were obtained from the completion of the project.

- The robot was capable of adapting to pipe diameters in the range of 8 to 12 inch.
- The robot was tested for motion in a PVC pipe.
- It was found to move well in both forward and backward direction.
- A live video footage was provided to the operator on laptop screen.
- Blockages or Obstacles are detected effectively using IR sensor and path is cleared through milling.

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