Adjustable Pipe Inspection Robot with Video Monitoring and Jaw Control System for Fuel and Gas Pipelines

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Abstract— A pipe inspection robot is a device that is inserted into a pipe to check for any obstruction or damage. Basically, these robots are manufactured offshore and are most expensive. Also, these robots often not adequately support in the event or malfunction. Hence its maintenance is difficult. In this paper we have described about a Pipe Inspection Robot that monitors inside the pipe, recognizes faults by capturing continuous video throughout the robotic path and sends the captured video to the monitoring system using wireless communication for the correction of problems. The Pipe Inspection Robot has the ability to travel inside horizontal and vertical pipes, and also it consists of a jaw that helps to pick the obstacle out from the pipe.

Key words: Pipe Inspection Robot, faults, continuous video, jaw

I. INTRODUCTION

Robotics is one among the fastest growing engineering fields of today. Essentially, robots are designed for the convenience of human work. Humans are replaced by robots from labor intensive and dangerous work where he cannot access certain remote places for monitoring and repairing of the damages present in or around the remote places. Thus, the robots are used to act in inaccessible environment. The use of robots is very common today and no longer it is exclusively used by the heavy production industries for inspection of the instruments and components. Many fields of industries are using inspection robots and one such application is monitoring inside the pipelines, recognizing faults and solving problems through the interior of pipelines.

In a number of countries over a long time, pipelines are used as tools for transporting oils, gases, liquids and other fluids such as chemicals. To maintain the reputation of the standard of transportation, regular inspection and maintenance is required. Most of the problems in pipelines occurs due to aging, corrosion, cracks, and mechanical damages. Hence, to overcome this problem, we are designing a Pipe Inspection Robot that monitor inside the pipeline using a camera by capturing continuous video, recognizes faults and sends the location and position of fault present inside the pipeline. The robot has an ability to travel inside horizontal and vertical pipelines. Also, the robot consists of a jaw that helps to pick the obstacle that may be present inside the pipeline.

II. LITERATURE SURVEY

Several types of pipe inspection robots have been proposed. Xin Li et.al [1] proposed the optimal inspection of an autonomous robots in a complex pipeline system. They solved 3-D region-guarding problem to suggest the necessary inspection spots. They designed a Hierarchical Integer Linear Programming (HILP) algorithm to find an approximate optimal solution for guarding of a given 3-D region. Compared with existing manual inspection systems, the advantage of the new inspection system built upon optimal guarding is its thorough (making the system robust) inspection using fewest (making the system inexpensive and efficient) necessary checking spot.

Se-gon Roh et.al [2] proposed the robot movement patterns while passing through the fittings in urban gas pipelines. In this paper, they presented a comprehensive work for moving inside underground urban gas pipelines with miniature differential-drive. In-pipe robot, called the Multifunctional Robot for IN-pipe inSPECTion IV (MRINSPECT IV) has been developed for the inspection of urban gas pipelines with a nominal 4-in inside diameter.

Ankith Nayak et.al [3] proposed the investigation of the design issues pertaining to development of in-pipe inspection robot. In this paper, the aspects of working and mechanism involved with In-Pipe Inspection Robots are studied carefully, and their working ability according to orientation of pipes are considered, to identify issues related to design of In-Pipe Inspection Robots.

Changhwan Choi et.al [4] described a mobile feeder pipe inspection robot that can minimize the irradiation dose to human workers by automating the measurement process. The robot can move by itself on the feeder pipe by using an inch-worm mechanism which is constructed by two gripper bodies that can fix the robot body on to the pipe and one extension/contraction actuator and a rotation actuator connected to the two gripper bodies to move forward, backward and to rotate in a circumferential direction respectively. These actuators are driven pneumatically and are embedded inside the robot body to reduce the size of the robot so that it is applicable to the actual feeder pipes in a PHWR (Pressurized Heavy Water Reactor).

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Nur Afiqah Binti Haji **Yahya** et.al [5] proposed and improved few designs of the robot like the parallelogram wheel leg and studied the robotics application in various industries mainly for pipeline inspection. This paper was to fulfill the requirement of automation and robotics module assessment. The objective of this paper is to observe different robotic applications in pipeline inspection, to learn the different design of robots in pipeline inspection, to outline the problems and adaptability improvements in the robotics application that was applied.

III. BLOCK DIAGRAM

The various components used in this system as shown in the block diagram: PIC Microcontroller, Temperature Sensor, LCD, Gear Motors, Camera, Switch Pad.

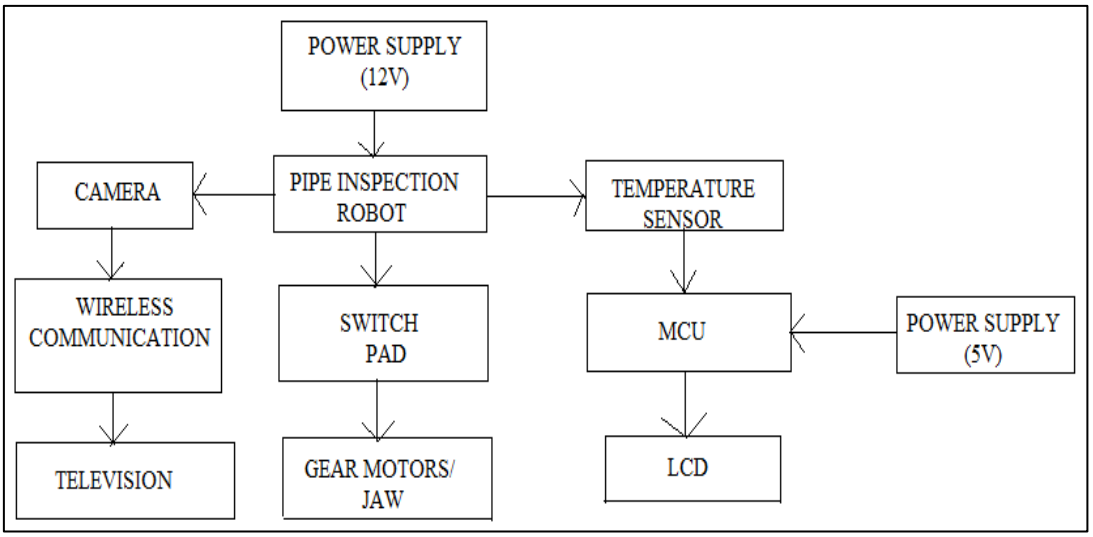

Fig. 1: Block diagram of Pipe Inspection Robot

A. PIC Microcontroller

Microcontroller Unit is considered as the heart of the pipe inspection robot. All major activities of the robot are controlled by the microcontroller. It needs a pure regulated +5V DC. The Microcontroller unit used is a PIC microcontroller.
The PIC microcontroller (PIC16F877) *architecture* is based on a modified Harvard RISC (Reduced Instruction Set Computer) instruction set with dual-bus architecture. This microcontroller is a 40-pin device. The device offers 8192 _14 flash program memory, 368 bytes of RAM, 256 bytes of non-volatile EEPROM memory, 33 I/O pins, 8 multiplexed A/D converters with 10-bits resolution, PWM generator, 3 timers, analog comparator circuit, USART and internal and external interrupt facilities.

B. Display Unit

Display unit used is a Liquid crystal display (LCD) which is used to display alphanumeric as well as special characters (like *, !, @, #, %, &, etc.),numbers and graphics.. The LCD which is used is a LMB162A which is 16 X 2 display and we use 8-bit data bus to transfer the data codes from MCU to LCD.

C. Simple Switch Pad

The switch pad used acts as a human machine interface and is used to give input to the movement of robot and for the operation of jaw. A particular task can be performed by pressing a particular switch so that the task corresponding to the pressed switch is achieved. A switch is nothing but an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.

D. Temperature Sensor (LM35)

The temperature sensor used is an integrated-circuit LM35 temperature sensor which measures output voltage that is linearly proportional to the Celsius (Centigrade) temperature. The LM35 sensor thus has an advantage over linear temperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. It has very low self-heating, less than 0.1°C in still air.

E. DC Gear Motor Drive using Motor Driver L293D

A gear motor is a type of electrical motor which uses the magnetism induced by an electrical current to rotate a rotor that is connected to a shaft. The energy transferred from the rotor to the shaft is then used to power a connected device.
DC Geared Motor Driver: To derive the DC geared motor near about 50-100 mA current is required. But any I/O pin of any MCU can source/sink a current of near about 20 mA. So for its interfacing with microcontrollers a power or current amplifier circuit is required. L293D is a H bridge IC which is used to control the direction of motor rotation.

IV. WORKING

The Pipe Inspection Robot firstly goes into the pipe by adjusting its wheels according to the dimension of the pipeline. The movement of the robot is controlled by the operator using switch pad. The switch pad consists of 3 micro switches, out of which 2 switches are used for forward and backward movement of the robot and another switch is used for contracting or expanding the jaw. The obstacle present is brought out from the pipeline using the jaw connected to the robot body. When the robot starts moving inside the pipeline, the camera which is connected to the robot body captures continuous video and gives the insight view of the pipeline to perceive the location and position of the faults and also it is possible to detect the obstacle present inside the pipeline based on the video captured and then it is displayed on Television.

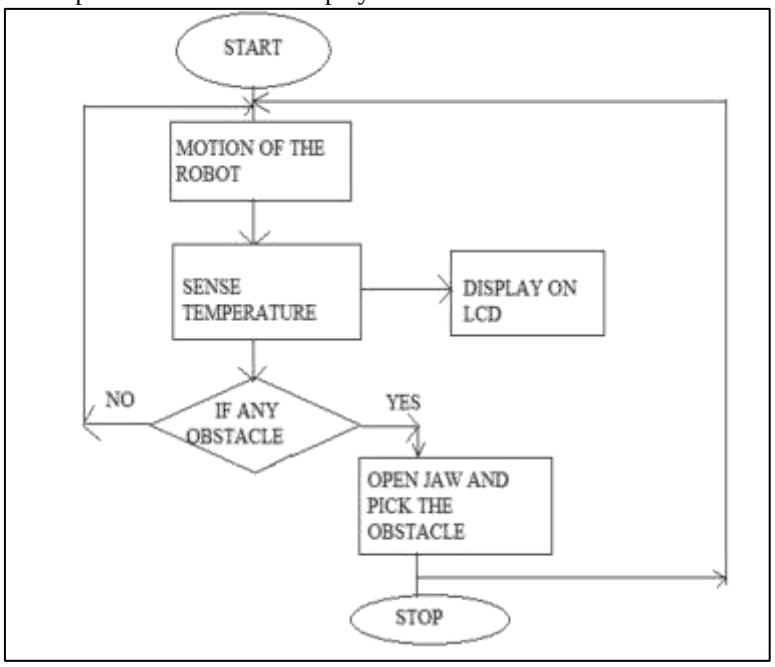

Fig. 2: Flow Chart of Pipe Inspection Robot

The controlling unit used in this the continuous video of the inner surface of the pipeline. Defects like corrosion or cracks or any faults present are detected while capturing video and this information is sent to the television via wireless communication. When the video is displayed on the Television, the operator checks for the damages or faults that may be present inside the pipeline. The temperature sensor in the robot senses the temperature inside the pipeline that checks for the feasibility of transportation of fluids or other liquids hence protecting it from ignition and undergoing reaction from overheating that may occur in the wall of the pipeline. In the meantime, the temperature sensed by sensor is sent to the Microcontroller Unit and from Microcontroller Unit the information is displayed on the LCD.

V. RESULTS

Fig. 3: Temperature sensor output

Fig. 4: PIR traversing inside the pipe

Fig. 5: Television Displaying Continuous Video Captured By The Camera

Fig. 6: Object picked by the jaw of the PIR

VI. CONCLUSION

Robots play an important role in pipe-network maintenance and their repairing. Presence of obstacles within the pipelines is a difficult issue. In the proposed system the robot is designed, so that is able to traverse inside the pipes and detects any corrosion or damage in the pipes. It also has the ability to pick up and remove the obstacles by using the jaw. Further it can be enhanced in future to send robot inside the filled pipes by providing insulation coating to the robot. So that it can traverse inside the filled pipes.

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