AUTONOMOUS PIPELINE ROBOT

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ABSTRACT

Crack inspection is an important task in the maintenance of pipe line and it is closely related to structural health of underground pipes. Currently it is done through a very manual procedure, experienced human monitors the whole structure visually and try to detect cracks on the pipe line structure and marks the location of crack. But this manual approach having some frailty issues as limited accuracy. Proposed research focuses on implementing a system having a robot, equipped with a thermal camera to efficiently detect small leaks in plastic or in any type of pipes with complicated pipeline configurations of inner structure of the pipeline; a global map is created locating position of cracks and a vacuum to collect if there are any sediments left below. The robot will navigate inside the pipe line surface to collect the structural image data and send it to the remote users through wireless. An image processing technique is used for processing the image and creating map of cracks. We will use different algorithm in image processing which can find out the cracks and non-cracks in an image. This proposed system will create 2D-map which is essential and main aim of this work.

Keywords: *- Pipeline Robot, Thermal camera, Crack Detection and Image Processing.*

1. INTRODUCTION

Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labour intensive or dangerous work and also to act in inaccessible environment. The use of robots is more common today than ever before and it is no longer exclusively used by the heavy production industries. Robotic sensor networks are a promising technology for leak detection of underground pipeline systems. Various developments of automatic crack inspections using image processing have been made in areas including roads, bridges, fatigues, and sewer-pipes. The Railway Technical Research Institute in Japan developed an image acquisition system of railway tunnel lining by using line CCD cameras. The crack detecting system is software that extracts crack information through image processing developed in mat lab from the acquired images. Measured crack information is composed of crack thickness, crack length, crack orientation. They are important factors for the fundamental inspection. The information, including length, width, and orientation of the cracks gives a clue to judge and determine the next stage of precision inspection of concrete structure safety. The mobile robot system consists of a wireless camera, controlling apparatus for an autofocus device and to compute the distance from the structure for an autofocus, and at the remote user side a computer for controlling the system.
Many kinds of pipes are being utilized to construct important lifelines such as water and gas supply in our contemporary society. Also pipes are widely used in chemical industries and in gulf countries for carrying petrol, diesel, oil etc. But after some years these pipes get damaged and defects are occurring in pipe. If the defects in the pipe are caused by rust and nature calamity, it is difficult to find out the defects and the place of the defects, and also there is great amount of loss. Thus scheduled inspection must be done. If we decide to do this inspection manually then large amount of time, effort and labour is necessary to grub up the pipes that are buried in the ground. If the robot can inspect inside the pipes, fast and accurate examination will be able to be done at low cost.
There are several types of pipe inspection robots some are in-pipe inspection robot and some are out-pipe inspection robot. A wheel type in-pipe robot was proposed for the inspection of urban gas pipelines with a nominal 12- inch.

1.1 Mobile Robots

. A mobile inspection robot was developed which can move by itself on a feeder pipe by using an inch worm mechanism. The mobile inspection robot is constructed by two gripper body that can fix its body on to the pipe.

A two wheeled type in-pipe mini-robot was proposed which is based on the linkage mechanisms. A sewer pipe inspection robot was developed which can move into the straight pipe without any intelligence of the controller or sensor information. Semi-autonomous robots that can investigate sewer pipes were proposed. The robot can detect and rate defects automatically using artificial intelligence techniques. A robot that was able to move in a pipe filled with water was developed by using a caterpillar. It can move only in the pipe horizontally arranged. A pipe inspection robot was proposed which is based on a helical motion of the driving body. The robot uses wheeled structures on elastic suspension. . A CCD camera is installed on front part of the fore leg system to do visual inspection of pipe.

2. SELECTION OF MATERIALS

The materials used for this machine are light and rigid. Different materials can be used for different parts of the robot. For optimum use of power, the materials used should be light and strong. Wood is light but it is subjected to wear if used for this machine. Metals are the ideal materials for the robot as most if the plastics cannot be as strong as metals. Material should be ductile, less brittleness, malleable, and high magnetic susceptibility. Among the metals, aluminium is the material chosen for the linkages and the common rod, which is made as hollow for reduction in weight. It is chosen because of its much-desired properties. Aluminium has lightweight and strength; it can be used in a variety of applications. Aluminium alloys with a wide range of properties are used in engineering structures. The strength and durability of aluminium alloys vary widely, not only because of the components of the specific alloy, but also because of heat treatments and manufacturing processes.

3. ROBOT DESIGN

There are a set of design considerations to be followed for designing a pipeline robot. They are as,

- The weight of the pipe inspection robot must be as low as possible.
- The motor used for pipe inspection robot must have high torque ranges from 2-4 kg torque.
- The wheels of the robot must have grippers to climb inside the pipes vertically.
- If the bent of the pipe is very small then the robot has to be made as flexible

The components used here are as follows,

1. HELICAL SPRINGS

- Inner diameter – 20mm
- Outer diameter – 24mm
- Pitch – 5 mm
- Length – 60 mm

2. CONNECTING RODS

- Link1, link2, link3 – 24, 56, 84 (mm)
- Thickness – 3 mm
- Fillet – 5 mm
- Width – 10 mm
- Drilled holes – 6 mm
- Material – Aluminum

3. DC GEAR MOTOR

- Length- 80mm
- Torque- 1.5kg/cm
- Shaft Diameter- 6mm
- Weight- 130.00g

4. BATTERIES

Batteries give supply for a motor and wireless camera. Motor and radio frequency gets 6v supply from the central body and wireless camera gets supply from a 9v battery. And 3v batteries for transmitter which has two toggle switch. One is for motor forward and reverse control and the other one is for glowing LED's.

5. WIRELESS CAMERA

Thermal imagers are long wavelength (8-12 micron).Visible color day/night cameras are repeatedly rendered ineffective by low contrast lighting or blooming bright light conditions; All imagers utilize uncooled technology to produce high quality imagery for high security applications. This type of thermal imager will detect thermal activity in total darkness, through smoke, dust, blowing sand, fog and other obscurants.

3.1 WIRELESS COMMUNICATION

RF Transmitter & Receiver:

The RF TX-434 and RF RX-434 are extremely small, and are excellent for applications requiring short-range RF remote controls. It is of very small in sizes and it may vary according to the applications. The RF TX and RX frequencies are of 433.92 MHz

RF Transmitter: The transmitter output is up to 8mW at 433.92MHz with a range of approximately 100 foot (open area) outdoors. Indoors, the range is approximately 50 foot, and will go through most walls. The TWS-434 transmitter accepts both linear and digital inputs, can operate from 1.5 to 12 Volts-DC, and makes building a miniature hand-held RF transmitter very easy. The TWS-434 is approximately the size of a standard postage stamp.

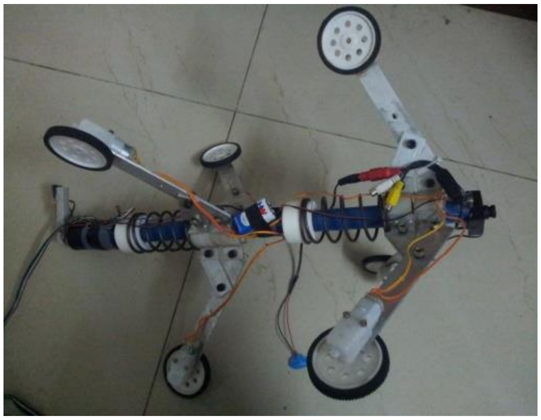
RF Receiver: The receiver also operates at 433.92MHz, and has a sensitivity of 3uV. The receiver operates from 4.5 to 5.5 volts-DC, and has both linear and digital outputs.

3.2 IMAGE PROCESSING ON MATLAB

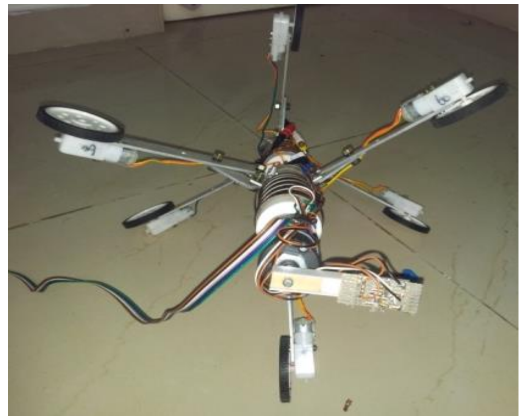
The images captured by robot are transmitted to the laptop/PC for image processing. Image processing is done in MATLAB software. Any image contains extra irrelevant information which needs to be removed by preprocessing to facilitate the process of crack detection by making it more efficient and time saving. We can employ the different techniques for image processing such as resizing the image, conversion of color image into grayscale, superimposing grayscale image with the original image, morphological operations etc. We will use different algorithm in image processing which can find out the edges in an image also we will implement such algorithm and techniques which can distinguish between cracks and non-crack. In this module we will create a 2D map which is essential for this work.

3.3 PIPELINE ROBOT TEST RESULTS

Following the design and modeling of the proposed mechanism a prototype unit was built. The prototype was built for a robot with the weight of 2.7 kg. The body of the robot was fabricated mostly from aluminum. The Robot was driven by seven dc gear motors. The robot is tested successfully for movement in horizontal and vertical pipes. The robot has a good mobility and ability to pass over small obstacles. The important thing is the amount of force between robot tracked units and pipe wall. Even in horizontal moving, attachment of the up tracked unit in addition to bottom ones, improve the movement of robot. Because in this state 7 motors participate in robot move although friction is more. In addition to this, the robot is more stable and distribution of load on different actuators is more similar. Monitoring the pipe inside was suitable and the control of different actuators was effectively possible.



Front view of the robot



Rear view of the robot

4. CONCLUSION

As a conclusion, all objectives for this project were managed to achieve such as to build a fully autonomous pipeline robot. This project is successfully designed, implemented and tested. The major advantage is that it could be used in case of pipe diameter variation with the simple mechanism. A real prototype was developed to test the feasibility of this robot for inspection of in-house pipelines. We used a PCB board that can operate DC motors. Good conceptive and element design could manage all the problems. The type of inspection tasks varies according to the environment. For the next robot development, it is hoped that this robot can be reconstructed with some modification to improve the abilities and to provide benefits in future and also be able to be marketed or commercialized.

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