International Journal of Robotics and Automation (IJRA)
Vol. 1, No. 1, March 2012, pp. 64~68
ISSN: 2089-4856

Design and Development of Vision Based Blockage Clearance Robot for Sewer Pipes

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Article Info

Article history:

Received Nov 17, 2011
Revised Mar 10, 2012
Accepted Mar 17, 2012

Keyword:

Capture images
Robotic
Sewer pipelines
Video
Wireless camera

ABSTRACT

Robotic technology is one of the advanced technologies, which is capable of completing tasks at situations where humans are unable to reach, see or survive. The underground sewer pipelines are the major tools for the transportation of effluent water. A lot of troubles caused by blockage in sewer pipe will lead to overflow of effluent water, sanitation problems. So robotic vehicle that is capable of traveling at underneath effluent water determining blockage using ultrasonic sensors and clearing by means of drilling mechanism is done. In addition to that wireless camera is fixed which acts as a robot vision by which we can monitor video and capture images using MATLAB tool. Thus in this project a prototype model of underground sewer pipe blockage clearance robot with drilling type will be developed.

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1. INTRODUCTION

In this a robotic system that is capable of traveling at underneath effluent water determining blockage using ultrasonic sensors clearing by means of drilling mechanism is designed to work in non-ideal environments.

Robotic systems are becoming ever more complex everyday and the need for visual feedback based systems is increasing by the hour for the development of efficient self-adaptive mobile robotic systems. In the system we present here, we amalgamate an MATLAB based Graphical User Interface for a robotic system. Here MATLAB acts as a Graphical User Interface and the appropriate signals are sent to a micro-controller through a serial interface. Once the command signals are received by the microcontroller the appropriate actions are performed by the robot. In this semi autonomous type of robot is designed so that even in the case of faulty condition we can manually control the robot.

Electronic systems onboard the robot has three primary tasks, to communicate with the PC, control the motion of the robot and to perform drilling mechanism when an obstacle is detected. A serial link is established between the computer and the micro-controller using serial modules. Motion control is achieved by interfacing two geared DC motors to a standard H-Bridge motor driver circuit. The microcontroller interprets the signals received from the computer and accordingly controls the motion of the robot by sending signals to the motor driver circuitry.

Additionally since these systems require different voltage supplies, a dedicated circuit is built to perform this task. The mechanical structure is designed keeping in perspective the weight and size requirements, and the required degree of mobility.

2. SYSTEM OVERVIEW

In this a semi autonomous robot that is fully submersible is to be designed that uses graphical user interface by which user can click the desired push button to perform the action. In our system MATLAB software is programmed according to the requirement once a user click a push button the system initiates and starts image acquisition from the device similarly various action such as forward, reverse action can be done. Once a particular push button is pressed an hexadecimal code corresponding to the particular value is transmitted to the serial port, from the COM port or serial port using RS-435 cable the data is transmitted to the robot

In the robot PIC microcontroller is programmed in such a way that in a infinite loop like while is used to check for a hexadecimal code if that particular value of the code is received it is moved to another port , from that a driver circuit IC such as L293D provides sufficient voltages to the motor to drive.

Since this type of the robot is semi autonomous, upon powering up preferences will be given to the ultrasonic sensor, it uses the echo pulse to detect an obstacle. When an obstacle is detected in front of the robot, the ultrasonic sensor initiates an interrupt mechanism to the PIC microcontroller; upon receiving the request drilling mechanism will be activated. The robot also has the provision of manually controllable in case of in faulty state. In addition a wired IR camera is fixed at front end which acts the robot vision

In this the user has to open the MATLAB software and execute the m-file that contains the created MATLAB user interface, the graphical user interface allows the following functions such as robot control function and image acquisition function. A robotic function includes start drill, stop drill, right, left and forward. Image acquisition function includes capturing live video and stopping them using MATLAB tool.

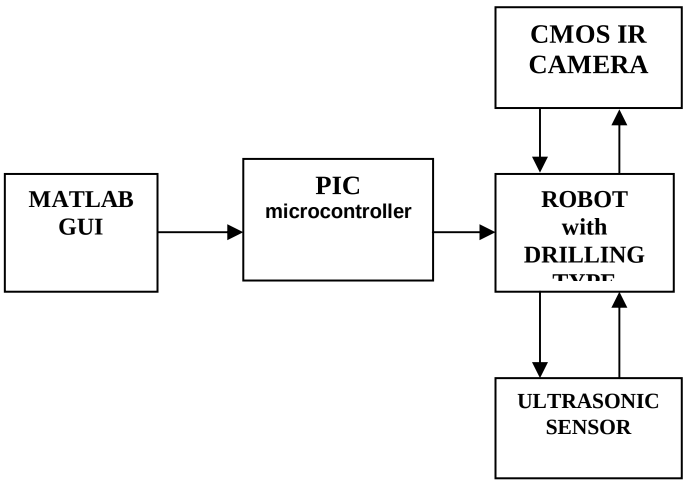


Figure 1. Block diagram of the overall setup

Once a particular push button is pressed an hexadecimal code corresponding to the particular value is transmitted to the serial port, from the COM port or serial port using RS-435 cable the data is transmitted to the robot, in the robot PIC microcontroller upon receiving the value performs the desired action, here the PIC microcontroller is programmed in such a way that when a particular value is received the desired action is performed.

In addition to that robot has the IR Camera that will provide vision to the robotic system travelling underneath effluent water, since it is wired robot power constraints will not an issue. Thus the GUI created in MATLAB with appropriate coding will control the Robot via serial port that interface with the PIC

Implementation Modules

The working module constitutes:

- <u>Creating GUI using MATLAB</u> – Graphical user interface provides the user control function menu, when an appropriate button is pressed desired action is performed. MATLAB has in build function called guide which provides a set of tools for creating graphical user interfaces these tools simplify the process of laying out and programming GUI, selecting and aligning the GUI components to be placed in it. For each button an appropriate call back function is generated, when programming the call back function the desired response is obtained.
- <u>PIC programming</u> – The PIC microcontroller is programmed in such a way that when a particular port is set to input and using the infinite programming loop keep on monitoring for a value, since for different

combination of values different output action is to be performed and in situation when an interrupt occurs it is served immediately.

- Design of drilling type robot and to interface sensor – The perceptive of design is to have a drilling type mechanism in front end, which is capable of detecting blockage in underground sewer pipes.

A graphical user interface (GUI) is a graphical display that contains devices, or components, that enable a user to perform interactive tasks. To perform these tasks, the user of the GUI does not have to create a script or type commands at the command line. Often, the user does not have to know the details of the task at hand. The GUI components can be menus, toolbars, push buttons, radio buttons, list boxes, and sliders. In MATLAB, a GUI can also display data in tabular form or as plots.

GUIDE, the MATLAB graphical user interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools simplify the process of lying out and programming GUIs.

- GUIDE is primarily a set of layout tools
- GUIDE also generates an M-file that contains code to handle the initialization and launching of the GUI – This M-file also provides a framework for the implementation of the callbacks - the functions that execute when users activate a component in the GUI.

The two basic tasks in Process of implementing a GUI is first, laying out a GUI where MATLAB implement GUIs as figure windows containing various styles of UI control (User Interface) objects. The second task is programming the GUI, where each object must be program to perform the intended action when activated by the user of GUI.

And finally writing the code to implement the behavior associated with each callback function in m-files. A callback is a function that writes and associates with a specific GUI component or with the GUI figure. It controls GUI or component behavior by performing some action in response to an event for its component. This kind of programming is often called event-driven programming. This last step is the difficult one and has to make an extra reading on how to write the coding before the GUI component can perform some task that user desire.

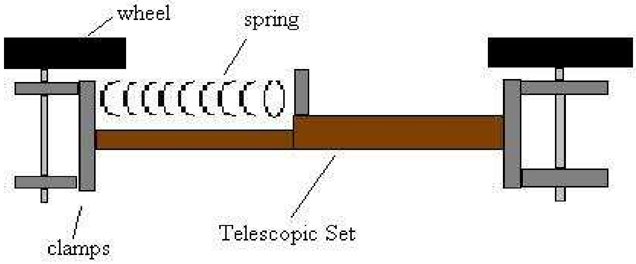
MECHANICAL DESIGN

The Mechanical Design of the sewer pipe inspection robot plays a very pivotal role in the “Design and Development of Vision Based sewer Pipe blockage clearance Inspection Robot”. The main objective of the robot is to traverse through the horizontal and vertical cross section of the pipe. Specific challenges associated with this application include space confinement, size and weight restrictions, wireless communication requirements, and adverse environmental conditions. The key problem in their design and implementation consists in combining the capacity of self-moving with that of self-sustaining and the property of low weight and dimension. A very important design objective is represented by the adaptability of the in-pipe robots to the inner diameters of the pipes

DESIGN OF HORIZONTAL SECTION

The horizontal section of the pipe consists of the following:

- Horizontal Telescopic set
- 2 DC Geared Motors
- a Spring
- 2 High Grip Wheels



Telescopic Set:

Figure 2. Telecopic Set

The telescopic set is made of drawer channels. The drawer Channels are divided into two:

- stationary channel
- mobile channel

Stationary Channel:

The stationary channel acts as the base for the mobile channel to move in forward direction and reverse direction. The stationary channel consists of an L shaped clamp and a dc geared motor to drive the wheel. The length of the stationary channel is 9.2 cm and breadth is 3 cm and the total area it occupies is 27.6 square-cm. The L clamp Height is 2 cm and width is 2.5 cm and the length is 1.5 cm. The function of the L clamp is to hold the spring. The L clamp is attached to the upper side of the stationary channel with the help of the bolt and nut. The DC geared motor is attached to the bottom side of the stationary channel

Mobile Channel:

The pipe is of variable size i.e. its diameter varies. To overcome this dampening environment, the mobile channel is used to assist the robot in adapting itself to the variable size of pipe. The mobile channel is smaller in size such that it fits inside the stationary channel. The mobile channel slides over the stationary channel with an insubstantial amount of friction. The sides of the mobile channel are completely greased so that sliding does not pose any problem. The length of the mobile channel is 7 cm and it extends out of the stationary channel to a maximum of 2 cm. It also consists of an L shaped clamp to support the other end of the spring. The L clamp height is 2 cm, length is 1.5 cm and width is 2 cm. A DC geared motor that has been fixed to this channel. The wheels are fixed to the motor shaft and the motors are fixed to the channel in such a way that the entire length of the vertical section is 22cm that is the diameter of the pipe.

DC Geared Motors:

The DC Geared Motors propel the robot in both the forward and reverse directions of the horizontal and vertical sections of the pipe. The motors are attached to the stationary and mobile channel of the telescopic set. The motor has sufficient torque to pull the robot against gravity while traversing the vertical cross section of the pipe.

Spring:

The spring plays the pivotal role in helping the robot to adapt itself to the varying size of the pipe. The spring is fixed between the 2 L clamps of the stationary channel and the mobile channel. Holes are drilled in the 2 L clamps of the stationary channel and the mobile channel in such a way that a screw is fixed between them. A screw is inserted into the spring to prevent it from slipping out of the clamps when it is getting compressed. The screw holds the spring in its position.

High Grip Wheels:

The wheels help the robot to grip to the pipe. The wheel diameter is 4.5 cm and the wheel thickness is 3.3 cm. The wheels are attached to the motor shaft by drilling wheel inner diameter

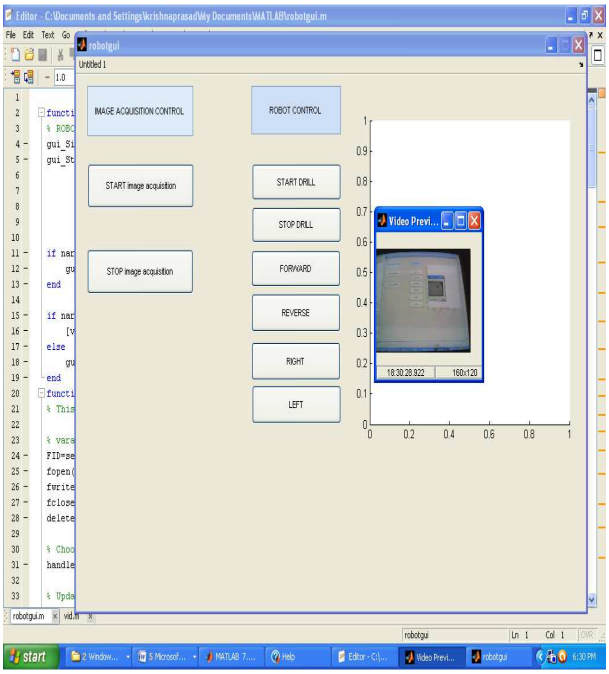


Figure 3. Robot GUI Interface

3. EXPERIMENTAL RESULTS

After laying out the GUI component, when executed the m files, for each push button desired output is obtained

After successful completion of creating GUI in MATLAB, we used HDD SERIAL PORT MONITER software to view the code generated for each push button pressed.

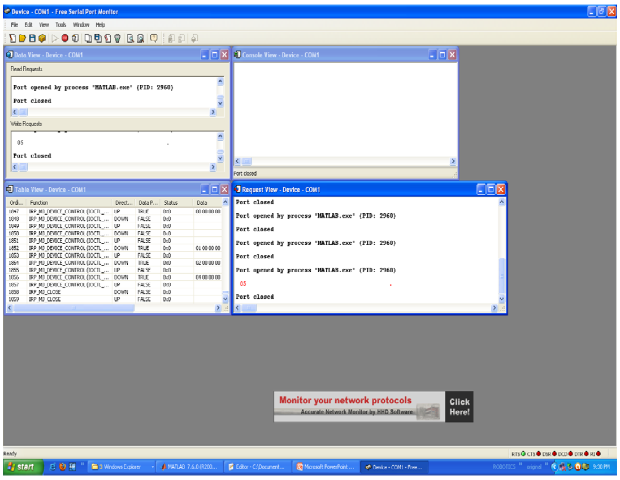


Figure 4. Monitoring transmission of signals

4. CONCLUSION

At the end of this a prototype system for cleaning and removing blockage of large sewer pipes, has been built and simulation results for software part of the robotic system is created successfully using MATLAB tool. The system has been tested in real sewer pipe during normal sewer operation. The cleaning and inspection system is unique in that it can clean and then carry out a high resolution, complete 3D inspection of large sewers while the sewer is partially filled and in operation. In addition to it the robot has a camera which can stream live video of the surrounding. The camera is controlled by the PC which enables the user to view the video using a wired receiver module. This vision feedback also enables us to be aware of the robot's surrounding.

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