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Research JoAIRA AI Robot for Sewer Inspection and Cleaning

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Abstract

The advancement in technology has provided solutions to many practical problems that humans encounter in day to day activities. Even today manual scavenging of the drainage is practiced in almost all places of India, wherein men enter the manholes and clean the waste materials in the drainage manually with no technical equipment. According to study, in Mumbai on an average, consistently 20 sewer laborers pass on because of mishaps and suffocation or openness to harmful gases. The proposed system is an innovative, fully autonomous, artificial intelligence based sewer inspection, blockage detection and clearance robot. Arduino Nano with sensors detects poisonous gases, the blockage and uses appropriate tools to clear the clog depending on it's hardness. Generally, 70% of the blockages are caused due to soft clogs and the rest of the 30% are caused due to the hard clogs. The soft clogs are removed using a water jet attached to the sewer cleaning system. The system has a cutter blade controlled by hub motors for removing hard clogs. The artificial intelligence system pre-process the sewer wall images captured through a camera attached in the system, does feature extraction and uses convolution neural network classifiers to predict the severity of the damaged inner walls of the sewer and reports it to the authorities.

Keywords: Sewer cleaning, AI robot for sewer, blockage, gases, inspection

INTRODUCTION

Idea itself is a testament to the fact that the currently available manhole clean up systems aren't quite capable of cleaning the manholes pipes thoroughly from inside. The current system and recent manhole cleaning robot introduced by Thiruvananthapuram based Genrobotics named Bandicoot ensured that crushed debris are pushed forward and don't remain inside the pipe. The robot is capable of cleaning the manhole floors by spreading its limbs [3, 5]. Some cleans blockage and does live streaming [4]. However, there is no current solution that can clean the manhole pipes as well as crush the heavy sediment waste like solidified cement and debris that is clogging it [8]. So, the proposed system provides a solution that is inspired by the working of tunnel boring machines. The tunnel boring machine works in such a way that it can dig its way through a mountain so as to pave a way through it. Similarly, in the case of a clogged manhole pipe proposed robot (which can be called as a stripped-down version of a tunnel boring machine) can crush through the clogged material while alongside clearing a way for the sewage water to pass. The blades of the robot are designed in such a way that they don't damage the inner surface of the pipe while at the same time making the way. The proposed system also provides an artificial intelligence based solution to inspect the condition of sewer walls.

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LITERATURE SURVEY

Hand excavation was the foremost form of sewer cleaning. The drainage and sanitation lines were cleaned by workers using metal scrapers, brooms or through their bare hands. Many workers lost their lives due to poisonous fumes emitted in the sewer. No mask protection is provided toworkers.

Sometimes, these workers need to go much deeper underground with only a rope for help and can even drown if they get caught in a sudden rush of sewage. These practices may risk human lives. Thus, there is a need to replace human intervention with an automatic drainage cleaning robot. The method used nowadays contains pumps to suck the drainage water but it fails to clean the rock solids inside the drainage hole. Garbage removing option through a cutter is proposed, but requires human intervention in operation [1]. The use of gripper for garbage collection is proposed, which will be manually operated and no sewer inspection feature is proposed [2]. The sewer pipes vary in diameter and cross section and hence a need for a reconfigurable type of cleaning robot was proposed [11].

It is important to timely check the status of sewer pipes for cracks and other deformations. Earlier this was only done when people used to go in the sewer for removing the blockage. Later on people used machines with cameras to inspect sewer walls [9]. It may be a difficult task to continuously keep inspecting videos sentby the machine.

In order to overcome the above issue, an attempt has been made to fully automate the maintenance and controlling of the sewer pipes through an artificial intelligent robot. The accuracy of pipeline blockage is detected through SVM classifier [6] and through artificial neural networks [7]. At some places, sewer pipeline fault detection is also done using anomaly detection algorithms [10].

PROBLEM STATEMENT

As per prior research, the pipeline performance is influenced by a number of reasons. Mostly it is a misconception that the solid objects that swirl down the drain, cause a clog. On the other hand, the fact is that the clog is gradually built from its internal diameter. As the time passes, the accumulated clog reduces the pipeline diameter, consequently restricting the free flow of water in the pipeline. Meanwhile, sludge starts forming, which is a sticky concoction of soap scum, grease, hair, food particles or even the dissolved minerals in the water. As the layer of sludge forms, more sludge tends to accumulate in that segment of the pipeline, increasingly narrowing the size of the pipe that will reduce the efficiency of the pipeline and even many times a total blockage. For smooth pipeline operation, blockage prevention and sewer wall damage inspection, a routine pipeline cleaning is the optimal solution. The proposed system aims to design a one structure module that can provide a technological solution for cleaning and maintenance of sewerage system.

IMPLEMENTATION

The proposed system aims to provide a solution to - timely detection of some issues or choke up in sewer, blockage removal, Sewer wall crack monitoring and damage prediction through Artificial Intelligence and communicating details to authorities.

1. **Timely detection of some issue or choke up in sewer system**

This will facilitate in reducing the incubation period of a major drainage issue. For timely detection of some issue or choke up in the sewer system, the streamlines are distributed almost evenly within the inner pipe area. The streamlines of the velocity profile show a uniform pattern. A uniform flow occurs when there is no blockage in the system. As the blockage is getting larger, the streamlines get closer and the gaps between the lines are narrower. These behaviours can be seen clearly when the water flow passes the blockage. As the fluid begins flowing through the obstacle, the streamlines start adjusting itself. At the same time, as the flow area decreases, the water velocity inside the pipe also increases. As shown in Figure 1., the pipe has two accelerometers. which are connected to the Arduino Nano These accelerometers sense the change in the vibration and identify it as an occurrence of blockage.

Accelerometer

This device observes vibration, and acceleration inside the sewerage pipe at different locations.

Transmitter

The whole setup of the transmitter part is placed inside the sewerage pipe. A single transmitter is

connected to accelerometers of multiple pipes. It acquires data from the accelerometers and sends it to the processor.

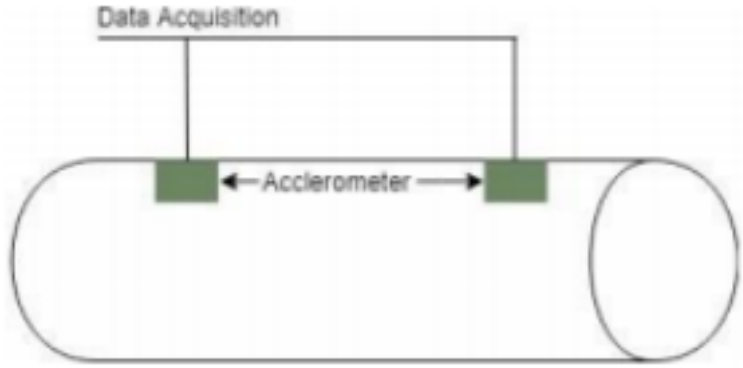

Figure 1. Choke detection system.

Receiver

Receiver receives the data acquired by the transmitter and feeds it to the processor.

Processor

Processor analyses if there is any instance of blockage. The pressure changes are calculated from the velocity profile. The higher the pressure drops more is the restriction to flow of fluid.

2. Blockage Removal

Rather than installing multiple units in all areas, a multifunctional machine is proposed. As it doesn't need to be installed at a particular area it is dispatch able and also a cost-effective solution. The robot will be capable of cleaning the soft clogs as well as the harder ones. Generally, 70% of the blockages are caused due to soft clogs and the rest of the 30% are caused due to the hard clogs. Once the blockage has been detected the machine in dispatched to the nearest manhole available. The machine will then adjust its size according to the diameter of the sewer pipe. Machine will be compatible with various diameters of the sewer pipe. This grinder works on an umbrella mechanism. So, if the size of the pipe is detected to be larger than its current settings the On-Off panels will start working so as to fit into the pipe. If the size of the pipe is smaller than its current settings, the panels will contract themselves to make it compatible to enter the pipe. The robot will then traverse through the sewer pipe.

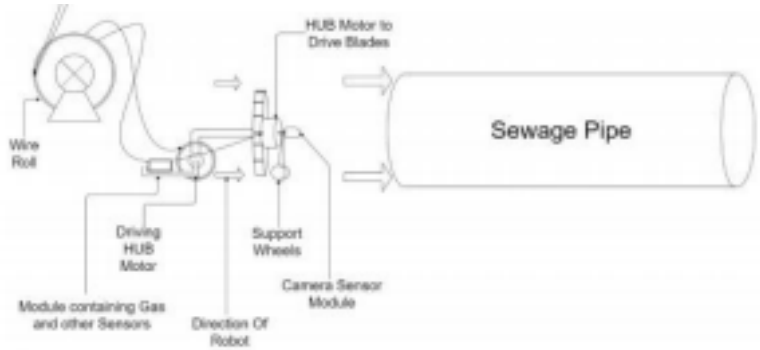

Figure 2. Architecture of sewage systems.

As shown in Figure 2, once the robot is in proximity to the location where blockage has occurred it will first try to get rid of the blockage by jetting the water at high pressure at an angle. If the jetting doesn't work, then it will start drilling. Hub motor are used to drive blades of drilling systems. The head of the robot will have one-degree freedom i.e. moving forward and backward. This degree of freedom

will help the drilling part to be more efficient. The robot will then travel through the pipe towards the next manhole. The gases generated in the sewer are very harmful for human beings. The proposed system also has MQ-2 and MQ-6 gas sensors for detecting the harmful gases in the sewer. The buzzer raises an alarm when the amount of harmful gas is more than the threshold value.

The robot consist of following components:

1. Arduino Nano
2. MQ-2 and MQ-6 gas sensors
3. Bluetooth Module
4. BLDC motor driver (2 nos.)
5. 300W BLDC Hub motor (2 nos.)
6. 350W 24V SMPS (2 nos.)
7. High pressure water Jetter
8. Motor HMI Control Throttle (2 nos.)
9. Electromagnetic active buzzer
10. Arducam MT9D111

3. Sewer inspection and damage prediction through Artificial Intelligence Artificial Intelligence in sewer management can help to achieve the major goal of timely detecting the cracks or any damage in the internal wall of sewer, which may sometimes gets ignored by humans while checking the recordings. In the proposed system, the robot has a camera that does recording while the robot moves along the sewer. The robot is trained using artificial intelligence algorithms to detect any sewer crack or damage in the internal sewer walls. A huge dataset of images is used for this. 70% images of the dataset are used for training purposes while 30% images for testing purposes.

The images are captured from the video recordings and then send to Sewer wall damage prediction system which predicts the severity of the damaged wall with an accuracy of 89%

4. Communicating to authorities

This system is connected to an online portal for each constituency as each municipal corporation office will have a complete notion of the present sewer's conditions and crosses a threshold then an indicator through HMI will be sent.

Human Machine Interface Human- machine interface (HMI) is a system of software and hardware elements that allows to:

- Directly allow sensors to interact through HMI software and monitor, gather and process the real time
- Maintains a log file for recording events
- The HMI system quickly notifies an operator that a specific area is showing a high incidence of blockage.

RESULTS

Figure 3 shows Jetting and drilling system with a high pressure water jet nozzle attached at the front of the cutter which can efficiently remove the soft clog in the sewer. If the clog isn't removed in a predefined time and the robot isn't able to move further then the cutter controlled by a 300W BLDC Hub motor with 328 RPM, starts drilling the clog. The implementation and testing of this was done by taking a container with water and the submersible motor in it. The submersible motor allows the water to flow through the pipe that is connected to the accelerometer through which it can detect whether the blockage is there inside or not.

The gas detection system as shown in Figure 4 has MQ2 and MQ6 sensors attached with Arduino Nano to detect gases and to give an indication whenever a threshold value of 400 is reached.

Figure 3. Jetting and drilling system.

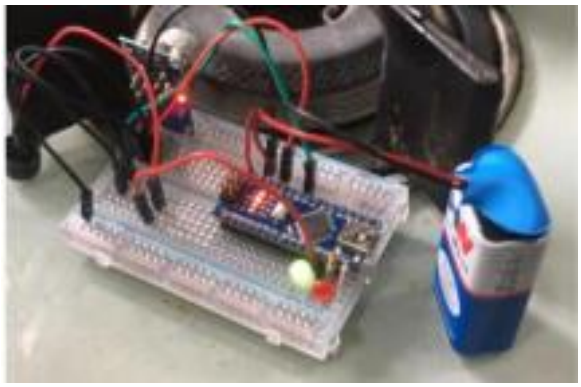

Figure 4. Gas detection system.

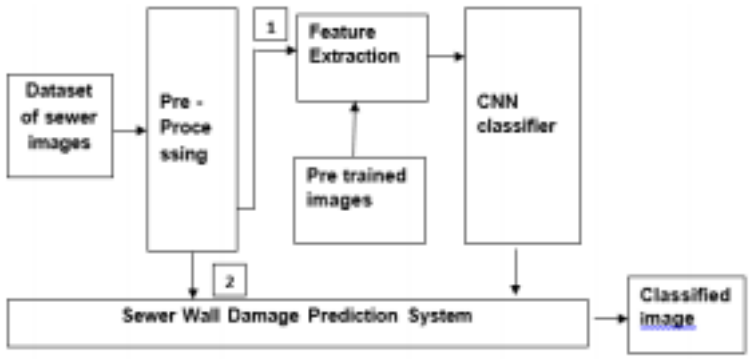

Figure 5. Sewer Wall Damage Prediction System.

Figure 5 shows the prediction system of damaged sewer walls using artificial intelligence. For Sewer inspection using artificial intelligence, the content of the dataset was pre-processed which included filling the missing values and encoding. Then the dataset was split into a Training set(70%) and a Testing set(30%). Feature extraction was done to get the best features from the dataset. The images were classified using CNN classifier. The model showed an accuracy of 89% when tested with the dataset.

CONCLUSION

The proposed system is an innovative, fully autonomous, artificial intelligence based sewer inspection and blockage clearance robot. During the inspection, from the video recording the artificial intelligence algorithms predict the damaged parts of the inner wall of the sewer and send the data to the operation centre. The robot can adapt to different pipe diameters. The proposed one unit model eliminates the human entry in sewage pipelines. Also, the work of cleaning and removing obstacles

would be done automatically. One can handle the whole framework by SCADA, just by seating in a control room. A need to visit work areas is eliminated. This proposed system is capable of handling nearly all possibilities of the problem faced by the government.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest

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