Leakage Detection Using "PLUMBOAT"

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Abstract- Plumboat is a robot which is specially designed to detect the cracks and leakages in the underground pipes. This project is a combination of embedded systems and Robotics. Leaky water pipes pose serious problems for cities, as it leads to the loss of roughly a billion Litres of clean drinking water every day. Whenever there is a leakage problem in the underground pipes, the entire roadways are dug to detect the cracks in the pipes and also the water supply is stopped for the same amount of span causing inconvenience to the people. Also, due to the destruction of entire roadways it becomes very difficult for the people to drive vehicles on the roads leading to traffic and inconvenience. To avoid these problems we have designed a robot which will detect the underground pipe leakages in the pipes with the help of a wireless camera due to which only the relevant part of the road will be dug for repair. This robot has a tripod design. It smartly detects the cracks and displays them on the screen by which we are able to locate the cracks and leakage easily.

We have developed a robot called Plumboat which will successfully detect leakages in the pipes. Our approach automatically analyzes the pipes using night vision camera. We used Xbee transmitter and receiver for wireless reception and transmission of data from our hardware to camera. While developing such system we focused more on hardware which will give accurate output and detects cracks more efficiently. The speed of the robot will be kept constant. As soon as the movement of the robot starts till the time a crack is detected, that particular time can be recorded in the stopwatch. In this way, with the help of constant speed and the recorded time the distance where the crack is located can be found. Plumboat is a robot that will go inside the pipe and scan, thus finding the exact location of the breach and can be repaired by opening up the smallest amount of street necessary, rather than digging up entire roadways.

Index Terms- Plumboat, Leakage Detection, Xbee.

I. INTRODUCTION

After the survey of various methods used for water leakage detection we came through a few of these like water leakage detection using acoustics and ultrasonic scanning.

Tubebot:

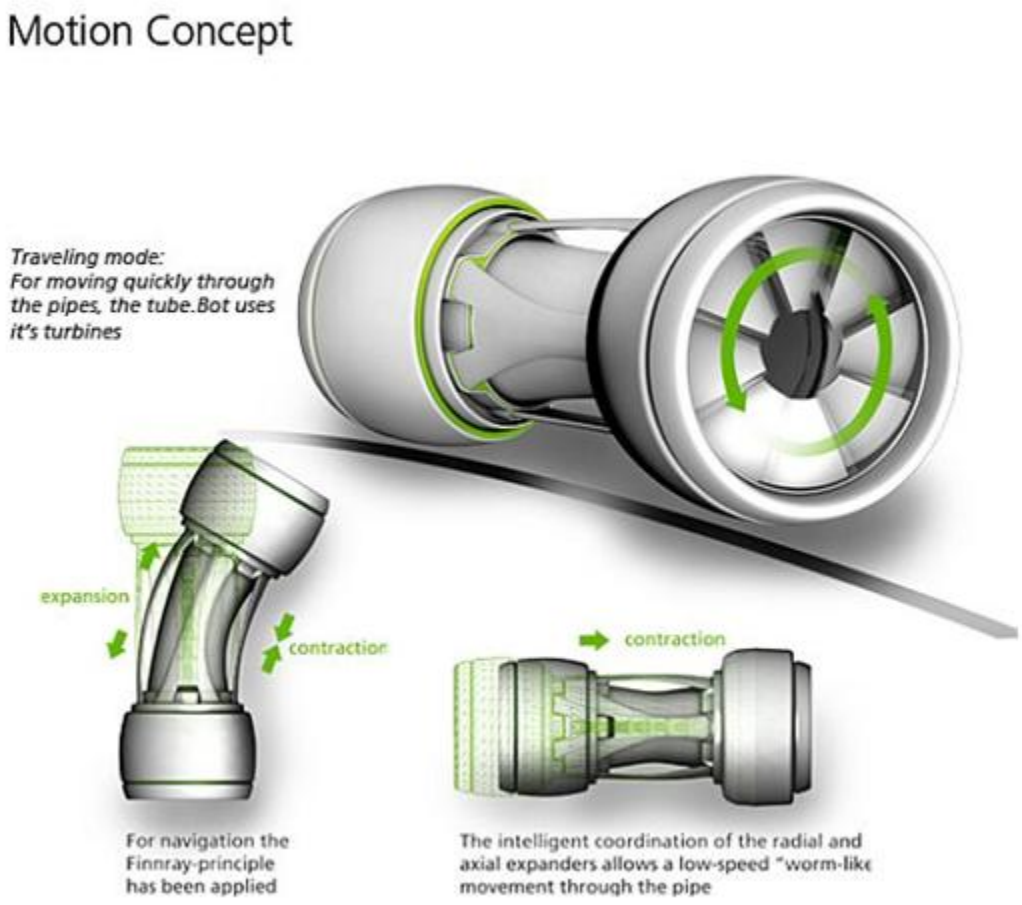

Fig.1 TUBEBOT

Leaky water pipes pose serious problems for cities, as it leads to the loss of roughly a billion liters of clean drinking water every day. A self-powering robot, called Tubebot, a maintenance robot designed for use in the piping of urban drinking water systems. Tubebot is an autonomous robot that generates electricity from the pressure of water to power itself and keep it moving. The system ultrasonically scans the whole length of the piping system and sends the data to a remote location. In this way the cracks are detected using this robot.

Tubebot can detect defects and breaches in underground water pipes by scanning a length of the piping system and sending data to a remote location. The leak is located and can be repaired by opening up the smallest amount of street necessary, rather than breaking up roadways the entire length of the pipe. This is the zero-energy solution for detecting leaks in the water supply pipes of the urban drinking water systems of the world. Tubebot generates the electricity to power itself by harnessing the pressure that exists in the pipes. It uses turbines at either end to move through pipes and the coordination of the radial and axial expanders allows a worm-like movement through the pipe.

It's quick at detecting and can fix almost all kinds of leaks. The Tubebot works without an additional energy supply; this is because it incorporates intelligent functionality of using the existing pressure in the pipes to move. By employing this robot, urban drinking water agencies can expect to save and conserve this precious resource. Tubebot is designed by Kunsthochschule Berlin students; Tubebot still needs considerable research to enable it to fit into the smaller pipes leading off from main pipes of the water stations before it is available for purchase. As observed the design in the above project is such that it requires ultrasonic scanning thus making it expensive. It also requires considerable amount of research to enable it to fit into the pipes of smaller diameter.

Understanding Acoustic Leak Detection:

What are the Sounds of Water Leaks?

Water leaks in underground, pressurized pipes may make many different sounds:

• "Hiss" or "Whoosh" from pipe vibration and orifice pressure reduction

• "Splashing" or "Babbling Brook" sounds from water flowing around the pipe

• Rapid "beating/thumping" sounds from water spray striking the wall of the soil cavity

• Small "clinking" sounds of stones and pebbles bouncing off the pipe

The "Hiss" or "Whoosh" sound, which often sounds like constant static noise, is the only one which is always present for leaks in pipes with 30 psi or higher water pressure. The other sounds may or may not be present, and usually they are not as

loud. So, we decide "Is there a leak?" by listening for the "Hiss" or "Whoosh."

Fig.2 Small Leak on Cast Iron Water Main

What Factors Affect These Sounds?

There are several factors that affect the loudness and the frequency range of the sounds made by water leaks transmitted on the pipes and transmitted to the surface of the ground:

1. Water pressure in the pipe
2. Pipe material and pipe diameter
3. Soil type and soil compaction
4. Depth of soil over the pipe
5. Surface cover: grass, loose soil, asphalt, concrete slab, etc.
6. The loudness or intensity of the leak sound is directly proportional to the water pressure inside the pipe (up to a limit).
7.

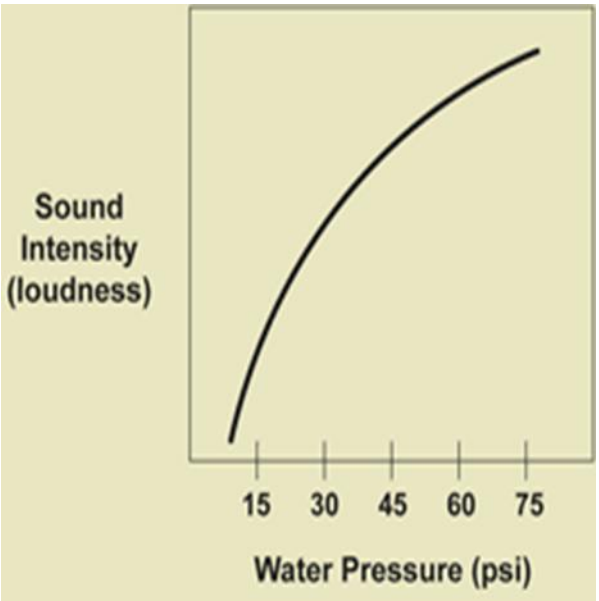

Fig.3 Sound Intensity (loudness) vs. Water Pressure

1. Metal pipes, such as iron mains, copper services, and steel pipes, transmit water leak sounds that are louder and higher frequency than do PVC pipes or asbestos-cement pipes. Thus, knowledge of the pipe material is important.
2. Large diameter pipes, whether they are PVC, concrete, steel, or iron, transmit much less sound from water leaks than small diameter pipes. And, large diameter pipes transmit lower frequency sounds than small diameter pipes.
3. Sandy soil and very loose soils, particularly over a freshly buried pipe line, do not transmit the sounds of water leaks very well, nor do water saturated soils such as bogs and swamps. Hard, compacted soil transmits the sounds of water leaks best. Soil absorbs the sounds of water leaks very quickly. Leaks in water lines that are only 3 or 4 feet deep are much easier to hear at the ground's surface than leaks in deeper lines. At 7 or 8 feet deep, only very large leaks with good water pressure will produce enough noise to be heard at the surface.
4. Finally, the ground cover, whether it is an asphalt street, loose dirt, concrete slab, or grass lawn, also makes an important difference. Hard street surfaces and concrete slabs resonate with the sounds of the water leak, and the leak may be heard for 5 to 10 feet or more on either side of the water pipe. Grass lawns and loose dirt surfaces do not offer such a resonating plate-like surface, and their surface variations make firm contact more difficult.

II. PROBLEM STATEMENT

Tubebot:

As observed the design in the above project is such that it requires ultrasonic scanning thus making it expensive. It also requires considerable amount of research to enable it to fit into the pipes of smaller diameter.

Detection using acoustics:

The above method is adopted in foreign countries for the detection of leakage in the underground pipes. It is also very costly since it requires the core knowledge and application of acoustics. It consists of methods wherein a human being has to hear the sounds and also study the intensity of the sounds underground. Also, the pressure and sound intensity need to be compared. Size of the pipe also needs to be considered. This method is not always accurate. Its implementation also requires a large amount of concentration. It is also very expensive.

Assuming the issues of concern from the above projects created in the past we have come to a conclusion to design a robot that will detect the underground water leakages in the pipes with the help of a wireless night vision camera. The speed of the motion of the camera will be kept constant. The time till the crack is detected will be noted on the stopwatch and assuming the speed and the time the distance can be calculated. This robot is simple to design and very cost efficient.

III. STUDY ANALYSIS

Pinpointing

1. "Water Leak Pinpointing" is the term applied to the process of pinpointing the exact leak location. For Acoustic Leak Detection, the exact leak location is usually the spot where the leak sounds are the loudest:
2.

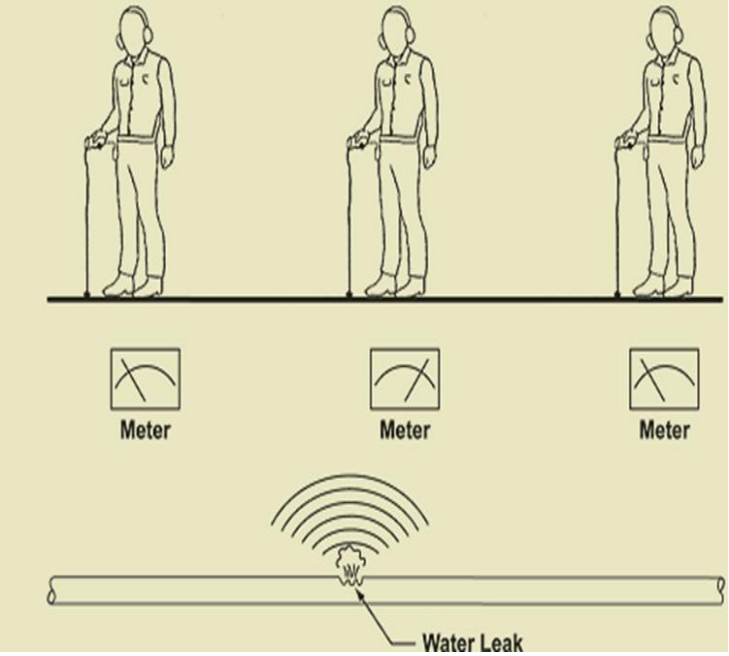

Fig.4 Determining Water Leak Pinpointing

3. To find this spot, the listener must carefully mark the location of the water line on the street after locating it exactly with a pipe and cable locator. Usually, the piping between the valve or hydrant with the loudest sound and the valve or hydrant with the second loudest sound is the section of the line that needs to be marked. The section must be accurately located and marked on the street in order for the listener to consistently listen directly over the pipe.
4. The listener moves the ground microphone 3 to 4 feet each time in the direction of the water line, listening, and moving closer to the water leak. While the listener is moving, he does not adjust the volume control, since the volume control must be held constant in order to make accurate comparisons. When the listener is very close to the leak, it may be impossible to decide based upon the user's hearing alone whether the leak is in one spot or in a spot 3 to 4 feet away. When this occurs, the listener must study the visible display (meter) to see if the signal is slightly stronger at one location than at another location.
5. The loudness of a leak heard on an asphalt street or a concrete slab depends upon the size of the leak, water pressure, and depth of the pipe. Hard, dry materials like asphalt, concrete, rock, and compacted soil transmit sounds better than wet clay, sand, or loose soil. The sounds travel further on iron and steel pipes than on PVC pipes or Poly pipes.
6. We have come to a conclusion to design a robot that will detect the underground water leakages in the pipes with the help of a wireless night vision camera. The speed of the motion of the camera will be kept constant. The time till the crack is detected will be noted on the stopwatch and assuming the speed and the time the distance can be calculated. This robot is simple to design and very cost efficient.

Proposed Work

Fig.5 Plumboat

The aim of the project is to find out the cracks in the pipelines which will be carried out by a vehicle and the wireless camera placed on it. This is embedded based system. This will help to drive vehicle, to control its direction i.e. to move left, right, forward or backward. To capture these cracks, camera needs to be moved in particular direction. This is achieved by embedded system which controls camera positioning and movement of camera. This information is send to the control house. For transmitting as well as receiving signals, wireless transmitter and receiver are used that is XBEE. Range of XBEE which we are using is from 100m to 750m. It will capture the commands; will display images of cracked pipelines. After decoding this information 89C51 will execute a program according to which XBEE will guide the vehicle. In this way, the objective is achieved.

Proposed Methodology

The problem of underground water leakages in the pipes without digging up the entire roadways and at a lower cost can be solved by using PLUMBOAT. Its rough physical design is shown as follows. It consists of a tripod design with spiral arms which are activated by the motor assembly. It consists of a wireless camera above the motor assembly. The three arms of the robot are along the circumference of the pipe.

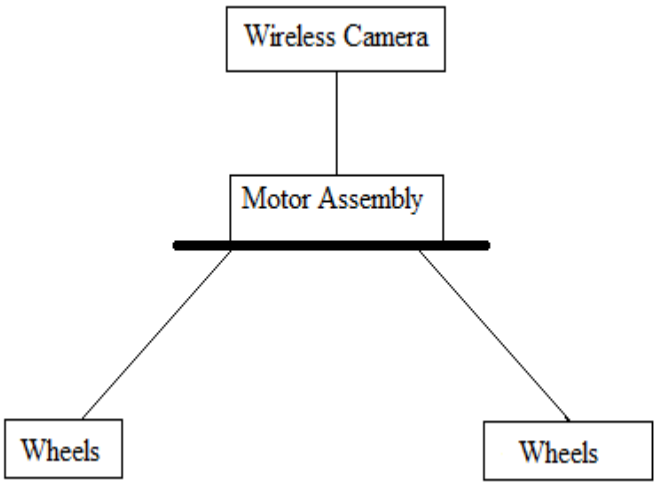

Fig.6 PLUMBOAT Design with Spiral Stand & Tripod

The main building blocks of the project are XBEE, stepper motor, and wireless camera which interact with each other using an embedded system. By analyzing the project we come to know that Xbee is a powerful means of way of wireless transmission and reception with some more advantages over Bluetooth. Range of Bluetooth is very limited viz. 15m and that of Xbee is 100m to 750m. This increases coverage range of project. Wheels of vehicles are driven by DC motor, in which its speed is an important parameter. Microcontroller 8051 executes the program and performs the desired action.

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