Use of a Robot to Clean Drainage Structures

Nyambane E. N, Mwaura C and Kamau L.

***Abstract*—** There is need for technology intervention in pollution and flood mitigation. This is because people litter everywhere which not only leads to accumulation of waste products that block the drainage systems but also pollution. Furthermore, whenever there is heavy downpour, the storm water tends to overflow onto the roads carrying waste products onto the streets. This has rendered some roads impassable and filled with gross waste products. Maintenance of this drainage structures especially without the CBD environment is little to none. The maintenance is usually done by Nation Youth Service (NYS) trainees and the city council. The process is manual, time consuming and requires a lot of labor. In other parts of the world like India, laborers who clean manholes have ended up dead due to the dangerous drainage structures.

The solution is to design a robot that can maintain clean and unclogged drainage systems. Being remotely controlled, it will collect waste products (like plastics, food wrappings), cut them up and store them in an in-built container. The container will then be emptied to a waste disposal site.

The expected result is to handle scheduled maintenance of the drainage system in an efficient manner with minimal labour. This in turn reduces risk involved in cleaning potentially dangerous drainage structures. In an effort to maintain the drainages on a regular basis, flooding, which arises from the blocked rains, will be more controlled.

Keywords—**Blocked Drainages, Flooding, GSM based system, Remote controlled Robots**

I. Introduction

A drainage structure provides a means of controlling flow of water from one point to another. Drainage structures functions include storm water management and flood control. These can only be achieved if the drains and sewers are clear to allow free flow of water. Unfortunately, this is not always the case. The structures are most often than not blocked by plastics, food wrappings, peelings, clothes and all kinds of debris. When it rains, the blocked drainage systems get filled with water. This leads to overflow of storm water onto the roads carrying waste products onto the streets. This has rendered some roads impassable and filled with gross waste products.

In various countries, different means are used to clean the drainage structures: Some states like New York have implemented mechanical hydraulic machines that are used to clean the sewers. They are work effective but costly. In other parts of the world like India manholes are cleaned manually by laborers who have ended up dead due to the poor drainage conditions. In Kenya it is done by Nation Youth Service (NYS) trainees and the city council. This is on occasional basis thus it is normal to find drains filled with garbage which causes blocking of the drains. Since the drains are poorly maintained flooding and pollution arises.

Nyambane E. N, Mwaura C. and Kamau L. ,Department of Telecommunication and Information Engineering, JKUAT (phone: +254717314073; e-mail: emilynnyambane@gmail.com).

Mwaura C, Kamau L. ,Department of Telecommunication and Information Engineering, JKUAT (e-mail:cathycat.cecy@gmail.com.; *kamaulincoln@jkuat.ac.ke*).

A. Statement of the problem

Most drainage structures are blocked and this is primarily due to:

- **Waste disposal**

Indiscriminate disposal of waste products interferes with the proper functioning of the systems

- **Poor maintenance**

Usually the cleaning of the systems is not done on scheduled basis. In Kenya emergency cleaning is usually done after a heavy downpour which doesn't help as much.

- **Lack of equipment**

The lack of proper equipment for cleaning the drains thus resulting to use of humans which is not very efficient.

This is a major problem because it leads to:

- Flooding

This renders most roads impassable and closure of most businesses.

- Pollution

This is a threat to the health of humans thus a major problem.

B. Research Objectives

The main aim of the project is to come up with a robotic machine that is able to maintain clean drainage structures by being remotely controlled to move through the drainage structure as it collects waste products.

II. LITERATURE REVIEW

Blocked drainage structures are a growing site today. Drainage's performance is rapidly dropping. Blocked drainage structures fail to prevent flooding, ponding, seepage and keep the roads, footpaths and carriageway free from standing water. Debris in the structures is a major cause of obstructed drains .The debris can be in the form of: litter, leaves, grass, plastic waste and miscellaneous debris. Blocked drains are also a result of failure to regularly clean and inspect the drainages to ensure that they are in proper condition. Routine maintenance is therefore needed to ensure continued efficiency of the drainage structures.

Blocked drains have adverse effects on the environment and the people living in it .One of the effects of blocked drains, is ponding and seepage which has led to sickness. This is due to the fact they allow breeding of mosquitoes that cause Malaria. Flooding on the other hand presents various health risks, which strongly affect the quality of life of individuals even after the flooding event has passed. There is therefore need to engineer new methods for maintaining these drainage structures.

The maintenance of the drains has proven to be at times costly, tedious and risky to human lives. Therefore methods proposed to keep the drains clean and unclogged should be cost effective. At the same time they should be able to reduce the risk of loss of lives incurred by manual laborers when they work in dangerous structures.

A. MAINTENANCE OF DRAINAGE STRUCTURES

Blocked drainage structures have adverse effect on the environment. They are mostly experienced during heavy downpour when the structures are not capable of handling the storm water. This storm water has nowhere to divert to since the drains are blocked and hence flooding on the roads and footpaths occurs. Flooding, especially on the highways, has devastating effects on the economy of the users[1]. Routine maintenance of drainage structures offers a sufficient and necessary precaution to minimise flooding along with the other effects mentioned in chapter 1.

In Nairobi drainage maintenance is important because it is usually cumbersome to drive in within the CBD because of flooding. Traffic gets worse during this season and even the travel time increases as one has to wait for the water level on the roads to fall so as to travel. This proves that there is a need for better maintenance.

[7]In India, cleaning of manholes has proved to be a lethal. This is because the manholes are not safe for humans and once workers descend into the manholes they are exposed to: noxious gases and vapour, bacteria, viruses and parasites. Despite of the risks involved, laborers are expected to descend into these manholes and clear out debris. Lack of emergency response protocols and staff training has translated to the death of the workers. There is therefore need for a technology to prevent deaths by the sewer.

Maintenance in Kenya is done by the City Council. Occasionally they contract the National Youth Service (NYS) to clean the drains. NYS personnel are deployed to unclog the drainage systems using brooms and rakes. The approach is cost effective, however it is slow. It also would require them going into potentially dangerous structures. Therefore this approach would still require ramifications to provide efficient cleaning in risky structures.

California stormwater BPM Handbook[2] offers great approaches in cleaning of the structures. They include:

- Regular inspection of the facilities.
- Cleaning the structures just before the wet season to get rid of debris.
- Conduct regular inspections during the wet season where blockage is imminent.
- Record the amount of waste collected.
- Store collected waste in a way that prevents discharge to the storm drain.
- Repair all outlet structures before the wet season.Abbreviations and Acronyms

B. DIRTY FLOOD WATERS

During the rainy season water flow in the drainage structures gets stuck due to plastics, paper bags and assorted waste. As the water runs off from higher areas towards the drains it is blocked. The water is hence diverted onto the roads and in lower areas of the city. An example is Hazina village, in South B division along Ngong, which is always affected by flooding during heavy downpour [8]. The natural cause of water is disrupted and ends up in the premises of the residents. The National Government has made efforts to clean the drains before the rains but they keep getting blocked once the rainy season is over.

Fig 1: BRIDGE COLLAPSES DURING FLOODS

C. IMPASSABLE ROADS

[1] Drainage systems along the highway require routine maintenance to ensure their optimal performance. Concentrations of debris in the drains close to the pavements prevent the run off of storm water. This causes water accumulation in the pavements that lead to stripping of bitumen. Water logging is also experienced due to the fact that water penetrates into the sub-grade and in turn makes the road weak and develops potholes.

The drains are also unable to handle storm water. The storm water gets polluted by the debris trapped in the drains. It picks up debris, chemicals, dirt and other pollutants and flow into a storm sewer system or directly to a water body such as a lake, stream, river, wetland or coastal water. In many cases storm water that enters into a storm sewer system is discharged untreated into water bodies we use for recreation, fishing and even drinking.

In the advent that the storm water is completely blocked or the run off is slow, the water becomes stagnated and the roads are

filled with dirty flood waters. This makes the roads impassable during the rainy season.
It is necessary to keep clean drains so that the drainage structures can better handle the storm water. If not the drains performance will continue to derail and the highways will continue to suffer the effects of blocked drains and flooding.

Fig 2: FLOODED ROAD IN NAIROBI

D. USE OF A ROBOT IN MAINTAINING DRAINS

There have been advancements in the engineering community to develop technologies that make cleaning of the structures safe and efficient.[3] Some engineers developed an intelligent arm robot to clean drainage systems. [4] Other engineers designed an autonomous robotic system to maintain free flowing drains. The number of service robots currently in operation is small but the number of people working in this service field shows a constant growth rate.
SEAVAX is a group of innovators that have engineered a robotic vacuum ship that will clean the ocean. The aim of their project is to promote a world ocean anti-plastic alliance. In other words they aim at eliminating plastic pollution in the ocean. The project is still in the testing phase. However, they have developed a prototype that is yet to be fully accepted by the regulators of U.K. A conceptually similar project to the one undertaken in this project was recently completed [5][6].
In summary, robotics is a growing sector especially in the service part. There is a growing interest in the robotic communities to design robots that will make domestic and commercial work easier for humans.

III. SYSTEM DESIGN

a) Technical design

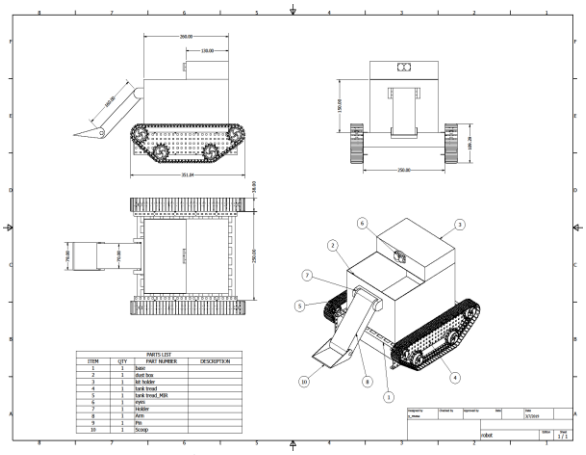


Fig 3: design specification and measurements

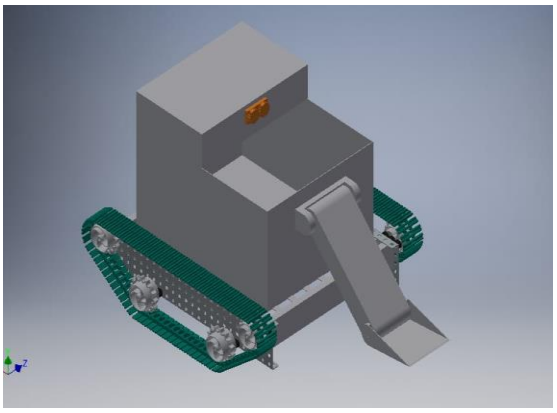


Fig 4: right side view of the robot

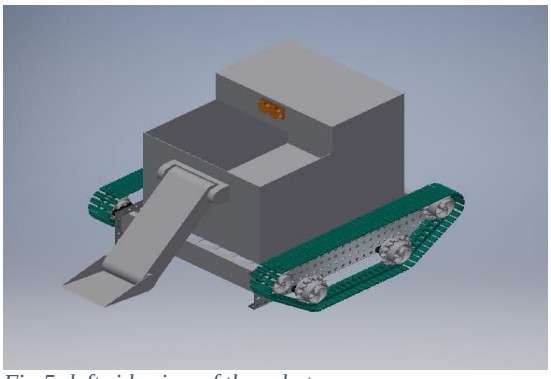
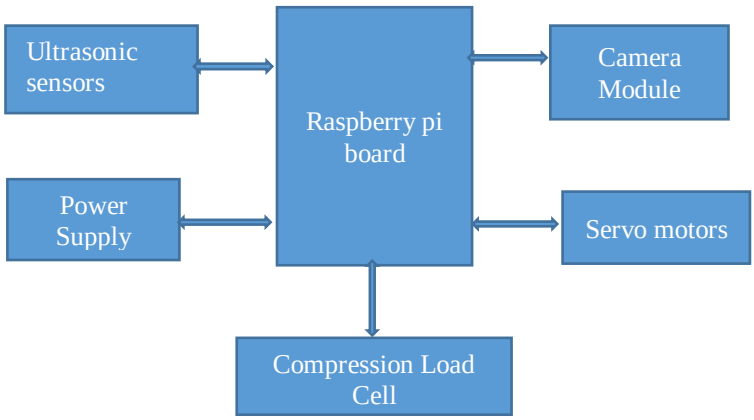
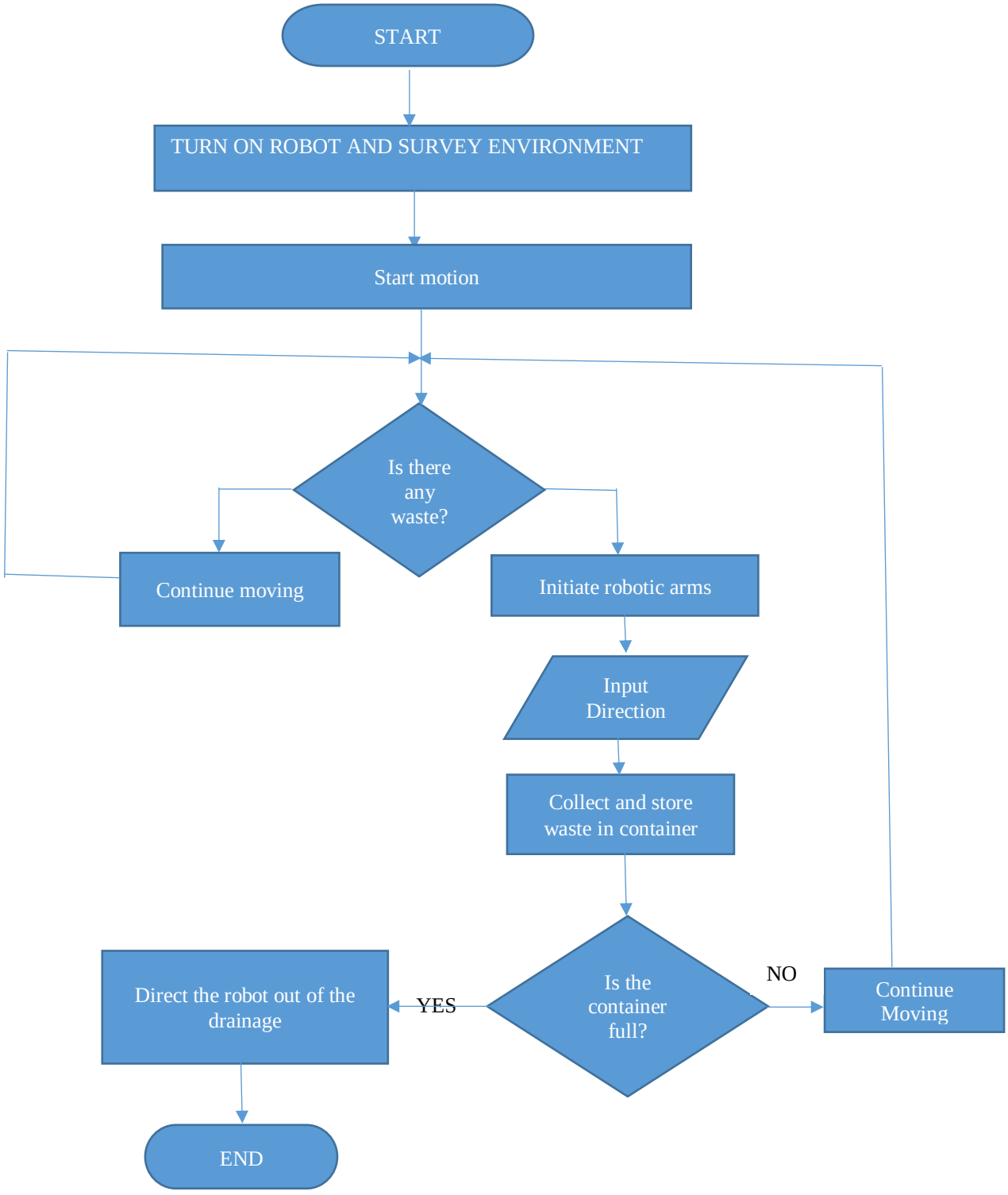


Fig 5: left side view of the robot

b) Block Diagram



c) Flowchart



d) Operation

The operation of the robot will be primarily broken down into 4 sub-sections:

1. **<u>Motion</u>**

There are two aspects involving motion:

- **The entire robot**

The robot will be moving in the drainage structures as it collects wastes. This will be aided by the use of servo motors.

Fig 6: servo motor

It will use continuous track wheels for motion because:

- The robot will be moving in water at some point and less power is needed for that.
- The tracks will balance the weight of the robot including that of the waste collected.

❖ **The robotic arm**

It requires motion of the arm so as to collect the waste products and feed it to the storage container.

Degrees of freedom needed:

Shoulder pitch

To allow the entire arm to move up and down

Shoulder yaw

allows the entire arm move side to side

Wrist roll

Allows the wrist (end part of arm) to rotate

Wrist pitch

Allows the wrist to move up and down

2. Vision

A Raspberry pi camera is installed in the robot that captures/records videos of the drainage structures as the robot moves. The videos are streamed using gstreamer technology and the information is then used to remote control the robot.

Fig 7: Raspberry pi camera module

3. Shredder

Consists of blades that are driven by the continuously running servo motors. It is housed in the storage container and as the arm feeds the container with waste products, it cuts them to smaller pieces to create room for more waste products to be collected.

Fig 8: Shredder blades

With the help of compression load cells at the bottom of the container, the capacity of the container will be monitored and once it is full, the collection process stops and the robot is removed from the drainages so as to empty the container.

Fig 9: Compression Load cell

4. Control system

A GSM based system will be used as the control system. It will control the robot to move forward, backwards, left, right and to stop motion.

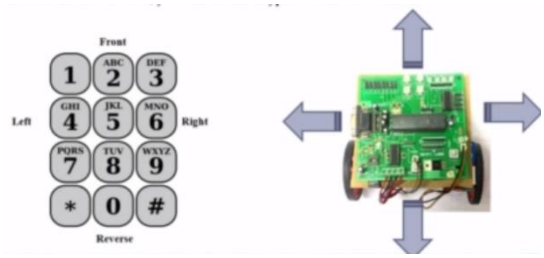


Fig 10:Motion controller

IV. Conclusion

In summary drainage structures need to be kept at their optimal best so as to control the hazardous effects it causes to the environment. Clean drains will mitigate flooding issues that renders the roads impassable. They will help in preventing run off of contaminated water that could spread cholera in a community. The stagnant water caused by

blocked drains could be avoided by ensuring that the water flows to its natural habitat.

Maintenance of the drains requires methods and tools that are not threatening to the well-being of the laborers. As discussed earlier some structures like the manholes are not conducive for men to work in. This deems it necessary to utilize methods and advanced equipment that will make the cleaning of the drains easier.

REFERENCES

1. [M. T. Tiza, V. T. Iorver, and E. T. Iortyom, "The Effects of Poor Drainage System on Road Pavement: A Review," *Int. J. Innov. Res. Multidiscip. F.*, vol. 2, no. 8, 2016.
2. "Sc-74 Sc-74," no. January, pp. 1–9, 2003.
3. S. Sharmili, T. Saarika, and R. Malar, "Intelligence Drainage Cleaning Using Arm Robot," vol. 24, no. 7, pp. 63–66, 2017.
4. J. Costa and S. Chowdhury, "An Autonomous Robotic System to Maintain Free Flowing Drains," no. 14101271.
5. A. Cemal TOZ, B. Koseoglu, and C. Sakar, "Marine Environment Protection: New Technologies on Oil Spill Response Industry," no. December, 2016.
6. R. N. Smith, "Robotic GNOME Lab - Fort Lewis College," 2016.
7. "More Indians die cleaning sewers than fighting terrorists in Kashmir", *Quartz India*, 2019. [Online]. Available: https://qz.com/india/1074911/more-indians-die-cleaning-sewers-than-fighting-terrorists-in-kashmir/. [Accessed: 02- Mar- 2019].
8. C. Home, "Heavy rains and blocked drains: Nairobi's recipe for floods", *Climate Home News*, 2019. [Online]. Available: https://www.climatechangenews.com/2018/11/18/heavy-rains-blocked-drains-nairobis-recipe-floods/. [Accessed: 02- Mar- 2019].