Pothole Detection, Reporting and Management using Internet of Things: Prospects and Challenges

Article · November 2017

3 authors, including:

Ebenezer Komla Gavua
University of Miskolc
9 PUBLICATIONS **1** CITATION

SEE PROFILE

Pothole Detection, Reporting and Management using Internet of Things: Prospects and Challenges

Collinson Colin M. Agbesi, Ebenezer K. Gavua, Seth Okyere-Dankwa, Kwame Anim Appiah, Kofi Adu-Manu Sarpong

Abstract: ***Road networks are the means of transporting, sharing and movement of goods and services from place to place in society. Road networks are also channels of communication in some parts of the world. Consequently, access to good road networks enhances the quality of life and work of people living in society. But the poor nature of design and development of road networks coupled with natural disasters such as heavy rainfall has brought about many unwanted potholes and scratches on the roads which are very dangerous to commuters and other road users as well as vehicles that utilise the roads. In addition, the lack of a proper road maintenance system has resulted in an ever increasing number of potholes which endanger efficient transportation and road safety. Meanwhile road maintenance works has largely depended on manual detection and reporting. The advent of computers, information technologies, network and communication technologies and sensors have brought about a new phenomenon known as "internet of things" also put "internet of everything" (IoT//IoE). The global network of things is the connection of the physical objects to virtual objects in the world. This enables physical world objects to be assigned unique internet protocol addresses with the purpose of sharing and exchanging data and information. The paper conducts a study into the use of internet of things to detect and report potholes on roads. The paper assembles an open hardware equipment and sensor to experiment the detection and reporting of potholes using IoT/IoE enabled devices. The paper presented the architectural design and system to detect, report and manage potholes and other road obstacles using IoT. The paper also presented some prospects and challenges in the implementation of internet of things (IoT).***

Keywords: Pothole Detection, Pothole Reporting, Pothole Management System, Internet of Things/Everything

I. INTRODUCTION

The fast advancements in information and communication technologies have brought better and efficient ways of undertaking work and living in society. New innovative systems and cutting edge solutions are emerging from the use of latest and emerging information and communication technologies worldwide. The recent convergence of sensor networks and communication technologies has led to the development of internet of things which is fast becoming the new wave in the era of computing (Sudarshan et al. 2009; Erikson et al., 2008).

Revised Version Manuscript Received on November 15, 2017.

Collinson Colin M. Agbesi, Department of Computer Science, Koforidua Technical University, Koforidua, Ghana.

Ebenezer K. Gavua, Department of Computer Science, Koforidua Technical University, Koforidua, Ghana.

Seth Okyere-Dankwa, Department of Computer Science, Koforidua Technical University, Koforidua, Ghana.

Kwame Anim Appiah, Department of Computer Science, Koforidua Technical University, Koforidua, Ghana.

Kofi Adu-Manu Sarpong, Department of Computer Science, Valley View University, Oyibi, Ghana. Email: koliny3k@gmail.com

Internet of things allows sensors with networking capabilities to be embedded in everyday objects to enable them communicate and share information with other objects in the physical and virtual worlds (Al-Fuqaha et al., 2015; Zanella et al., 2014). Potholes and speed ramps are among the most common obstacles on most road networks. These road obstacles and disruptions in the surface condition of roads are among the causative factors of road accidents, carnages and fatalities. This paper examines the prospects and challenges of internet of things (IoT) in detecting, reporting and management of potholes and other obstacles on our road networks.

1.1. Problem Statement

Potholes are very harmful road surface conditions that prevent a safe, secure and reliable transportation and movement of people, goods and services. Road surface obstacles such as potholes affect the safety and comfort of most road users and commuters (Zoysa et al., 2007). Bad road networks hamper the smooth movement of goods and services and contribute to the poor growth and development of the economy whiles good road networks provides access to markets and enable fast and smooth transportation of goods and services from producers to consumers. Early detection and maintenance of potholes helps to create a conducive and reliable road network that facilitates the smooth movement of people, goods and services (Mednis et al., 2011; Yu & Yu, 2006).

II. LITERATURE REVIEW

The advent and emergence of sensor networks has enabled these devices to collect vital information about the environment and also to undertake context processing. Radio Frequency Identification (RFID) and Sensor Based Networks enable objects in the physical world to be fitted with network capabilities thereby enabling them to collect and process vital information about their environments. The term internet of things (IoT) was first coined by Kevin Ashton in 1999 at MIT during their study of using radio frequency identification and sensor networks for supply chain management. The global network of things provides a context aware processing and computations of objects in the world and their environmental conditions using network resources and also facilitates the sharing of data and information among various objects (Al-Fuqaha et al., 2015; Zanella et al., 2014). There has been several studies into the detection, reporting and maintenance of potholes. Pavan et al. (2014) explored the use of android smartphones to detect and report potholes.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

Also Kulkarni et al. (2014) studied the use of machine learning on android to detect and report potholes. Other studies have used RFID, sensors and cameras to detect and report potholes (Sudarshan et al., 2009; Youngtae & Seungki, 2015). Further research works have also studied pothole detection and management using simulated potholes.

Figure 1: Potholes and Road Obstacles

2.1. Challenges of Internet of Things

Some key challenges of internet of things (IoT) identified during the study are as follows;

Connectivity Issues: Network connectivity and integration of devices into various networks for communication is a challenge to internet of things. Heterogeneity of network technologies and low communication speed and bandwidth is a challenge to internet of things (IoT).

Power Issues: Power is one of the challenges of internet of things. Most IoT enabled devices and systems operate wirelessly and are fitted with batteries that last for very few hours.

Context Processing: Another challenge of internet of things is that; some IoT enabled devices are unable to detect and process complex environments.

Security Issues: Security is another great challenge of internet of things which seeks to interconnect the world of objects to the virtual world thereby allowing all kinds of objects to communicate and share information.

Standards, Policies and Regulations: The lack of standards and policies hampers the fast development of internet of things. Rules and regulations are needed to enhance the development of IoT devices and systems and their implementations.

III. METHODOLOGY

This paper used an open hardware device and a prototype vehicle to build an IoT enabled device to detect, report and manage potholes and road surface obstacles. The paper used an Arduino microcontroller board to build an interactive and context aware system which can sense and control objects in the physical environment. An alarm system and a light emitting diode (LED) were interfaced with the Arduino microcontroller to give signals of the detection of potholes and bad road surface conditions. The study used a light dependent resistor (LDR) controller to sense, detect and report potholes and other road obstacles. Potholes and bad road surface conditions detected were sent via a subscriber identification module (SIM) card for onwards transmission to the server for processing.

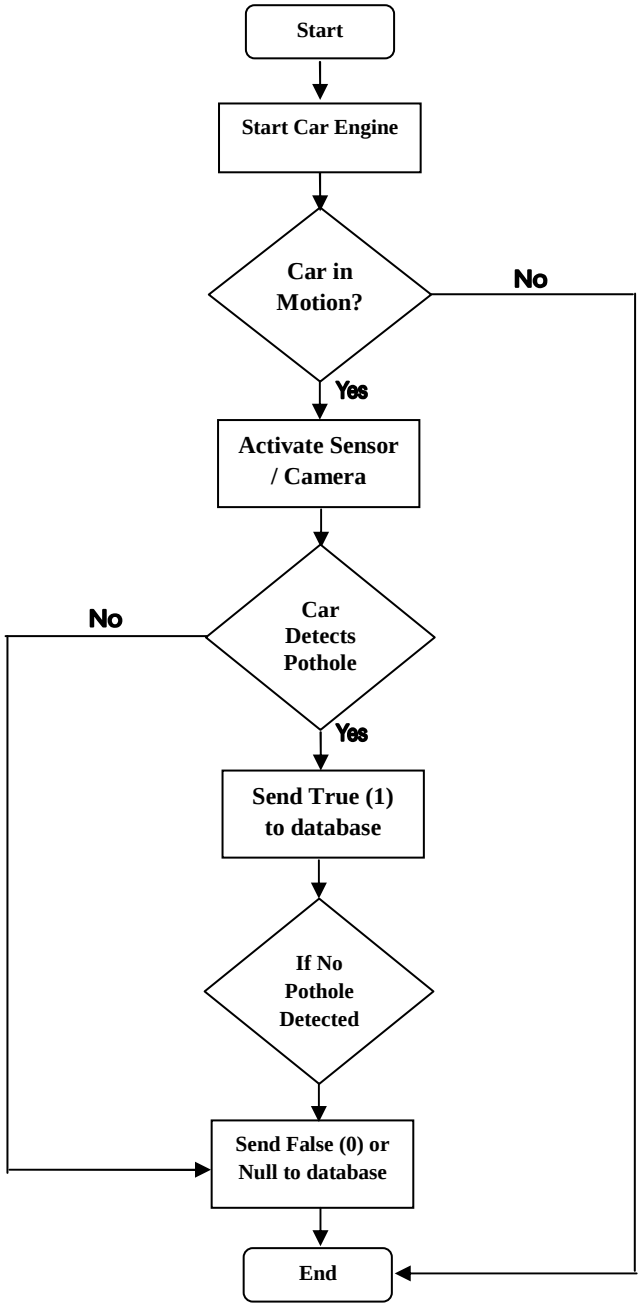

Figure 2: Algorithm for Pothole Detection and Reporting

The figure 2 shows the algorithm of pothole detection and reporting. The car engine is ignited on start up. If the car is in motion, the IoT sensors and camera are activated. If a pothole or road surface obstacle is detected, a true value of 1 is sent to the server otherwise if no pothole is detected then a null or false value of 0 is sent to the server.

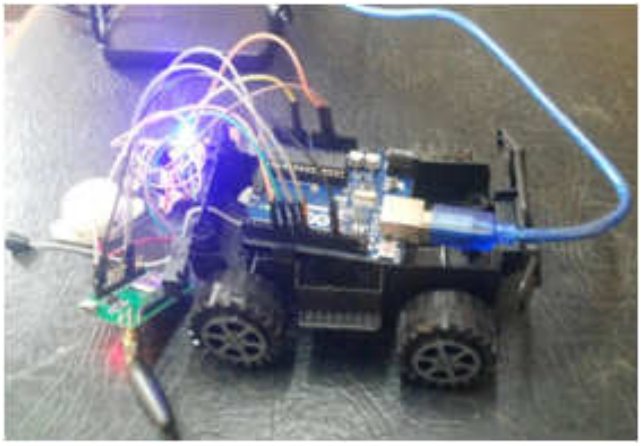

Figure 3: Experimental Setup

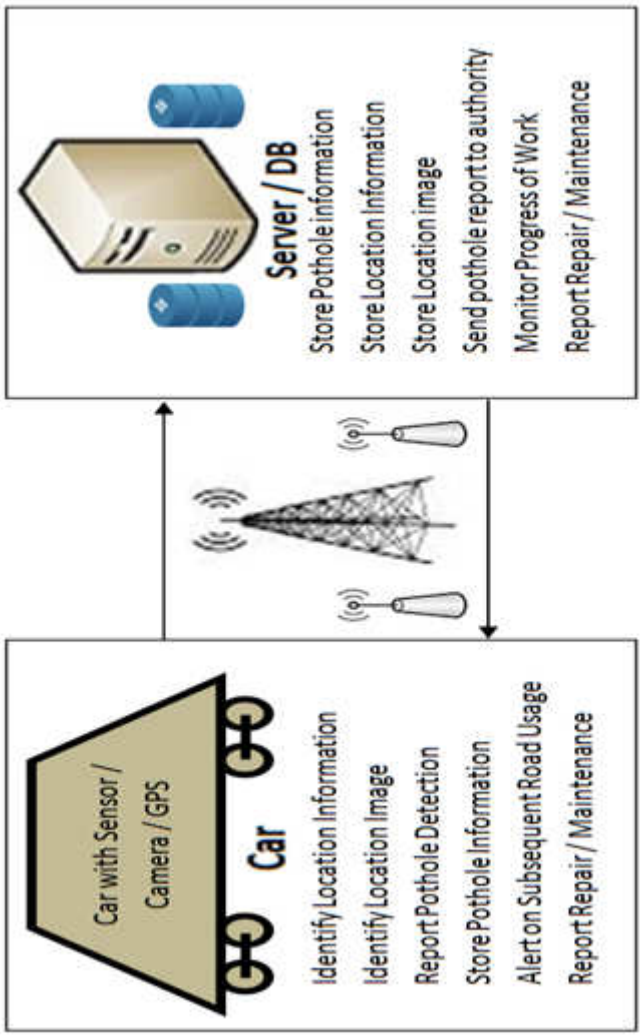

Figure 4: Experimental Framework

The figure 4 shows the experimental framework of pothole detection and reporting using IoT enabled devices. The car fitted with sensors moves along a road network. The car is setup to identify potholes and road obstacles. If the car is fitted with camera, it is configured to take the image of pothole location and send pothole detection information to the server. The car also stores pothole detection information locally and alerts the users whiles it approaches the same location another time. Similarly, the server stores the pothole information, location and image in a database or pothole management system. The server sends the reported pothole information to road authorities for investigation and maintenance. The status of repair and maintenance works is stored in the pothole management system and feedback sent to the road users and commuters.

IV. EXPERIMENT RESULTS

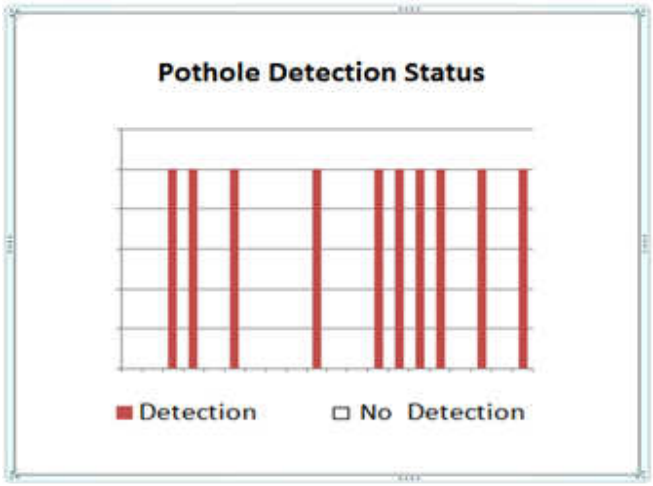

Figure 5: Results

The result from figure 5 shows pothole detection status of the car. If a pothole is detected, the car reports a true value of 1 and if no potholes are detected the car sends a null or false value of 0 to the server. It can be seen from the results that some sections of the road are smooth without potholes or road surface obstacles. Also from the results, it was observed that some portions of the road had isolated potholes whiles other sections had multiple potholes at the same place which hampers a safe transportation and movement on the road network.

V. CONCLUSION

Computers for that matter information and communication technologies has increasingly contributed to the quality of life and work of many individuals and organisations. This has provided convenience, comfort and several other benefits to people across the world. The convergence of network and communication technologies and sensor based networks has given rise to a new phenomenon called internet of things (IoT). The global network of things has enabled objects in the physical and virtual world to communicate and share information. Radio Frequency Identification (RFID), sensors and emergent network and communication technologies are seen as a driving force behind IoT enabled devices with capabilities of sensing and processing their contextual and environmental conditions. The emergent of internet of things (IoT) has greatly contributed to the bringing together of the virtual and physical world. This enable objects in the physical world to have unique internet protocol addresses to be able to identify and interact with other objects in the virtual world using various technologies and systems. The study conducted an experiment by assembling an Arduino microcontroller board and sensors.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

To detect and report potholes and other road surface obstacles. If a pothole or road obstacle is detected, a true value of 1 is sent to the server and if no pothole is detected a false value of 0 is sent to the server. During the study, it was observed that potholes remain a key challenge to most motorists and road users. Potholes and road surface obstacles hamper a safe, secure, reliable and convenient transportation and movement of goods, services and people across the world.

Additionally, it was observed during the study that using IoT to detect, report and manage potholes and other road surface obstacles gives a real time detection, communication and sharing of relevant information about the conditions of road networks. Additionally as internet of things is becoming a reality in society, using this technologies would provide a fast and reliable source of information for road authorities. The study further recommends the integration of smart cameras for the detection and reporting of potholes and the use of geographic position system and geographic information systems in order to track and monitor conditions of road networks.

REFERENCES

1. Al-Fuqaha et al., (2015), "Internet of Things: A Survey on Enabling Technologies, Protocols and Applications", IEEE Communication Survey, Vol. 17, Issue 4
2. Erikson et al., (2008), "The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring", Proceedings of 6th International Conference on Mobile Systems, Applications and Services, USA
3. Kulkarni et al., (2014), "Pothole Detection System Using Machine Learning on Android", International Journal of Emerging Technology and Advanced Engineering, Vol 4, Issue 7
4. Mednis et al., (2011) "Real Time Pothole Detection Using Android Smartphones With Accelerometers", International Conference on Distributed Computing in Sensor Systems and Workshops, Barcelona, Spain.
5. Pavan et al., (2014), "Real Time Pothole Tracking System Using Android Smart Phone", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Vol 3, Issue 5
6. Sudarshan et al., (2009), "Pothole Detection and Warning System Using Wireless Sensor Networks" Embedded Real time systems laboratory, India Institute of Technology, Bombay.
7. Yougtae Jo & Seungki Ryu, (2015), "Pothole Detection System Using a Black-box Camera", Highway Research Institute, Korea Institute of Civil Engineering and Building Technology
8. Yu, B.X. & Yu, X. (2006), "Vibration Based System For Pavement Condition Evaluation", Proceedings of 9th International Conference on Applications of Advanced Technology in Transportation, USA
9. Zoysa et al., (2007), "A Public Transport System Based Sensor Network For Road Surface Condition Monitoring", Proceedings of Workshop on Networked Systems for Developing Regions, Kyoto, Japan.
10. Zanella et al., (2014), "Internet of Things for Smart Cities", IEEE Internet of Things Journal, Vol. 1, No.1

(About Authors)

Mr. Collinson Colin M. Agbesi is a lecturer at the Department of Computer Science, Koforidua Technical University. He is currently pursuing a postgraduate research program at the Department of Computer Science, University of Ghana, Legon.

Mr. Ebenezer K. Gavua is a lecturer at the Computer Science Department of Koforidua Technical University.

Mr. Seth Okyere-Dankwa is a lecturer at Computer Science Department of Koforidua Technical University.

Mr. Kwame Anim Appiah is a lecturer at the Computer Science Department of Koforidua Technical University.

Mr. Kofi Adu-Manu Sarpong is a lecturer at the Department of Computer Science, Valley View University. He is currently pursuing a postgraduate research program at the Department of Computer Science, University of Ghana, Legon.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.