LITERATURE SURVEY ON

IoT BASED SMART WASTE MANAGEMENT IN METROPOLITAN CITIES

PAPER 1: Smart Waste Management System Using LoRa and Tensorflow Deep Learning Model

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Summary: Traditional waste management system operates based on daily nd allow for better waste management. The aim of this research is to develop a smart waste management system using LoRa communication protocol and TensorFlow based deep learning model. LoRa sends the sensor data and Tensorflow performs real time object detection and classification. The bin consists of several compartments to segregate the waste including metal, plastic, paper, and general waste compartment which are controlled by the servo motors. Object detection and waste classification is done in TensorFlow framework with pre-trained object detection model. This object detection model is trained with images of waste to generate a frozen inference graph used for object detection which is done through a camera connected to the Raspberry Pi 3 Model B+ as the main processing unit. Ultrasonic sensor is embedded into each waste compartment to monitor the filling level of the waste. GPS module is integrated to monitor the location and real time of the bin. LoRa communication protocol is used to transmit data about the location, real time and filling level of the bin. RFID module is embedded for the purpose of waste management personnel identification.

Methodology used: This work was supported in part by the Ministry of Malaysia under Grant LRGS MRUN/F2/01/2019/1/2, and in part by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, Saudi Arabia, under Grant RG-39-135-40.

Conclusion: This article presented a smart waste management system by implementing sensors to monitor the status of the bin, LoRa communication protocol for low power and long-range data transmission, and TensorFlow-based object detection to perform waste identification and classification. The pre-trained object detection model, SSDMobilnetV2 is able to perform well in Raspberry Pi 3 Model B+ due to its lightweight nature. The model was able to detect and classify waste according to classes such as metal, plastic, and paper. However, the accuracy of the model can be improved by increasing the number of training data—in this case, the number of waste images—and by increasing the training time. The segregation of waste is interfaced and coordinated well between the object detection performed by Raspberry Pi and the servo motor controlling the lid of the individual waste compartment. An RFID module controls the locking mechanism of the bin. Ultrasonic sensors monitor the filling level, while the GPS module monitors the location and real-time of the bin. LoRa operating at a frequency band of 915MHz transmits data regarding the status of the bin regarding filling level, location, and real-time from the bin to the LoRa gateway. The data received at the gateway is decoded by a terminal program, RealTerm. This automated segregation and monitoring system implementation in the bin aims to reduce the operating cost and improve the waste management system. At the same time, we are eager to develop the city into asmart city. In the future, the waste detection model is to be improved by increasing the number of waste images in the dataset to increase the flexibility of the system in identifying waste. Moreover, an automated routing system can be developed to identify and pinpoint the shortest path to the bin for the purpose of maintenance. With this in mind, the existing waste management system can be improved and bring society towards a greener and healthier life.

PAPER 2: Smart City Platform Environment

for Waste Management

Publication year: 05 | May 2019

Author name: G. Paulin Nancy1, R. Resmi2

Journel name: International Research Journal of Engineering and Technology (IRJET)

Summary: Coimbatore city is one of the smart cities. There are many projects going on for the development of Coimbatore as a smart city. Waste

management has become a challenge before society as it is being continuously neglected in the field of environment which is getting harmful for the health of living organism's as well as the environment. Effective waste management strategies are required that involves a synchronized system of controlling the production and disposal of wastes. Most of the waste management techniques like landfills, incineration, sanitary landfills provide a variety of environmental benefits but have negative impacts too like emission of large amount of green house gas. This paper reveals the risk and issues occurred during all stages of waste management and find the smart solution for those major issues thereby developing the platform of smart city for waste management.

Methodology used: Identifying the key risk factors of waste management process by reviewing the literature and through the additions that could be made by the participants i.e. workers .Questions are prepared based on the identified risk factors such as storage system, lack of proper segregation, area coverage, capacity issue, climatic change, etc. Major factors and issues are identified with the help of questionnaire survey. Providing practical suggestions and recommendations pointing toward upgrading waste management process and improve the performance of workers thereby create platform of smart city.

Conclusion: From the survey report, several risk factors such as storage system, lack of proper segregation, area coverage, capacity issue, climatic change were identified. Based on these risk factors, smart solutions recommended were automated sorting system, automated solid waste management, smart planning by using web camera & load sensor, Smart garbage.

PAPER 3: IoT-based smart waste level monitoring system for smart cities

Publication year: January 2021

Author name: A.A.I. Shah1 , S.S.M. Fauzi2 , R.A.J.M. Gining3 , T.R.Razak4 , M.N.F.Jamaluddin5 , R. Maskat6

Journel name: Indonesian Journal of Electrical Engineering and Computer Science

Summary: Smart cities are covering the population that are seeking the best lifestyle and fulfilling their needs. Through smart cities, necessary modern facilities using ICT emerging technologies such as the internet of things (IoT) had been installed to ensure the sustainability of the city. In the perspective of waste management, several different IoT-based solutions also had been

proposed as an alternative to monitor and to ensure the health of communities. This paper reviews existing IoT-based solutions in smart cites' waste level management system to bring together the state-of-the-art. We performed reviews on 16 research articles from the past 5 years in the literature to provide a comprehensive review of different works on IoT-based solutions related to the smart waste level monitoring system, possible solutions and technologies used. The results obtained shows that existing solutions were similar in the platform used to integrate with the IoT technologies but had some differences in term of the used of sensors and communication technologies. The study also shows that many of the prior studies used Arduino Uno. Results from this study will assist the researcher, focusing on expanding further the used of different technologies or improved the existing system

Methdology used: This study employs a necessary systematic mapping study (SMS) steps [35]. An SMS is intended to encompass an exhaustive search. It aims to provide a thorough and repeatable analysis of all relevant literature. The five main steps in the method are: definition of research questions, searching for relevant papers, screening papers, keywording of abstracts, and data extraction and mapping

Conclusion: This study contributes to research on smart waste level monitoring system by synthesising the literature on the current state-of-the-art. This study is crucial as it provides a clear overview of the state-ofthe-art of the development and implementation of the smart waste level monitoring system. An in-depth review suggests that the existing solutions were similar in the platform used to integrate with the IoT technologies but have some differences in term of the used of sensors and communication technologies. The study also shows that many of the prior studies used Arduino Uno. In future research, we intend to identify the requirement of the proposed .

Paper 4: Smart Waste Management under Smart City Mission – Its Implementation and Ground Realities

Publication year: October 2019

Author name: Priyanka Mokale

Journal name: International Journal of Innovative Technology and Exploring Engineering (IJITEE).

Summary: This paper is based on the secondary as well as primary data. Secondary data took from the newspaper, article, etc. And primary data based on the observation and survey that did in 2016 and recent in Mumbai. At the end in the discussion try to show the difference between small-town waste management and Metropolitan cities challenges and how to manage it and then gave the recommendation for solid waste management improvement.

Methodology used: This paper is based on secondary literature, data like, news reports, research paper, journal, etc.

Conclusion: Solid Waste Management but several other schemes like Swachh Bharat Mission have also played a vital and significant role in bringing public awareness on health factor related to waste. Therefore successful implementation only happened of such policies when not only the city's local government but also the city's citizen involve to make their city clean, healthy smart and for that strong bonding in between cities citizen and Urban local bodies of that cities must be important to exposed.

PAPER 5: Smart cities: A case study in waste monitoring and management.

Publication year: 2017

Author name: Lundin, Andre Castro; Özkil, Ali Gürcan; Schuldt-Jensen, Jakob

Journal name: Published in: Proceedings of the 50th Hawaii International Conference on System Sciences.

Summary: This paper explores the potential of employing sensor enabled solutions to improve on waste monitoring and collection in public trash bins. Through a user- centered design approach, an inexpensive monitoring system developed and tested in pilot study. The system consists of wireless nodes that use ultrasonic sensors to measure the empty space in the bins, a sensor gateway that is based on Long Rage Wide Area Network (LoRaWAN) protocol and

cloud-based back/front end for data collection, analysis and visualization. The system was evaluated through a pilot test, where six outdoor trash bins were remotely monitored at a university campus and a number of stakeholders were observed and interviewed. The results show that the existing technologies are mature enough to be able to develop and implement inexpensive add-on sensors to exiting trash bins, and employing such a system can provide the necessary insights to optimize waste collection processes, to avoid overfilled bins, and to improve the experience of the citizens.

Methodology used: Design methodology [44], and applies the user-centred design principles [22]. The design process starts with identifying the needs, deriving requirements, conceptualisation of the solutions, evaluating the concepts and finalizing the design.

Conclusion: This paper presented a smart monitoring system for public trash cans. The user-centered design approach was used to understand the needs of the users, derive the requirements and develop the system. Continuous involvement of the stakeholders during design phase assured the alignment between design objectives and the results of the pilot study.

PAPER 6: Smart Waste Management for Smart City: Impact on Industrialization

Publication year: 2021

Author name: G U Fayomi , S E Mini , C M Chisom , O S I Fayomi, N E Udoye,O Agboola and D OOmole

Journal name: International Conference on Science and Sustainable Development (ICSSD)

Summary: Waste in different forms such as solid waste, gaseous waste and liquid waste increases due to population increase, urbanization, and industrialization and affect the globe. Waste management involves activities such as reuse, recycling and reduces waste generation and other strategies to combat the effect of waste generation due to increasing population and industrialization. Monitoring is one of the key functions of waste management, as it is needed to address the issues faced by waste management, which includes waste generation, waste collection, transportation of waste, waste treatment and waste disposal processes. This paper reviewed the technology involved in achieving a smart management and suggests the use of artificial intelligence (AI) to solve waste management such as convolutional neural network for efficient classification and waste identification and other AI technology.

Methodology used: Sanity landfill, incineration and pyrolysis-gasification, other methods exist.

Conclusion: Satisfying the area of environmental safety, in-depth understanding on factor is considered while making decisions with respect to how best to

manage waste. Waste generated in smart cities is a category of municipal waste. Traditional approach in solving waste management issues have failed as it is not reliable or sustainable as it takes a lot of input to have little or no work output. The increase in population, urbanization and industrialization have increased waste generation in an alarming rate, hence traditional approach is not able to properly collect and analyses the data from waste dumps. A more critical analysis of waste data is assured in a short time with the best possible output thereby ensuring a better output. Therefore, research on application of artificial intelligence tool with already existing technology to perform waste management processes.

PAPER 7: A facilitating framework for a developing country to adopt smart waste management in the context of circular economy

Publication year: 1 December 2021

Author name: Feroz Khan1 · Yousaf Ali1

Journel name: Environmental Science and Pollution Research

Summary: To achieve higher standards of sustainability, the waste management sector now requires the incorporation of circular economy (CE) principles. However, an easy transition toward the particular goal would require the use of smart waste technologies. To achieve the aforementioned goal, this study aims to provide a facilitating framework for the adoption of smart waste management in the context of CE for Pakistan. To help Pakistan transition toward the new paradigm, a total of 16 critical facilitators are evaluated based on fve distinctive criteria using a novel fuzzy hybrid multi-criteria decision-making (MCDM) approach. The hybrid MCDM approach includes fuzzy

Stepwise Weight Assessment Ratio Analysis (SWARA) for allocating weights to the determined criteria; whereas, the fuzzy VIšekriterijumsko kompromisno rangiranje (VIKOR) approach is used to rank the critical facilitators adopted from the secondary literature. The fuzzy approach in both cases is to deal with any kind of uncertainty during the data collection process. Based on the achieved results, the study suggests that before the application of smart waste technologies in the country, Pakistan should frst focus on devising regulations that efectively address the mismanagement of waste produced in the country. Also, the industries in the country need to become more responsible and should adopt environmental management systems that foster waste minimization. Lastly, the country in the third phase should focus on the wide application of digitalization both in the streams of ICT and IoT, for collecting, sharing, and receiving waste data. The study further provides policy recommendations to the respective stakeholders that will help the country achieve zero-waste CE.

Methodology used: The next step in the data collection process was to collect data from the experts to rank the most critical facilitators based on their experience. The 16 facilitators were ranked based on fve criteria that include (C1) environmental, (C2) social, (C3) economic, (C4) technical, and (C5) regulatory perspectives. A total of 33 experts took part in the survey

Conclusion:solid waste management is becoming more complex and difcult to manage because of the increase in the world population. To engage in a more sustainable waste management approach, most countries around the world are moving toward the adoption of CE principles. The aim of this paradigm shift is to engage people and industries into becoming more responsible by reducing, reusing, and recycling waste.

PAPER 8: Smart City Waste Management through ICT and IoT

Publication year: May 2021

Author name: Dipak S. Gade1 & P. S. Aithal2

Journel name: Post Doctoral Research Scholar, Department of Computer Science and Engineering, Srinivas University, Mangalore, India

Summary: Ever growing population causing a lot of issues and one of the biggest issues is increasing generated waste. Such waste can be food waste, material waste, waste from human beings, waste from useless stuff, waste from industries, etc. Such generated waste is hazardous for the overall environment if

not managed systematically. Hence waste management is a very important issue that requires high attention and resolution on priority.

Methodology used: While conducting the research and proposing a new solution for Waste Management, multiple methodologies and techniques were used by us. The main focus was on carrying out a time-bound existing literature review. For this purpose, we studied the relevant research papers, journal papers, white papers, conference papers, online blogs, and dedicated websites for Smart Waste Management. Specific keywords such as "Smart City", "Smart Waste Management" "Waste Handling", "Waste Generation", "Waste Recycling" were used while identifying relevant research papers and book chapters. The collected literature was then analysed considering the year it is published, proposed solutions for Smart Waste Management, notes on existing techniques while carrying out waste management across the globe, new considerations in new Smart Cities for waste management and also the operating cost, manpower and required infrastructure for doing the Smart Waste Management. We also went through the existing Interviews of Subject Matter Experts, researchers and industry professionals working in Smart Waste Management. Few Interviews were also taken of some wellknown industrial professional enquiring their opinions and views on existing Waste Management techniques and suggestions for improvements in Smart Waste Management. Last we carried out certain experiments through simulations and prototypes to some extent to build a proof of concepts around the proposed solution (at lab level) to measure its efficiency and effective operations meeting the state objectives

Conclusion: The testing of POC of iSmartWMS System successfully demonstrated that iSmartWMS solution effectively carried out all the intended functionalities. Due to limited test data and in absence of reallife waste material related data, full potential of iSmartWMS PoC could not be tested and it is difficult to judge the overall performance of iSmartWMS as a Smart Waste management system. However, the encouraging results confirmed that iSmartWMS can be effectively used for Smart Waste Management if implemented fully. To take full advantage of the benefits offered by iSmartWMS, it is highly recommended to develop the full-fledged system as per stated requirements and building blocks.

PAPER 9: IoT-Enabled Smart Waste Bin Management System and Efficient Route Selection

Publication year: 16 December 2019

Author name: Asim Zeb , 1 Qurban Ali,2 Muhammad Qaiser Saleem,3 Khalid Mahmood Awan , 4 Ali Saeed Alowayr,3 Jamal Uddin,2 Saleem Iqbal , 5 and Faisal Bashir6

Journel name: Hindawi Journal of Computer Networks and Communications

Summary: Internet of things (IoT) is an emerging technology that offers promising solutions to modernize the traditional systems. It accords promising result in crystallizing smart cities, smart homes, smart industries, and smart environment. -is article presents the smart waste management architecture for smart cities and efficient routing technique considering least delay for the architecture. In wireless sensor networks, end-to-end delay is one of the important Quality of Services (QoS) parameter to overcome delay in data communication. In this article, we consider end-to-end delay minimization in smart waste management application. -e term "end-to-end delay" is defined as the total time taken by a single packet to reach the destination node. -e proposed scheme considers the interference level, the length of the routing path, and the number of hops along the path. -e simulation results show that the proposed scheme outperforms current schemes

Methodology used: section provides the proposed methodology which demonstrates the smart waste management system to empower the cleaning operations and to detect cleaning issues Physical world Information world A Device Gateway Physical thing Communication via gateway Virtual thing Communication Mapping Communication without gateway Direct communication Communication network B C A BC Figure 1: IoT communication [14]. Journal of Computer Networks and Communications 3 in real-time IoT.

Conclusion: article proposes IoT-enabled waste management system (SWM) for smart city applications. therefore, an application is developed initially in the smart cities, namely, the smart waste management (SWM) system.

Paper 10: Implementation of an smart waste management using IoT

Publication year : 2017

Author name: P Haribabu, Sanit R Kassa, J Nagaraju, R Karthik, N Shirisha, M Anila

Journal name: International Conference on Intelligent Sustainable Systems (ICISS)..(IEE)

Summary: The main aim of this application is to reduce human resources and efforts along with the enhancements of smart city vision.

Methodology used : Aurdino ,GSM MODEM,Ultrasonic sensor.

PAPER 11: IoT based garbage management

Publication Year:2017

Author name: E&TC Department ,S.V.P.M.'s C.O.E. Malegaon(Bk) ,Baramati,India

Journal name: IoT based garbage management (Monitor &acknowledgement) system (IEEE) Summary: This paper reviewed system

Summary: This paper reviewed system for garbage management and proposes a system which will take care of the proper processing of garbage

Methodology used: The reviewed systems use ultrasonic sensor,infrared sensor[2][7] for detecting the level of waste,Arduino UNO [6],microcontroller[3][11],Raspberry pi2[7] as controlling boards.

Paper 12: IoT enabled dustbins

Publication year: 2017

Author name: Sahil Mirchandani,Sagar Wadhwa,Preeti Wadhawa, Richard Joseph.

Journal name: International Conference on big data,IoT&Data science.

Summary: To tackle the problem of wastage they propose IoT enabled dustbins in this paper.These bins used RFID tags for tracking wastes linked with a web-based online system.

Methodology used: gas detectors, servers, radiofrequency ,monitoring fuels