Intelligent Smart Waste Management Using Regression Analysis: An Empirical Study

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Abstract. The term deep learning is seen as an important part of artificial intelligence that allows the system to understand and make decisions without special human intervention. In-depth learning uses a variety of statistical models and programs that allow different computational properties to reach the highest point. It is estimated that the market development of artificial intelligence and technology for deep learning will amount to USD 500 billion by 2026. The use of advanced technology, such as neural networks, enables better image recognition and the use of automated processes for deep operations. The main purpose of the study is to understand the critical determinants of Deep Learning in Creating a better City through Intelligent Smart Waste Management, the major determinants cover: System usability scale, Implementation of RFID sensors and Optimizing route selection. The proposed work is that implementation of advanced tools like deep learning methodologies and machine learning tools can support in managing the waste in a smart way, this will enable in creating better cities, enhance the environment and support sustainable living. Smart cities today need to use tools like deep learning and other artificial intelligence to effectively manage waste. Smart vessels are mainly controlled and implemented, which makes it easier for users to open vessels, it is also suitable for storing solid and dry waste, but provides information on the total degree of filling, can share data and information with central waste management service, you can collect waste quickly and avoid flooding. To achieve this, governments, administrators and communities are introducing sensors that transmit data and information to the waste management company in real-time and take appropriate action.

Keywords: Deep learning · Smart waste management · Regression analysis · Analysis of variance

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1 Introduction

The increase in population and relocation of citizens from rural and semi-urban to smart cities has posted an increase in a greater number of individuals being accumulated in a specified location which creates an increase in tons of waste. The term waste management intends to focus on end-to-end activities which is involve in monitoring of waste from the source point when the companies, individuals and other produce waste. There exist numerous ways through which the waste can be controlled and disposed, recycled in an effective manner [1]. In the present day, waste management is considered to be a challenge as the waste is increasing due to usage of products and services. The waste management tend to refer to those action which need to dominate from the inception to the demolish of an activity. The waste can be categorized into solid aspect, liquid and gas, there are numerous processes tend to deal with different type of waste which includes biological, household, industrial aspects. The household waste tends to include the plastics, papers, glasses etc.

The term deep learning is considered as part of the significant part of Artificial Intelligence (AI) which will allow the system to ability to understand and make decision without much human intervention. The deep learning tends to apply different statistical models and program which will allow different features in computing that has reached the highest aspect [2]. It is estimated that the market growth of AI and deep learning technologies tend to grow to nearly $500 billion by 2026 [3]. The implementation of advanced technologies like neural network supports in enhanced image recognition, support in using automated procedures for making profound actions.

The traditional waste management system involves in the collection of waste through manual effort directly from the public waste bins. The manual disposal is mainly made through defined process, through which it involves in recycling through defined process. Hence, it involves more human efforts and there may be significant errors as many processes are handled manually. However, it also creates various other issues which includes application of waste bins, the overfilled waste bins can enable in creating toxic hazes and increase foul smell which causes allergic and ecological imbalances [4]. The waste collection from the underfilled waste bins tend to increase inefficiency in the process. The waste collection vehicles tend to collect the waste in sequence so that it takes more time to collect which will increase excess fuel consumption.

In order to avoid the traditional waste management system, smart cities are now using Deep learning tools and other artificial intelligence (AI) technologies in order to manage the waste in an efficient manner. The AI technologies are Smart trash bins are mainly tested and applied which will enable the users to open the bin more conveniently, this trash can also store the dry and solid waste, but offer the overall fill level information, this supports in sharing the data and information to the central waste management agency which can collect the waste quickly and can avoid spillovers. In order to accomplish this the governments, administrators and communities implement sensors which will transmit real time data and information to the waste management company and appropriate actions are taken [5].

Ultrasonic Sensors are mainly used to measure the fill levels of the trash bins through different technologies, these sensors can also estimate the exact location of the bins so that the refill can be made quickly. The information from these sensors is monitored

and communicated trough deep learning tools, Internet of Things (IoT) techniques etc. The data are then stored so as to take informed action and decision making. The next aspect considered in the implementation of smart waste management is through Radio frequency identification (RFID) sensors which are highly compact and can be fixed in any place [6]. These tags act as transponders which can be installed in monitor the trash bins, also provide critical information about the usage of these bins and number of other bins located in the area.

Smart waste management involves in using image processing and neural network which supports in classifying the waste which are available in the bins. The research has stated that the neural network and related tools is used for managing the solid waste, this tool support in detecting the plastic and non-plastic materials, support in organizing the waste so that they can be recycled and managed effectively [7]. Furthermore, smart waste management server is considered as the main component in the entire process, it is mainly work on the cloud server and be easily accessed by the waste management company, government administrators and others through remote access [8]. This application is mainly responsible in communicating with the smart bins for implementing appropriate control, track the number of bins reaching its maximum and send the delivery truck to collect the garbage. Furthermore, it analyses the information from the truck control system, recycling plant and other aspect for forecasting the data and information.

The communication status with the stated controllers and report the communication failure for the suitable action. These systems also run the waste management application and carry out the required data analytics based on the waste management. These systems also store the data related to waste management update information from trash bins and controllers for analyzing it. Support in creating alerts and notifications during emergency situations related to waste disposal. Provide information on the type of waste disposal in the locality and provide necessary information to the individuals and citizens to act responsibly [9]. Also analyses the fill level stats data for each bin and instruct to make profound actions. Provide the optimized route information for garbage collection so that the fuel and other expenses can be curtailed effectively.

Hence, this study is focused in analyzing the key factors of deep learning tools in Creating better City through Intelligent Smart Waste Management. The major factors are system usability scale, implementation of Radio frequency identification (RFID) sensors for effective tracking and optimizing the route selection for effective waste management.

2 Review of Literature

The author has proposed a unique allocation model which will enable in identifying different type of waste through deep learning mechanisms. It has been stated that these tools can also be enabled in enhancing the recycle of different type of waste. The research has stated a scheme through which the deep learning tools can automatically identify the type of garbage and propose immediate actions [10].

The researcher has noted that the deep learning model was applied in the overall classification of the waste, it also supports in measuring the trash bins in each location and analyses the total capacity. The Convolutional neural network (CNN) model is considered as one of the effective mode which supports in extracting higher image content also

enable in effective management by identifying different type of waste. Furthermore, the authors have stated that the optimal planning algo can support in solving sustainability issues, enable in identifying optimal transportation so that the waste can be collected at lower cost.

Due to population growth, urbanization and industrial treatment, a lot of waste is generated daily. If this waste is not treated and handled properly, there is a great risk of health risks, pollution and contamination [11]. In order to avoid such problems in advance, waste management is considered a priority that needs to be addressed for several years. Researchers, researchers and engineers around the world are working to improve existing intelligent waste management systems and identify new features and functions that will be integrated into the new intelligent waste management system that is under development [12]. Many research articles and important reading are available on the Internet on the Intelligent Waste Management System. Let's take a look at some of the existing research articles to get enough information on this research topic.

The authors claim that this ideal design algorithm can calculate the best garbage collection routes for smart and sustainable cities with the right software platform. An ideal programming algorithm that runs on an open source programming tool called Net2Plan. Net2Plan is often used to model and design communication networks. Net2Plan as well as the Net2Plan-GIS library make it easy to enter city layout information into the algorithm, including smart storage locations. The calculated optimal waste collection routes minimize the number of trucks used for waste collection and thus fuel consumption, which in turn reduces the impact of CO_2 emissions and noise. The authors also discussed a practical case from the city of Cartago (Spain), where the ideal way to collect plastic waste is discussed [13].

An intelligent network based on smart sensors, which can communicate with any original server located in the communication area, is also becoming a practical idea and requires broad coverage in waste collection and management [14]. The authors discussed a solution based on an RFID tag that provides information about garbage. This information was then used to improve waste management, enabling automatic and rapid identification of waste at the waste level. The authors confirm that no other external information system is required to track waste with RFID-tagged Smart Bins, and this solution enables better waste sorting [15]. In addition, this RFID tag allows the residual contents of the Smart Bin to be returned to the recycling system.

Today, based on the coverage areas, the municipality and the smart city administration organize garbage collection vehicles to collect garbage from different parts of the city and geographical areas. This manual waste management is a long and tedious job., hence automating them tend to save more time and enable in automating the whole process in a better manner.

3 Methodology

The researcher has used descriptive research design as this supports the researchers in analyzing the key determinants in an effective manner, this also enable the researchers for measuring the main aspects of the deep learning aspects in enhancing the waste management in city. The study involves in sourcing the information from primary and

secondary sources, which involves in using questionnaire to collect the information from the respondents, nearly 156 respondents were chosen based on purposive sampling method. The secondary data is collected through online data base like EBSCO, Google scholar and published research articles from Scopus indexed journals.

The research is mainly intended to understand the key components of deep learning in enhancing the smart waste management in cities. The government, policy makers and others are focusing in using the digital technologies to carefully plan and manage the waste in an efficient manner [16]. The application of deep learning-based garbage system support in efficient tracking of waste, forecast the bins required for each area, track the data on a real time basis and provide necessary information to the law makers for efficient decision making. The implementation of different router and sensors enable in analyzing the key information, support in enhancing the smart garbage system efficiently[17].

Critical Determinants of the Study

There exist no major differences among system usability scale and creating better city with smart waste management.

There exist no major differences among implementation of RFID sensors and creating better city with smart waste management.

There exist no major differences among optimizing the route selection and creating better city with smart waste management.

4 Analysis and Discussion

The data analysis covers frequency table analysis of critical variables, regression analysis and Analysis of variance for testing the hypothesis.

The authors intend to understand the importance of Deep learning supporting in smart waste management, as the government and others are increasingly using these tools in order to enhance the implementation process and manage the waste better (Table 1).

Table 1. Deep learning supporting in smart waste management

Particulars	Frequency	Percent
Strongly disagree	9	5.8
Disagree	15	9.6
Neutral	26	16.7
Agree	57	36.5
Strongly agree	49	31.4
Total	156	100

The above table states that the deep learning is highly supportive in managing the waste in making smart city more sustainable, it is noted from the literature that waste disposal and management is one of the critical issues faced by government to transform

into smart city, from the table it is noted that 31.4% have strongly agreed to the statement and 36.5% have agreed to the statement that deep learning is highly supportive in smart waste management whereas 16.7% of the respondents mentioned as neutral, 9.% were disagreeing to the statement.

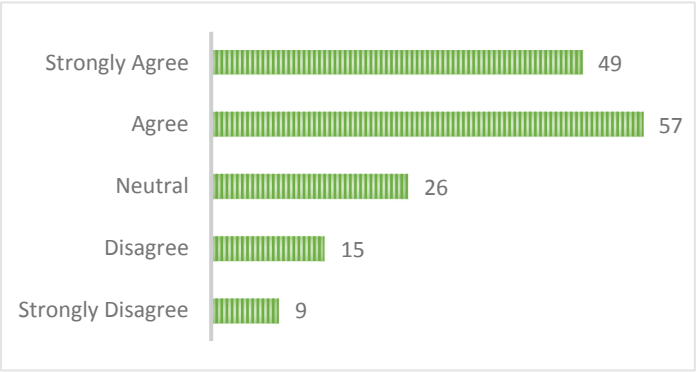

Fig. 1. Deep learning supporting in smart waste management

The Fig. 1 confirms that most of the respondents agree that the deep learning support in smart waste management, hence this confirms with the literature review. Hence, the respondents were stating the deep learning tools Neural designer, Microsoft cognitive toolkit, Pytorch etc. support in monitoring the fullness of torch, this allows the municipalities to optimize the waste collection routes, times etc.

The second aspect to be analyzed is the identification of waste management as critical aspect in making smart city, with the increase in population climate changes has become huge concern for government and Nongovernmental Organisation hence creating smart city can enable in using the resources efficiently and support in reducing the increase in temperature (Table 2).

Table 2. Waste management is key concern for developing smart city

Particulars	Frequency	Percent
Strongly disagree	11	7.1
Disagree	14	9
Neutral	25	16
Agree	53	34
Strongly agree	53	34
Total	156	100

The table shows that the waste management is considered as the critical component in creating and sustaining smart city by the authorities. With the use of digital tools and

intelligent systems the policy makers can enable in creating better waste management and thereby enable in creating sustainable smart city. From the above table nearly 68% of the respondents have agreed to the statement that waste management is the key concern in developing smart city, whereas 16% are neutral and remaining are disagreeing with the statement.

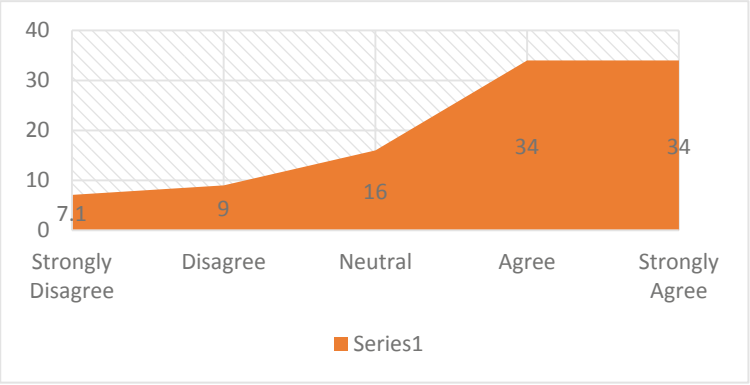

Fig. 2. Waste management is key concern for developing smart city

Furthermore, Fig. 2 states that the 68% of the agreed to the statement the use of digital tools and intelligent systems the policy makers can enable in creating better waste management and thereby enable in creating sustainable smart city. Hence, this is confirming that government and others are focusing in stating that the waste management is more concern in creating a smart city.

Regression Analysis

The critical part in the data analysis is to understand the overall relationship between the independent variables and dependent variable (Table 3).

Table 3. Regression analysis

Regression analysis	B	SE	P val.
(Constant)	0.2	0.18	0.269
System usability scale	0.431	0.098	**0.00**
Implementation of RFID sensors	0.384	0.095	**0.00**
Optimising route selection	0.073	0.083	0.381
ANOVA	SS	F	P
Regression	**163.88**	153.66	.000b
Residual	**54.04**		
Coefficient of determination	0.752	75.20%	

Based on the above table the determination coefficient is 0.752 or 75.2% which shows that the model is regarded as good fit. The sum of squares of the ANOVA table states that the regression coefficient is 163.38, F value is at highest level of 153.66 and the significance value is 0.00 which is less than 5% hence the variables are statistically significant.

Furthermore, the regression expression is stated as

Smart waste management = 0.20 + 0.431 × System usability scale + 0.384 × implementation of RFID sensors + 0.073 × Optimizing route selection.

Hence stated that all the variables possess positive association towards creating smart waste management.

Testing of Hypothesis Using Analysis of Variance

The last step is to test the hypothesis using ANOVA.

Hypothesis 1 – Null: There exist no major differences among system usability scale and creating better city with smart waste management (Table 4).

Table 4. ANOVA between system usability scale and creating better city with smart waste management

ANOVA	SS	F	P
Between groups	165.8	143.29	0
Within groups	43.67		
Total	209.4		
Levene's	Value	df1	P
Levene's test	6.647	4.00	0

The Analysis of variance (ANOVA) analysis states that the Sum of squares (SS) between groups is 165.8 and within groups is 43.67, whereas the F value is 143.29 and significance value is 0.00, also the Levene test shows a value of 6.64 and significance value of 0.00, which is less than 0.05. Hence concluded that there exist major differences among system usability scale and creating better city with smart waste management.

Hypothesis 2 – Null: There exist no major differences among implementation of RFID sensors and creating better city with smart waste management (Table 5).

Table 5. ANOVA between RFID sensors and creating better city with smart waste management

ANOVA	SS	F	P
Between groups	195.5	165.98	0
Within groups	44.47		

(*continued*)

Table 5. (*continued*)

ANOVA	SS	F	P
Total	240		
Levene's	Value	df1	P
Levene's test	42.89	4.00	0

The ANOVA analysis states that the SS between groups is 195.5 and within groups is 44.47, whereas the F value is 165.98 and significance value is 0.00, also the Levene test shows a value of 6.64 and significance value of 0.00, which is less than 0.05. Hence concluded that there exist major differences among implementation of RFID sensors and creating better city with smart waste management.

Hypothesis 3 – Null: There exist no major differences among optimizing the route selection and creating better city with smart waste management (Table 6).

Table 6. ANOVA between optimizing the route selection and creating better city with smart waste management

ANOVA	SS	F	P
Between groups	145.7	82.36	0
Within groups	66.78		
Total	212.5		
Levene's	Value	df1	P
Levene's test	6.247	4.00	0

The ANOVA analysis states that the SS between groups is 145.7 and within groups is 66. 78, whereas the F value is 82.36 and significance value is 0.00, also the Levene test shows a value of 6.64 and significance value of 0.00, which is less than 0.05. Hence concluded that there exist major differences among optimizing the route selection and creating better city with smart waste management.

5 Limitations

The major limitations of the study are focused in analyzing the key determinants like System usability scale; implementation of RFID sensors and Optimizing route selection in measuring the Intelligent Smart Waste Management to create better city. The researcher has not applied other factors in managing the waste management are considered. The time available to perform the study is short and hence only 156 respondents were chosen. The responses received from the sample population may have biased information.

6 Conclusion

The Intelligent waste management consists of image processing and a neural network that classifies waste that is thrown in the trash. Research has shown that neural networks and related devices are used to treat solid waste, this tool helps to detect plastic and non-plastic materials, helps to organize waste so that it can be recycled and managed efficiently. The implementation of a coherent neural network achieved 96% accuracy in the detection of solid waste and provided important data and information. In addition, the intelligent waste management server is a key component of the entire process, runs primarily on a cloud server and is easily accessible to the waste management company, government administrators and others with remote access. This application is primarily responsible for communicating with the smart landfills to implement the correct control, monitor the amount of landfills that reach the maximum and send the truck for garbage collection. It also analyzes the truck's control system, recycling facility information and other aspects to predict data and information. The researcher noted that the deep learning model has been used to classify waste in general, supports the measurement of trash at each site and analyzes total capacity.

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