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Enriching Construction Waste Management through Deep Learning

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ABSTRACT – The activity of construction is a constant process that determines the development of the city. The construction allows for the building of residences and offices that can be useful in accommodating the increasing workforce and residential complexes to house the rising population. The process of construction generates a lot of waste that can be highly problematic to get rid of and dispose accordingly. The garbage generated is posing an increasing concern to the residents in the immediate landscape. The garbage is the most hazardous since it may disturb local inhabitants' lives and create health issues. These substances are frequently just thrown around while work is being done, establishing a toxic environment for children and anybody who walks through all those regions. Therefore, there is a need for an effective construction waste forecasting technique that is described in this research paper that deploys Fuzzy C-Means clustering and linear selection along with Deep Belief Network and Decision Making. The evaluation has been performed to determine the accuracy of the prediction which has received satisfactory results.

Keywords: Construction Waste Management , Fuzzy C means Clustering, Linear Selection, Deep Belief Network, Decision Tree.

I. INTRODUCTION

The construction sector is experiencing rapid growth, consuming a significant proportion of the global resources each year while also producing large quantities of solid waste and environmental damage during development, dismantling, and restoration operations, posing a formidable threat to world wide management of solid waste. Humans have not always lived in constructed houses, early humans to insulate ourselves from the effects of the elements, such as fire, cold, and rain, humankind started to live in confined dwellings. Traditionally, they included a wide range of poisonous creatures as well as enormous cats that stalked and killed humans. Before caves had become the standard practice, early human’s people lived in them, and they provided much-needed refuge that could not have been obtained in the surrounding wilderness. Homo sapiens gradually developed clothing, learnt to utilize fire, and eventually became a civilized race.

Humans were able to dwell in groups because to the construction of homes, which strengthened their safety by reliance on one another. Humans subsequently decided to construct structures which would protect them and offer a secure environment in which to live. Some of the structures were large repositories that could also be utilized to gather goods for the difficult colder months; others are being used for residing or sheltering these individuals. As the numbers grew as a consequence of the buildings additional protections and reliability, far more of buildings were required to service the expanding population. Constructions used to be tiny and simple, comprised of confined chambers with a covering on top to enable people to sleep easily at nightfall.

High rises and tall structures with multiple stories grew more prominent as the fast growth of people needed a considerable measure of innovative thinking and smart use of land availability. To accommodate the population explosion, an escalating volume of items had to be produced, resulting in the creation of gigantic megastructures called as industrial facilities, which permitted mass processing to take place in one location. So according estimates, building and demolishing waste makes for the bulk of total worldwide waste material, with non-hazardous and harmless components being the most frequent, which may be treated in an ecologically acceptable manner. As a result, determining ways to reduce and reuse construction waste via proper governance has become a global issue that has been highlighted by government agencies and local administrations.

Trying to measure the quantity of construction waste created is widely acknowledged as necessary for creating and deploying management systems at the individual or local scale. Due to large waste volumes and insufficient storage capacity, projecting possible Construction waste production at a provincial scale can assist the government in estimating current storage capacity and enacting rules to address it. Predicting the production of construction trash has traditionally been done using previous data. Approaches for forecasting has been extensively used to produce accurate forecasts. The disposal of construction trash is typically a mammoth task that the owner of the site should care for. This is a wasteful expenditure that may be readily minimized by efficient construction waste forecasting and management.

For this rationale, the construction circumstances must always be properly analyzed even before work begins. The machine learning methodology will aid in the much more economical achievement of the identified research goals. Among the most ideal uses for this is the establishment of Deep Belief Networks, or DBN. Deep Belief Networks are computer networks modeled by the organic brain's activities. Deep Belief Networks employ neurons as their most basic processing system. The properties among these neurons, including certain threshold stimulation and connections amongst huge neural circuitry, are chosen depending on the application's restrictions. Because it is predicated on a supervised learning model, the Deep Belief Network requires previous data in order to create accurate and trustworthy recommendations which will be utilized to achieve effective reduction in the construction waste.

This paper dedicated the next section for the evaluation of the previous works in the form of a literature review. The section after the review discusses and illustrates the proposed methodology and the section 4 provides effective assessment of the approach and eventually the section 5 provides the conclusion for the same.

II. LITERATURE SURVEY

Tauha Hussain Ali [1] states that construction waste has been one of the most troublesome issues in recent years. To address this issue, the researchers have described a strategy that would allow the user to enter site circumstances, waste kind, as well as other pertinent information, as well as make decisions based on available evidence. The client will enter the necessary information into the software. In the meantime, this software will be associated to the database that has been created. The provided data collected will be connected and examined in the repository for scenarios that are similar to those encountered in earlier cases. The constraints of each approach will be matched with the present scenario in the event of significance.

Wu Xiaonan [2] explains that there has been increased prevalence of development activities that are being performed in major cities and towns across the world. This rapid development activities are not just limited to the urban environments but also quite frequent in other parts of the world and rural areas as well. This type of activities put an undue pressure on the surroundings and the environment close to the construction or demolition sites can lead to a lot of waste generated. This construction waste is problematic as it can cause a lot of degradation of the environment along with posing as a threat to the health conditions of the people living nearby. Therefore, the authors in this publication have proposed the use of radial basis function neural network for the purpose of achieving the precise forecasting of the generation of waste while construction or demolition.

ChenkunJin [3] expresses that there has been an increase in the construction of various development projects that facilitate the improved services to be available to the region. The implementation of the various amenities such as regular utilities including water, electricity, drainage, along with other necessities such as roads, and railway. The railways are one of the most essential as it allows for the effective and highly efficient transportation of raw materials and other goods easily. The construction and the management of the construction of the railways is one of the most complicated and complex mechanisms. Therefore, the authors have proposed the use of Building information modeling to achieve streamlined development of the electronic and electrical systems in a railway construction.

Ting Cai [4] discusses that the rapid development across the world has been essential for the growth and development of the cityscapes. This is essential due to the fact that the population of working individuals is increasing every day. This is the reason why there is a need for facilitating the development to house and cater to an ever growing number of individuals. This influx needs to be effectively managed to determine the improved lifestyle that is achieved after the successful development. But due to the large inaccessibility of the construction process generates an inordinate amount of waste products that would be very problematic to deal with. Therefore, the authors in this publication have proposed the use of a Hybrid LSTM technique for the purpose of prediction of demolition and construction waste that can lead to highly promising results.

SevilayDemirkesen [5] provides a unique set of criteria for adopting Lean in ventures and attaining organizational performance, as well as showing the advantages of Lean adoption. Success criteria such as budget, schedule, reliability, and protection continue to be a challenge for the construction business. As a result, the sector's need for creative systems and technologies is critical. Between these, Lean has a number of advantages for industry professionals, including amount of labor and resolving security problems, as well as enhance customer satisfaction and achieving performance specifications. Nonetheless, for a variety of purposes, such as the expense of adopting Lean technologies or a lack of expertise in Lean implementation, the advantages of Lean have yet to be fully appreciated by industry stakeholders.

Gayathri N [6] seeks to persuade individuals to eat only the quantity of food they need in order to effectively reduce waste. In this approach, the researchers have proposed using cloud technology and Internet - of - things sensing devices to incorporate only in locations where a RFID system is furnished, which will save money as well as time in creating customized managerial documentation, and will have a greater influence on personal food surplus in the workplace. It will encompass additional places in their anticipated future expansions, such as party locations, tech parks, universities, schools, eateries, hotels, and so on.

Zainal Hisham Che Soh [7] narrates that by using Arduino Uno combined with Arduino Ethernet Shield technology and ultrasound monitoring devices, suggest a novel way to improve rubbish collection efficiency. Garbage overflowing may be minimized and handled efficiently using this suggested technique. This will notify the approved individual via Email or SMS using the defined method. The existing waste management system and rubbish collection facilities do not meet the current requirements. As a result, improved rubbish handling and storage facilities should be created. This device lowers the handful of times the garbage collection van arrives by presenting knowledge when the bin is entirely populated with waste.

Aparna H [8] discusses the development and operation of a real-time monitoring and tracking technology for home garbage. According to the MIT app developer, the recommended method employs a QR-based monitoring and tracking function that assists in informing clients. In addition, the inspected bin's monitoring information will be saved in the public cloud for future reference, which will contribute to making decisions about how to handle the collected garbage from the collection point. Waste material must be treated properly. It is necessary to properly separate biodegradable and non-contaminants. To reduce the quantity of garbage that ends up in the disposal, waste reuse and recycling should be advocated.

Parth M. Jardosh [9] explains how modernization and technological advancements have improved the current antiquated garbage categorization, collecting, and management procedures. The researchers developed the algorithms for automating routine tasks of waste collection system by effectively utilizing their understanding of Neural Networks. They can therefore address the age-old difficulty of garbage collection in their nation by employing evolutionary algorithms like the Traveling Salesman Problem. The usage of an application to simulate the complete concept makes it more user-friendly and accessible to the general public. The total deployment of Intelligent Bins, together with effective trash disposal, will help to create a safer and happier ecosystem.

Arafat Ali Khan [10] describes the process of developing a smart garbage collection system as well as how to construct a digital bin that might be utilized in Bangladesh. There are indeed a variety of equipment that may be utilized to create a smart bin, but the goal of this study was to develop a straightforward and cost-effective smart trash cans. Numerous studies that utilized infrared devices to detect generation of waste, but infrared sensors quantify distance just under ultrasonic sensors, as well as more than one possible explanation to choose ultrasonic sensors over IR is that they can be conditioned to set the parameters of waste detection and measurement based on the requirements of the consumer. Finally, the entire network exhibits several characteristics that can be utilized in a number of different ways, depending on the situation, and so this

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architecture of a smart solid waste managing and designing of dustbins is efficient and effective.

Shabir Ahmad [11] expresses that management of waste is a difficult issue to solve in the development of smart cities and the conservation of the ecosystem. Materials are few in emerging nations, necessitating careful management. An ideal strategy allows for the smart use of these assets while avoiding both overuse and underuse. The authors presented a policy approach for waste collection authority in this study, recommending a personalized optimum strategy for each home grid. The strategy is clever and ideal, and it is predicated on people's attitudes regarding the volume and frequency of garbage disposal. In the long term, this study might be expanded by automatically recognizing the best approach without the requirement for predictive modeling or large datasets.

III PROPOSED METHODOLOGY

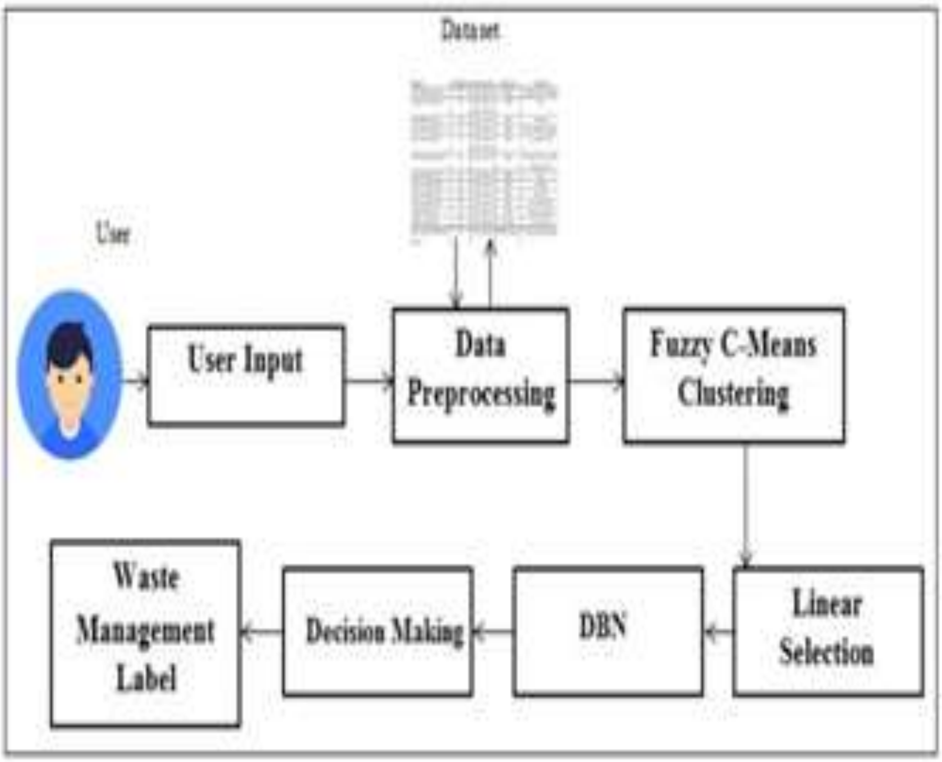

Figure 1: System Overview Diagram

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The presented technique for management of construction waste through deep learning methodologies is illustrated in the figure 1 above. The incremental steps that are performed to achieve the goals of this approach are stipulated in the section given below.

Step 1: User input and Dataset Preprocessing – The proposed approach uses an intuitive graphical interface to collect input from the user for the aim of managing and organizing construction waste. The specified User Interface is extremely receptive and was created through using Java Swings framework. The frontend is used to provide construction specifications for both conventional and RCC building projects.

There are quite a variety of characteristics that are used as inputs for wide assortment of structures. Plot Area (in sq. ft.), number of cement bags (50 kg each), sand (in cu ft.), stone aggregates of size 10 mm, stone aggregates of size 20 mm, quantity of bricks, and reinforcing steel weight in kg are all necessary for standard builds.

Whereas, in contrast to Reinforced Cement Concrete constructions in addition to the previously stated attributes for standard construction, additional characteristics are added. The additional attributes considered for RCC are Sand (cu ft.), stone aggregates 20 mm, cement (no of bags), thickness (feet), breadth (in feet) and length (in feet).

The numbers entered through this user interface are saved in the system statically for future computations and evaluations.

The dataset for this system was synthesized, which means it was compiled from a variety of sources and other internet resources on construction activities. This URL has been used to extract the dataset for the standard construction. https://civiconcepts.com/raw-material-calculator-for-construction/. On the other hand the RCC construction, this URL was visited - https://www.materialtree.com/bengaluru/rcc-calculator.

The dataset is stored in the form of a workbook. The JXL API is used to extract the contents of the dataset through the use of java and store it in the form of a double dimension list.

Step 2: Fuzzy C-Means Clustering – The previously preprocessed dataset in the steps provided earlier have been taken as an input to this step of the methodology. The dataset is in a row format, therefore, the rows are processed and the addition of all the values of the row is performed and subsequently added to the end of the particular row. This process is repeated until the all of the rows of the dataset are appended with the sum along with the ones consisting of the RCC construction.

The sums of the rows with the biggest and smallest values are retrieved. The difference between the extracted values of lowest and highest sums is computed and then divided by 5.

This is performed to achieve 5 separations that are categorized with accordance to the fuzzy crisp values such as, VERY HIGH, HIGH, MED, LOW, and VERY LOW. The dataset is then grouped conferring to the boundary ranges that are employed to characterize the 5 collections. This formula is represented in aspect in algorithm 1 given below.

ALGORITHM 1: FCM Cluster Formation

//Input : DataSet List D_L
//Output: Clusters C_L
1: Start
2: $C_L=\emptyset$, $S_L=\emptyset$ [Summation List]
3: **for** i=0 to Size of D_L
4: R= $D_{L[i]}$ [R= Single Row]
5: sum=0
6: **for** j=2 to Size of R
7: sum=sum+ $R_{[j]}$
8: **end for**
9: $S_L = S_L$ + sum
10: $D_{L[i]} = D_{L[i]}$+sum
11:**end for**

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```
      R_SET= getFuzzyRules(S_L)
for i=0 to Size of R_SET
       T_LST =R_SET [i] [T_LST = Temp List]
       MIN= T_LST [0], MAX= T_LST [1]
       S_LC=Ø [ Sinlge cluster List]
for j=0 to Size of D_L
       R_SUM = D_L [j][SIZE-1] [R_SUM = Row sum]
if( R_SUM >=MIN AND R_SUM <= MAX),then
       S_LC= S_LC+ D_L [j]
end if
end for
       C_L= C_L+ S_LC
end for
return C_L
 Stop
```

Step 3: Linear Selection – The output of the previous step achieves the clusters using the Fuzzy C Means algorithm which are provided as an input to this stage of the methodology. The user input is utilized by adding up all the values of the attributes with respect to the obtained clusters. The list containing the clusters and the sum is then sorted in an ascending order of the respective attribute tally. This results in a list consisting of the lowest attribute sum at the top whereas the highest attribute sum can be found at the bottom of the list.

The highest and the lowest values achieved in the previous step are used for the purpose of formulating the boundaries for the linear selection. The sum of the attribute values provided by the user are then subjected to these boundary values of the clusters. The comparison allows for the precise cluster selection that agrees and correlates to the user input accurately. This achieves the proper cluster that is selected and provided as an input to the next step for further processing.

Step 4: Deep Belief Network – The cluster selected in the previous step is then utilized to deploy Deep Belief Network for calculating the probability. The selected cluster is then assessed and the rows contained in the cluster are identified and the respective dimension and ID are fetched. The index value of 0 and 1 from the rows are selected and the value of the dimension at index 1 is set as the target 1 value. The hidden and output layer probability is evaluated using all the other attributes of the selected row through estimating the probability of the dimension value.

The equation 1 and 2 given below are utilized for evaluation of the hidden layer and output layer values respectively.

$$Y= (T1* Wt1) +(T2*Wt2) +BWt1 \qquad (1)$$

$$H_{LV}= \frac{1}{(1+\exp(-Y))} \qquad (2)$$

Where,

Wt1 ,Wt2 - Random weights,
(Other random weights set is also used like {Wt1,Wt2,Wt3,Wt4,Wt5,Wt6,Wt7,Wt8,BWt1,BWt2})

T1, T2 - Attributes for which prediction probability is estimated

H_{LV} – Hidden layer

The prediction probability list is generated by collecting the target values along with the output layer values obtained through the evaluations to aggregate a prediction probability list. The values of the input provided by the user are correlated with this probability list and then both the lists are then transferred to the next step for the classification through decision making.

Step 5: Decision Making – The cluster probability list is then examined for the row with the smallest matching value to determine the input probability. The input attributes of the user as well as the attributes achieved in the obtained row are combined with the other attributes of the row. The scarcity of abundance of the construction waste is then determined using the If-Then rules of the Decision making approach with respect to the user input. These results are then shown to the user through the designed user interface.

IV RESULTS AND DISCUSSIONS

The presented technique for management of construction waste through deep learning methodologiesis realized through the use of Java Programming language on the Integrated Development Environment of NetBeans. The development is achieved on a machine consisting of a regular configuration such as, an Intel Core i5 processor assisted by a RAM of 6 GB and Hard Drive storage of 1 TB. The database interfacing and management is provided by the MySQL database server.

The evaluation of the accuracy of the prediction of the construction waste through this approach will be assessed through the use of the Root Mean Square Error or RMSE. The metric of RMSE is highly useful in determination of any error existing amongst any two correlated and continuous variables.

The proposed approach for the construction management consists of two distinct labels that fit this category of continuous and correlated variables, namely, achieved construction waste management labels and the confirmed number of construction waste management labels. These two labels are subjected to the equation 3 below to calculate the RMSE values.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(x_{1,i} - x_{2,i})^2}{n}} \quad \text{\_(3)}$$

Where,

$\sum$ - Summation

$(x_1 - x_2)^2$ - Differences Squared for the summation in between the confirmed number of construction waste management labels and the achieved construction waste management labels

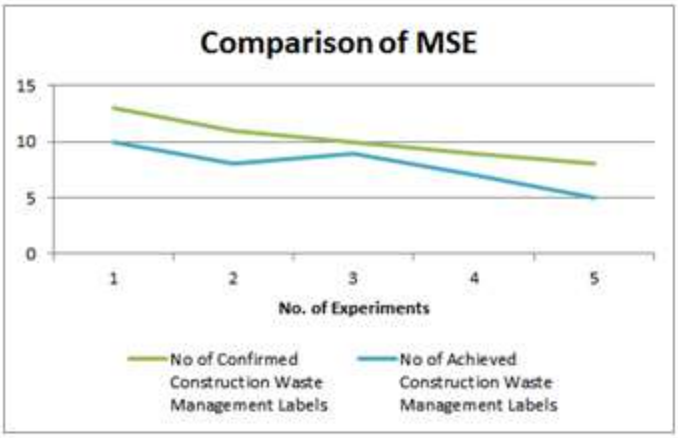
n - Number of samples or Trails

In-depth evaluation is conducted using the RMSE approach, and the values are tabulated in the given table 1.

Table 1: Mean Square Error measurement

Experiment No	No of Confirmed Construction Waste Management Labels	No of Achieved Construction Waste Management Labels	MSE
1	13	10	9
2	11	8	9
3	10	9	1
4	9	7	4
5	8	5	9

Figure 2: Comparison of MSE in between No of achieved construction waste management labels V/s No of confirmed construction waste management labels.



The experimentation have been performed for the evaluation of the Root Mean Square Error and the outcomes are tabulated in the table 1 above. The values in this table are further utilized to generate a line graph to better understand the accuracy achieved by the proposed approach. The evaluation has been performed in a set of 5 experiments. Each of these experiments consisted of 10 trials performed iteratively. The evaluation of the RMSE initiates with the evaluation of MSE which attains a value of X and an RMSE value of Y. The RMSE values attained by the presented approach are well within the expected values of error. The outcomes indicate an accurate deployment of the Deep belief Networks that achieves highly precise construction waste management labels.

V. CONCLUSION AND FUTURE SCOPE

The proposed methodology for the purpose of achieving an effective and accurate construction waste management through deep learning has been elaborated in this research paper. The methodology initiates with the user providing the input for the construction to be made through the graphical user interface. The approach also utilizes a dataset consisting of various attributes related to the raw materials being used or the purpose of achieving two different types of constructions, a regular construction and Reinforced Cement Concrete construction. The user input is correlated with the user input and then provides it for clustering to the Fuzzy C Means clustering approach. The clusters are formed using the fuzzy crisp values to attain 5 clusters. These clusters need to be selected with linear selection before being provided to the Deep Belief Networks. The DBN achieves the probability scores through the evaluation of the hidden and output layer values. These probability scores are then subsequently subjected to classification using the Decision making module to achieve the results of the construction waste which are displayed to the user in an interactive graphical user interface.

For the purpose of future research, the approach can be deployed in a real time scenario to provide assistance to the civil engineers and it can also be developed into a mobile application to improve accessibility.

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