EFFICIENT INCORPORATION OF ML IN CONSTRUCTION WASTE MANAGEMENT

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Abstract - *The construction process is one of the most useful and important processes necessary to have livable spaces and other structures for work. There will always be a need for facilities that need to be constructed to provide protection against the various elements of the environment. The process of construction creates a lot of waste in the form of steel bars, waste materials in the form of sand, excess cement and other materials. These materials are usually on the construction site well after the construction has been done. This wastage is highly problematic as it can cause a lot of environmental pollution and can be a breeding ground for diseases. There is a requirement for an effective approach that needs to evaluate the amount of materials required for achieving a construction that can minimize the amount of waste. Therefore, an effective approach for the purpose of managing the construction waste through the use of Fuzzy C-Means clustering and Linear Selection along with the use of Artificial Neural Networks and Decision Tree has been proposed in this research article. The approach has been effectively quantified through the use of extensive evaluation through experimentation which has achieved highly satisfactory results.*

Key Words: **Fuzzy C-Means clustering, Linear Selection, Machine Learning, and Decision Tree**

1. INTRODUCTION

Humans began to live in enclosed environments to protect themselves from the effects of the seasons, such as rain, cold, and fire. Previously, these involved a variety of venomous species as well as massive cats that would stalk and kill humans. People used to dwell in caves until it became the standard, and they offered much-needed shelter that could not be found in the open wilderness. Humans increasingly invented clothes, learned to use fire, and ultimately evolved into a civilized species. This allowed humans to live in groups, which increased protection by relying on each other. Humans gradually but slowly began to build buildings that would defend them and provide a stable place for them to call home Not all of the buildings were used for living or housing these people; others were massive storehouses that could be used to store provisions for the harsh winter months. As the population grew as a result of the improved protection and dependability of the structures, more and more of them needed to be constructed to serve the growing population. Earlier buildings were small and basic, consisting of enclosed spaces with a roof on top to allow humans to sleep soundly at night. Since the rapid rise of populations necessitated a great deal of creative thought and effective use of available land, skyscrapers and massive buildings with several floors became more popular. To serve the growing population, an increasing number of products had to be made, which led to the subsequent construction of massive megastructures known as factories and industries, which allowed mass manufacturing in one area.

Many of these systems have significantly improved the working conditions of people all around the world. And, owing to the innate arrogance of humans, the large-scale building continues at a growing rate across the planet. Construction operations for search and rescue damage forest cover and raise emissions in all ways. The waste created as a byproduct of these operations is one of the most significant and severe losses caused by these constructions. This is exacerbated by the fact that, due to their massive scale and capability, skyscrapers necessitate a large number of materials.

The waste produced is becoming a growing threat to the people who live in the surrounding area. The waste is the most dangerous because it can cause a lot of disruption and health problems for the residents. Sometimes, these chemicals are simply tossed around as work is taking place, creating a hazardous atmosphere for the children and all individuals who walk through those areas. Most of that is attributed to the organization's failure to complete the building process. The site owner is unable to handle waste while still constructing an efficient and solid structure as the structure grows in scale. The removal of building waste is often a herculean activity that must be accounted for by the site owner. This is a needless expense that can be easily avoided by efficient building waste prediction and maintenance.

Before the building operation starts, the construction conditions must be carefully evaluated for this reason. The machine learning paradigm will help achieve the defined research objectives more efficiently. The implementation of artificial neural networks, or ANN, is one of the most suitable applications for this purpose. Artificial neural networks are computational networks that were inspired by the operations of the human brain. Neurons are used as the most fundamental computational unit of artificial neural networks.

These neurons have a variety of parameters that are set based on the application's constraints, such as threshold activation and interconnection between large networks of neurons. Since the artificial neural network is based on a supervised learning model, it needs prior data to make reliable and effective predictions.

This research article dedicates section 2 to related works on fire detection approaches, whereas section 3 details our solution for the implementation. Section 4 describes the experimental evaluations and the final section concludes the article and provides future directions for the research.

1.1 Literature Survey

P. Karningsih [1] addresses the issues that arise during the construction of a building, such as poor quality, budget overruns, and repeated schedule delays. The writers of the paper go into great detail on these issues. To address these issues, the authors of this paper present an approach called lean design, which identifies the situation and formulates different proposals to minimize or remove waste. These suggestions are a series of questions to ask to emphasize waste reduction. The suggested methodology has been thoroughly validated and has resulted in a substantial waste reduction.

According to M. Bajjou, new construction management methodologies are inadequate and often result in poorer efficiency. Traditional building methods are also one of the reasons for significant cost overruns in the majority of construction programs. Most traditional techniques have numerous limitations that make them unsuitable for use in Moroccan construction [2]. As a result, the authors of this paper suggest a lean construction approach that has shown to be constructive in various legislation [3]. As a result, the authors of this paper suggest an effective method for recycling, reusing, and recovering demolition Moroccan construction projects.

M. Covaciu discusses the issues that numerous renovation and building projects cause. These large-scale schemes are the primary source of waste produced on a large scale. Construction and demolition waste must be controlled and minimized successfully as a result of reforms in European Union and building waste using high-frequency electromagnetic fields. Since undertaking restorations, the proposed technique has resulted in many products being revitalized.

1.2 Proposed methodology

The presented approach for the management of fo construction waste through machine learning techniques has been illustrated in the figure given above. The steps for achieving the presented technique have been described below.

Step 1: User input and Dataset Preprocessing – The first step of this presented technique utilizes an interactive user interface to take the user input. The swings platform on java has been used to achieve an extremely responsive user interface. This user interface can be used easily by the user to provide the various parameters for the construction of Reinforced Cement and Concrete or normal structures.

Their several parameters are provided to the system to achieve effective management of the constructions. As there are two different types of constructions, there are different parameters that need to be provided to the system. The required attributes for a normal construction are, reinforcement steel (in Kg), Number of Bricks, stone aggregates (20 mm), Stone aggregates (10mm), Sand (in cu), bag of cement (one bag weights 50 Kg) and area of the plot. The attributes required for RCC construction are different from the attributes taken as an input for the normal construction. The attributes for this type of construction are, sand (in cu feet), stone aggregates, (20mm and 10 mm), bags of cement (each weighing 50kg), thickness (ft.), breadth (in ft.), and the length (in ft.).

These attributes and their values are extracted and provided as an input to the system which stores it effectively into the database for easy retrieval for further evaluation and calculations.

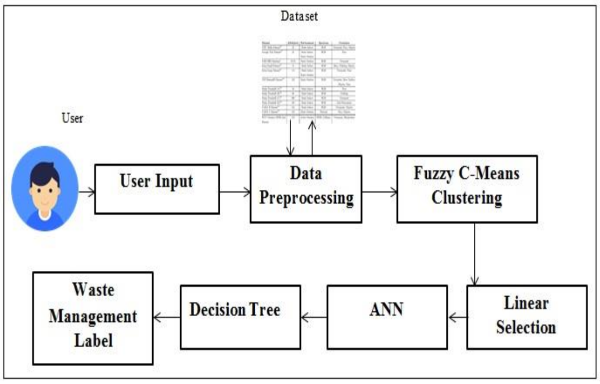
This system utilizes a synthetically generated dataset for the realization of the proposed system. This means that the dataset has been generated through multiple sources and repositories that have been combined to achieve the synthetic dataset. There are two sources utilized for this purpose, the first source is for the normal construction obtained from the URL - https://civiconcepts.com/raw-material-calculator-for-construction/ and for the RCC Construction, the data is extracted from this URL - https://www.materialtree.com/bengaluru/rcc-calculator.

The synthetic dataset that is achieved is stored in a spreadsheet format. This file is interfaced with the java code through the use of JXL API for effective extraction of the contents which are effectively stored in the double dimension list which is provided in the next step of the system.

Step 2: Fuzzy C-Means Clustering – The preprocessed dataset achieved in the preceding step is utilized as an input in this step for cluster formation. The rows of the double dimension list are read accordingly and processed. The values of the attributes are effectively added up and the sum of the attributes is added to the end of the release vant row. This procedure is repeated for all of the attributes. The RCC and the construction materials are also added with the sum that is achieved.

The values of the sum achieved are sorted and the biggest and the smallest values of the sum are extracted and their difference is computed. The obtained difference value is then subjected to division by 5.

This division achieves 5 different segregations based on the value obtained. These segregations are referred to as the fuzzy crisp values. These 5 fuzzy crisp values arena as VERY LOW, LOW, MEDIUM, HIGH an,d VERY HIGH. The values in the dataset are then subjected to classification using



2.

Figure 1: System Overview

Step 3: Linear Selection – This step utilizes the output clusters achieved in the previous step of the approach. Another input to this step is the values provided by the user through the interactive user interface. The attributes in correspondence with the values entered by the user are selected along with the clusters. The sorted cluster list is achieved in the ascending order of the attribute sum from the previous step. This ensures that the lowest attribute sum is on the top, whereas the highest attribute sum in the bottom of the cluster list.

ALGORITHM 1: FCM Cluster Formation

//Input : DataSet List D_L

//Output: Clusters C_L

Start

C_L=∅ , S_L= ∅ [Summation List]

for i=0 to Size of D_L

R = $D_{L\,[i]}$ [R = Single Row]

sum=0

for j=2 to Size of R

sum=sum+ $R_{[j]}$

end for

S_L =S_L + sum

$D_{L[i]}$= $D_{L[i]}$+sum

end for

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}=∅ [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

The highest and the lowest values are then considered as the boundary values for the attribute sum of the cluster. The received user input attributes are utilized in this step to compare with the attribute sum values of the clusters. This is done to achieve the effective realization of the selection of the cluster values and the corresponding response to the input given by the user. This confirms the preciseness of the cluster formation approach which can now be provided for the next step of the ANN evaluation.

Step 4: ANN – The cluster values obtained in the previous step are utilized as an input in this step of the process. This Artificial Neural Networks have been implemented to achieve the probability values through the provided input. The clusters are utilized to achieve the dimension and the ID for each of the rows, and the respective values are stored in the 0th and the 1st indices, for the labeling of the dimension as the value of target 1. The output and the hidden layer probability are calculated through the estimation of the probability of the dimension along with the attributes contained in the same row.

The output and hidden layer is achieved through the use of the equation 1 and 2 given below.

$$X= (AT1 * W1) + (AT2 * W2) + B1 \quad \text{\_\_\_\_ (1)}$$

$$HLV= \frac{1}{(1+\exp(-X))} \quad \text{\_\_\_\_\_ (2)}$$

Where,

W1 ,W2 - Random weights,

(Other random weights set is also used like

{ W1,W2,W3,W4,W5,W6,W7,W8,B1,B2 })

AT1, AT2 - Attributes for which prediction probability is estimated

HLV – Hidden layer

The achieved values of the output layer are then combined with the target values to attain the prediction for the probability list. The input attribute values from the user are also subjected to the probability list evaluation and the resultant list is also provided for the next step of the process for classification.

Step 5: Decision Tree – This step takes the output of the previous step as input in this step. The matching row with the least probability is being used for the assessment of the probability of the input values. The achieved row is subjected to the combination of all the attributes according to the attributes given as an input by the user. The If-then rules are utilized for the estimation of the scarcity or the wastage of the construction materials based on the input by the user. The output is then displayed to the user through the use of an interactive user interface.

2. RESULTS AND DISCUSSIONS

The presented technique for the evaluation and management of the construction waste has been evaluated through the use of the Java programming language, based on the NetBeans IDE. The machine for the development of the approach is being powered by an Intel Core i5, along with 500 GB of hard disk and 4GB of RAM. The storage capabilities have been handled by the MySQL database storage mechanism.

For the evaluation procedure, the preciseness of the predictions achieved by the system for the management of the construction waste needs to be evaluated for the presence of errors. The performance metric being utilized for this purpose is the RMSE or the Root Mean Square Error. This approach is being utilized to achieve an effective rate of error between two continuous and correlated variables.

The continuous and correlated entities achieved in our system are the actual quantity of construction waste management labels and the obtained construction waste management labels. The value of RMSE can be realized in equation 3 given below.

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

Where,

$\sum$ - Summation

$(x1 - x2)2$ - Differences Squared for the summation between the actual construction waste management labels and the obtained construction waste management labels

n - Number of samples or Trails

Experimental evaluation achieved through the RMSE approach is tabulated in Table 1 given below.

Experiment No	No of Actual Construction Waste Management Labels	No of Obtained Construction Waste Management Labels	MSE
1	14	10	16
2	13	8	25
3	11	9	4
4	10	7	9
5	8	5	9

Table 1: Mean Square Error measurement

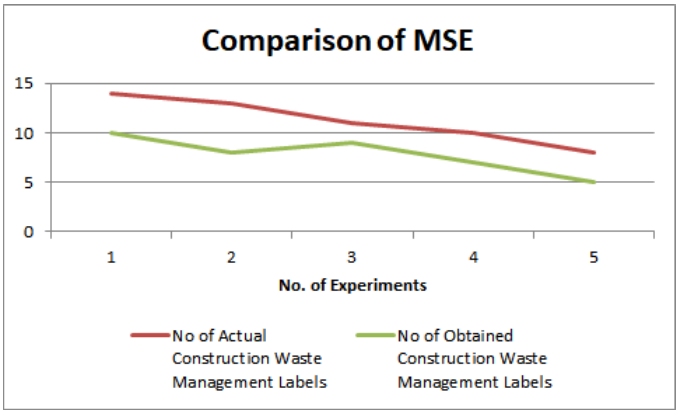


Figure 2: Comparison of MSE in between No of Actual construction waste management labels V/s No of obtained construction waste management labels

The tabulated values are realized to achieve the graphical representation of the values in the form of a line graph given in figure 2 above. The error achieved between the values of actual construction waste management labels and the obtained values of construction waste management labels has been assessed through a series of 5 experiments. 10 trials are conducted for each of the experiments. The assessment results have resulted in the MSE and RMSE of 12.6 and 3.54 respectively. The error rate of the system is within the expected range with highly satisfactory performance of the initial implementation.

3. CONCLUSION AND FUTURE SCOPE

The proposed technique for construction waste management through the use of Fuzzy C-Means clustering and Linear Selection along with the Artificial Neural Networks and Decision Tree has been elaborated in this research article. These approaches have been effective in the realization of the minimization of construction waste. This is achieved through this system that utilizes the user input for the various parameters of construction. These parameters are then utilized for extraction of the relevant data from the dataset and then using it to achieve Fuzzy C-Means clustering. The clustering approach then uses the Fuzzy crisp values attained from the synthetic dataset created through the amalgamation of the user input and the input dataset. The clusters achieved are then provided to the linear selection according to the user parameters provided. The selection is then provided to the Artificial Neural Networks module for the evaluation of the probability scores. These scores are then provided to the Decision tree to achieve the classification of the probability scores. The classification through the use of the If-then rules of the decision tree provides the scarcity and the abundance of construction materials to the user. The experimental evaluation provides the error rate of the proposed system which is within the desired limits.

For future research, the approach can be implemented in the form of a web application that can be easier to use and provide effective improvements.

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