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Original Article

An Improved Model for Waste Management Recommender System in Rivers State Using Deep Learning Approach

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Abstract *- The unavailability of Waste Sort Recyclables (WSR) is a serious waste management problem in Rivers State, Nigeria. WSR is a deep learning process that involves the classification of Waste into four recycling categories which include glass, paper, metal and plastic. Secondly, there is a need for a recommender system for relevant waste management agencies in Nigeria. In this study, we developed an improved model for Waste Management Recommender System (IWMRS) in Nigeria using the Deep Learning approach. Software Development and Lifecycle Methodology (SDLC) was utilized in this approach. Furthermore, we implemented Hypertext Pre-processor, JavaScript Programming Languages and MySQL Relational Database as backend. The parameters for our results performance achieved an overall performance rate of 94% when compared with the most recent Waste Management System. The parameters for the comparative analysis included Time Complexity (TC), Life-Cycle Assessment (LCA), Benchmarking (B), Multi-Criteria Decision Making (MCDM), Risk Assessment (RA), Cost-Benefit Analysis (CBA) and Speed (S) which was also presented as TC, LCA, B, MCDM, RA, CBA, S = 20, 36, 14, 10, 7, 2, 5 respectively as compared with the existing parameters values of 14, 31, 14, 10, 7, 2 and 5 and further confirmed outperformance of the existing system by the proposed system. The obtained results also show the importance of Deep Learning techniques in Recommender Systems. This is because we live in a World of Information and Big Data. In addition, we boldly recommend this study to seekers of waste management information through recommender systems that utilize Deep Learning Techniques.*

Keywords *- Deep Learning Approach, IWMRS, Recycling, SDLC, WSR.*

I. INTRODUCTION

The unavailability of Waste Sort Recyclables (WSR) is a serious waste management problem in Nigeria, especially Rivers state. WSR is a deep learning process that involves the classification of Waste into four recycling categories which include glass, paper, metal and plastic. Secondly, there is a need for a database/recommender system with the relevant management and recycling information of the four grouped recycling categories. WSR is a new technological waste management innovation that uses a deep learning approach. According to Alexander [1], A computer vision approach to classify garbage into recycling categories could be an efficient way to process waste. Also, knowing that a good part of the generated Waste in large cities are recyclables, there is a need to know and apply reuse methods through deep learning that could bring benefits or at least reduce environmental problems.

The existence of techniques or models that help people to sort garbage has become essential in the correct disposal of those materials. Although there are different types of recycling categories, people still can be confused or do not properly recognize how to determine the correct trash bin can to dispose of each garbage. In order to minimize the impact caused by the incorrect disposal of garbage, more specifically domestic (i.e., paper, plastic, glass and trash), we proposed to use an improved and automated system based on deep learning and neural network techniques aiming at the correct separation of Waste in recycling categories. Ways in which humans have managed solid Waste over the centuries are still based on the original strategy of just eliminating them. Population growth has been the main factor for the increasing production of garbage. Therefore, it should be reduced on a personal basis to maintain the balance at which the Waste is managed. Waste management and efficient sorting of them have been considered as an important role for ecologically sustainable development worldwide. It is essential for society to reduce waste accumulation by recycling and reusing disposed of products. Efficient selective sorting is often implemented to improve recycling and reduce the environmental impact Glouche [2]. This problem should be specially treated in developing countries, where the waste management is a severe problem for their urbanization and economic development. Garbage has become a major problem worldwide due to the uncontrolled disposal of household waste from citizens' homes and industries without an effective and efficient waste management program that can result in health risks and a negative impact on the environment. Waste management with efficient classification plays an important role in ecologically sustainable development by ensuring that waste is properly disposed of. Efficient selective collection is often implemented to improve recycling and reduce environmental impact, especially in developing countries where waste management is a serious problem for economic development. The unsustainable development of most nations has created a problem due to the growing generation of Waste that must be solved. In spite of the social and governmental commitment, there are hardly any technological means to make optimal management of the waste collection process. In fact, traditionally, the solid waste collection was carried out without previously analysing the demand, or the routes of the vehicles and the decisions about the routes were taken by the drivers, although the solutions were far from optimal. The solid waste collection is usually performed based on static plans, with a pre-determined number of visits per week, designed manually in most cases. The fast demographic growths, together with the concentration of the population in cities and the increasing amount of daily Waste, are factors that push to the limit the ability of waste assimilation by Nature. It is very important to improve existing waste management recommender systems through the application of automation.

A. Statement of the Problem

The study addresses the unavailability of Waste Sort Recyclables (WSR) in Existing Waste Management Systems Rivers State, Nigeria. The unavailability of WSR is a serious waste management problem in Rivers State, Nigeria. WSR is a deep learning process that involves the classification of Waste into four recycling categories which include glass, paper, metal and plastic. Secondly, another problem with the Existing Waste Management method in Nigeria is that it does not implement waste recycling datasets with automation (i.e. deep learning, data mining, clustering, etc.) This is what the work intends to address.

B. Aim and Objectives of the Study

The aim of this study is to design and develop an improved model for Waste Management Recommender System in Rivers State, Nigeria. The specific objectives of the study are to:

- design a waste management information system for the Rivers State Government
- implement the system with JavaScript programming language and MySQL database .as backend
- compare our results with the existing Waste management system

C. Review of Waste Management

These are the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process. Waste can be solid, liquid, or gaseous, and each type has different methods of disposal and management. Waste management deals with all types of Waste, including industrial, biological and household. In some cases, Waste can pose a threat to human health.

a) Classification of Waste

There may be different types of Waste such as Domestic Waste, Factory waste, Waste from oil factories, E-waste, Construction waste, Agricultural Waste, Food processing waste, Bio-medical Waste, Nuclear Waste, Slaughterhouse waste etc. We can classify Waste as follows:

- Solid Waste- vegetable waste, kitchen waste, household waste etc.
- E-waste- discarded electronic devices such as computer, TV, music systems etc.
- Liquid wastewater used for different industries, tanneries, distilleries, thermal power plants
- Plastic waste- plastic bags, bottles, bucket, etc.
- Metal waste- unused metal sheet, metal scraps etc.
- Nuclear Waste- unused materials from nuclear power plants Further, we can group all these types of Waste into wet Waste (Biodegradable) and dry Waste (Non-Biodegradable).

Furthermore, Wet waste (Biodegradable) includes the following:

- Kitchen waste, including food waste of all kinds, cooked and uncooked, including eggshells and bones
- Flower and fruit waste including juice peels and house-plant Waste
- Garden sweeping or yard waste consisting of green/dry leaves
- Sanitary wastes

- Green Waste from vegetable and fruit vendors/shops
- Waste from food and tea stalls/shops etc.

Dry Waste (Non-biodegradable) includes the following:

- Paper and plastic, all kinds
- Cardboard and cartons
- Containers of all kinds, excluding those containing hazardous material
- Packaging of all kinds
- Glass of all kinds
- Metals of all kinds
- Rags, rubber
- House sweeping (dust etc.)
- Ashes
- Foils, wrappings, pouches, sachets and tetra packs (rinsed)
- Discarded electronic items from offices, colonies viz. cassettes, computer diskettes, printer cartridges and electronic parts.
- Discarded clothing, furniture and equipment

In addition to the above wastes, another type of Waste called Domestic Hazardous Waste may also be generated at the household level. These include used aerosol cans, batteries, household kitchen and drain cleaning agents, car batteries and car care products, cosmetic items, chemical-based insecticides/pesticides, light bulbs, tube lights and compact fluorescent lamps paint, oil, lubricant and their empty containers. Waste that is considered hazardous is first required by the agencies to meet the legal definition of Solid Waste. The agencies incorporate hazardous Waste into three categories. The first category is source-specific wastes, the second category is nonspecific wastes, and the third is commercial chemical products. Generally, hazardous waste is Waste that is dangerous or potentially harmful to our health or the environment.

b) Disposal vs Waste Management

There are common practices to dispose of Waste from ordinary people. But disposal of Waste is becoming a serious and vexing problem for any human habitation all over the world. Disposing of solid waste out of sight does not solve the problem but indirectly increases the same manifold, and at a certain point, it goes beyond the control of everybody. The consequences of this practice, such as health hazards, pollution of soil, water, air and food, unpleasant surroundings, loss of precious resources that could be obtained from solid Waste, etc., are well known. That's why it is essential to focus on the proper management of Waste all over the world. Waste management has become a subject of concern globally and nationally. The More advanced the human settlements, the more complex the waste management. There is a continuous search for sound solutions for this problem, but it is increasingly realized that solutions based on technological advances without human intervention cannot sustain for long, and it, in turn, results in complicating the matters further. Management of Solid Waste, which generally involves proper segregation and scientific recycling of all the components, is, in fact, the ideal way of dealing with solid waste.

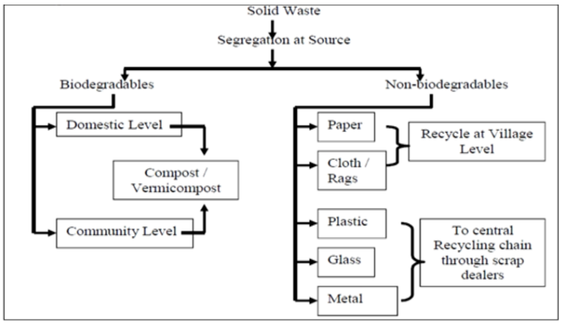

Fig. 1 An ideal Solid Waste Management at a glance
(*Source: [2]*)

D. Overview of Recommender Systems for Waste Management

Recommenders are being used in many applications and circumstances to make ease of social life by generating categorized and personalized recommendations to the individuals. These categories may be chosen by the users to get recommendations for movies, songs, products and various services etc. One of the challenges of a recommender system is to generate recommendations in real-time for many people by analysing a huge amount of data. Recommendation systems are the type of information retrieval mechanisms used to predict users' interest in a given context on an item. Recommendation system found its applications in news personalization, product/item recommendations, in E-commerce websites, Songs and movie recommendation in online streaming websites and friend recommendation in social networking sites. The process of making recommendations involves two steps which include: the learning of data, also known as model building step or offline step, and the generation predictions, also known as execution or online step. In many cases, Recommendations should be real-time, so the offline step should be able to scale up a massive amount of data and help to generate real-time recommendations. The challenge of recommendation systems is to mainly understand the user's requirement and recommend items that are related to a users' interest which he may not know but like when recommended. The recommendation system uses many parameters to generate recommendations. The history of recommender systems ranges from Google Page rank system, Pandora music streaming website, CDnow, to Amazon.com. These websites use recommendation engines to provide valid recommendations in real-time.

Types of Recommender Systems:
Recommender Systems are of two types, namely: Non-Personalized Recommender System and Personalized Recommender System. The Non-personalized recommenders never consider users' interests into account to provide recommendations. These types of recommenders are highly beneficial. For example, in a news recommender system, even if a user is not interested in politics, it is essential to recommend major political news like the new president-elect of the country to all users. On the other hand, personalized recommenders customize recommendations according to a user's taste. Non-personalized recommender system gives common recommendations to all users. The simple formula used by earlier non-personalized recommender systems like Zagat is:

$$Score = (mean (ratings)) * 10 \quad (1.1)$$

The rating values are between 1 and 5, and the mean is multiplied by ten to make it non-decimal. Some non-personalized recommender systems like Conda Nast used the formula to calculate Rating Prediction Ru as:

$$Ru = (\sum i = i * ri / \sum i = Iri) * 100 \quad (1.2)$$

Where $\sum$ urui is the number of people with good ratings for item i, and I am the total number of ratings for that item. Non-personalized recommenders are used to provide a new review. For example, the average rating of a new movie in blogs has nothing to do with a user's interest. In cases of fewer ratings, the mean can be misleading. So the mean ratings are modified by:

$$Ru = \sum urui + k\mu / n + k \quad (1.3)$$

Where $\sum$u is the sum of user ratings for item i, n is the total number of ratings, k is the strength of evidence required to overcome the global mean, and μ is the average rating of item i. The advantages of a non-personalized recommender system are less time complexity, less space complexity and can generate recommendations for even new users. And the draw-back of non-personalized Recommender is that it never considers the user's interest. Furthermore, the research results from most related works on recommender systems show that most industries still operate the Non-personalized recommender system model. The utility matrix is considered as input to make recommendations. Secondly, this matrix has rows as users and columns as items. The intersection is the vector of ratings given by a user on an item. The main agenda of content-based filtering is to find similar items to items the user is looking for. Content-based recommenders found their applications in digital documents, online articles and news portals. Collaborative filtering predicts the preference of a user on an item based on the taste of another user. The criteria here are to find a set of users similar to a user u and recommend the items consumed or preferred by these users. Memory-based collaborative filtering techniques find similarities between user/items using neighbourhood methods. The similarity is typically calculated by Pearson correlation, cosine similarity measures, and Jacquard coefficients. Here, the similarity between users/items is computed offline. There are two types of collaborative filtering techniques, user-user collaborative filtering and item-item collaborative filtering. The basic idea of user-user collaborative filtering is to let us consider a user x to find a group of users whose likes and dislikes are similar to defined user x.

E. Overview of Deep Learning Paradigm for Waste Management

Deep Learning is an artificial intelligence function that imitates the workings of the human brain in processing data and creating patterns for use in decision making. Deep learning is a subset of machine learning in artificial intelligence (AI) that has networks capable of learning unsupervised from data that is unstructured or unlabelled.
The deep learning paradigm tackles problems on which shallow architectures (e.g. SVM-Support Vector Machines) are affected by the curse of dimensionality. As part of a two-stage learning scheme involving multiple layers of nonlinear processing, a set of statistically robust features is automatically extracted from the data. In statistical machine learning, a major issue is the selection of an appropriate feature space where input instances have desired properties for solving a particular problem. For example, in the context of supervised learning for binary classification, it is often required that the two classes are separable by a hyper-plane. In the case where this property is not directly satisfied in the input space, one is given the possibility to map instances into an intermediate feature space where the classes are linearly separable. This intermediate space can be specified explicitly by hand-coded features, be defined implicitly with a so-called kernel function, or be automatically learned. In both of the first cases, it is the user's responsibility to design the feature space. This can incur a huge cost in terms of computational time or expert knowledge, especially with highly dimensional input spaces, such as when dealing with images. As for the third alternative, automatically learning the features with deep architectures, i.e. architectures composed of multiple layers of nonlinear processing, can be considered as a relevant choice. Indeed, some highly nonlinear functions can be represented much more compactly in terms of a number of parameters with deep architectures than with shallow ones (e.g. SVM). For example, it has been proven that the parity function for n-bit inputs

can be coded by a feed-forward neural network with O(log n) hidden layers and O(n) neurons, while a feed-forward neural network with only one hidden layer needs an exponential number of the same neurons to perform the same task. Moreover, in the case of highly varying functions, learning algorithms entirely based on local generalization are severely impacted by the curse of dimensionality. Deep architectures address this issue with the use of distributed representations and as such may constitute a tractable alternative.

II. RELATED WORK

Raveesh et al. [3] researched Waste Management Initiatives in India for Human Well-being. The work offered deep knowledge about the various waste management initiatives in India and found out the scope for improvement in the management of Waste for the welfare of society. The work also attempted to understand the important role played by the formal sector engaged in waste management in our country. Generation of Waste is inevitable in every habitation howsoever big or small. Since the dawn of civilization, humanity has gradually deviated from nature and today, and there has been a drastic change in the lifestyle of human society. A direct reflection of this change is found in the nature and quantity of the garbage that a community generates. We can dispose of the Waste or reuse Waste and can earn money through proper management. Indian cities which are fast competing with global economies in their drive for fast economic development have so far failed to effectively manage the huge quantity of Waste generated.

Cenk [4] looked at RecycleNet: Intelligent Waste Sorting using Deep Neural Networks. They illustrated that Waste management and recycling are the fundamental part of a sustainable economy. For more efficient and safe recycling, it is necessary to use intelligent systems instead of employing humans as workers in the dump-yards. This is one of the early works demonstrating the efficiency of the latest intelligent approaches. In order to provide the most efficient approach, they experimented with well-known deep convolutionary neural network architectures. For training without any pre-trained weights, Inception-Resnet, Inception-v4 outperformed all others with 90% test accuracy. For transfer learning and fine-tuning of weight parameters using ImageNet, DenseNet121 gave the best result with 95% test accuracy.

Kate [5] looked at Recommendations for Waste, Waste Reduction and Recycling using Deep Learning. She illustrated that a zero-waste approach is one of the fastest, cheapest, and most effective strategies we can use to protect the climate and the environment of all of the recommendations put forth by the Waste Reduction and Recycle working group, the recommended one from work is the most essential. The city must shift the way it deals with Waste and develop strategies to drastically reduce the amount of debris currently going to landfills. The goal of Zero Waste is to maximize recycling and reuse of products, thereby avoiding wasting our natural resources in creating products that will end up in the waste stream. It encourages the design of products that have the potential to be repaired, reused or recycled. When materials can be reused and recycled wisely, it also eliminates the discharge of potentially hazardous substances to our land, air and water.

Ahmed [6] looked at Solid Management Practices in two Northern Manitoba First Nation Communities: Community Perspective on the Issues and Solutions. According to the study, the authorities, usually municipal, are obligated to handle solid Waste generated within their respective boundaries; the usual practice followed is of lifting solid Waste from the point of generation and hauling it to distant places known as dumping grounds and/or landfill sites for discarding. The treatment given to waste once thus emptied is restricted to spreading the heap over larger space so as to take away the Waste from the public gaze.

Awomeso [7] researched Waste Management Disposal and Pollution Management in Urban Areas: A Workable Remedy for the environment in developing countries. The study illustrated that waste collection is usually done on a contract basis. In most cities, it is done by rag pickers, small-time contractors and municipalities. There are different sweepers employed in street sweeping and primary waste collection in each city. Each sweeper is responsible for the daily cleansing of a fixed area, usually a street, including all side lanes.

Danilo [8] looked at Sustainable Solid Waste Management System. According to the study, domestic solid Waste is usually thrown on the streets directly or in plastic bags from where road sweepers collect it into heaps. These wastes are then transported by hand-cart trolley to the nearby open dumps or to bins, or directly by tractor trolley to the outskirt of the cities. The road sweepers are equipped with a broom, pan, fovea (spade/shower), hand-carts (small pointed hand-rake), (pointed small spade to clean roadside open drains) and buckets.

Elena [9] researched analysis and measures to improve waste management in schools. The study illustrated that the Waste from street cleansing is collected in wheelbarrows, and thereafter, it is dumped into roadside bins or at open dumping spaces along with the household waste. Municipal workers collect Waste from collection points (open dumping spaces or bins) into various vehicles, including tractors and bull carts and haul it to disposal sites. In some cases, the workers collect the Waste from the collection points using wooden baskets and transfer it into the vehicles manually.

Taiwo [10] looked at Waste Management Disposal and Pollution Management in Urban Areas: A workable remedy for the environment. According to the study, the entire operation of the Solid Waste Management (SWM) system is performed under four headings, namely, street cleansing, collection, transportation and disposal. The cleansing and collection operations are conducted by the public health department of the city Municipality Corporation, while transportation and disposal of Waste are carried out by the transportation department of the city Municipality Corporation. The entire city can be divided into two different zones. These zones are further divided into different sanitary wards for the purpose of solid waste collection and transport operations. Currently, waste management in Nigeria mostly means picking up Waste from residential and industrial areas and dumping it at landfill sites.

III. MATERIALS AND METHODS

A. Methodology

The Methodology adopted for the Improved Waste Management Recommender System is System Development Lifecycle Methodology (SDLC). The System Development Lifecycle Methodology (SDLC) involves a standardized set of a task carried out in order to improve an Existing Project.

B. Analysis of the Existing System

Kate [5] developed the Smart Waste Management System using the Internet of Things, i.e. (IOT-SWMS) see figure 3.1. With the increasing population and industrialization of nations throughout the globe, Waste has become a great concern for all of us. Over the years, researchers figured that only waste management is not enough for its proper treatment and disposal techniques to preserve our environment and keep it clean in this era of globalization. With the help of technology, researchers have introduced IoT based Smart Waste Management solutions and initiatives that ensure a reduced amount of time and energy required to provide waste management services and reduce the amount of waste generated. Unfortunately, developing countries are not being able to implement those existing solutions due to many factors like the socio-economic environment. The IOT-SWMS will ensure proper disposal, collection, transportation and recycling of the household waste with the minimum amount of resources being available. Waste management is one of the core concerns of the modern age. As nations around the world are developing, their concerns and accountability for a healthier and sustainable environment are also increasing. While developed countries are inventing and implementing smart solutions for waste management and bringing about huge positive impacts, waste management seems to be a play out of the league for underdeveloped or developing countries.

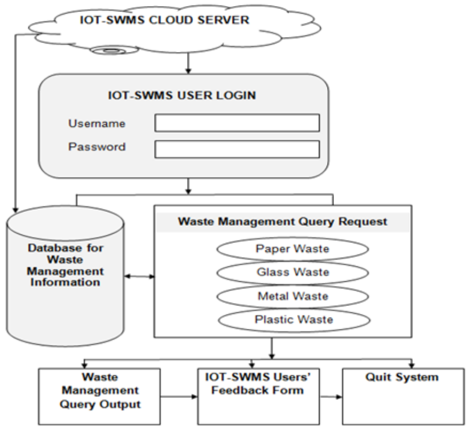

Fig. 3 An IOT-Based Smart Waste Management Syste *(Existing System) (Source: [5])*

C. Advantages of the Proposed System

The following advantages of the Proposed System are:

- In-depth recommendation of waste management information for paper waste, glass waste, metal waste and plastic Waste.
- Automated updates of waste management information for its users through the implementation of the Internet of Things.
- Implementation of Waste Sort Recyclables (WSR) through Deep Learning Approach.

D. Existing System Algorithm

a) Applied Dijkstra's Algorithm For Waste Management

```
/* Program of shortest path between two node in graph using
Djikstra algorithm */
Start
Declare Variables
#include<stdio.h>
#include<conio.h>
#define MAX 10
#define TEMP 0
#define PERM 1
#define infinity 9999
struct node
{int predecessor;
int dist; /*minimum distance of node from source*/
int status;
};
int adj[MAX][MAX];
int n;
void main()
{
int i,j;
int source,dest;
int path[MAX];
int shortdist,count;
```

```
clrscr();
create_graph();
printf(The adjacency matrix is :\n);
display();
```

E. Proposed System Algorithm

b) Improved Dijkstra's Algorithm For Waste Management (Proposed System)

```
Start
Declare all variables
L, UN, PW, WMQ, QO, UFB, QS: Where L is Login, UN is Username, PW is password, WMQ is Waste
Management Query, QO is Query Output, UFB is User's Feedback and QS is Quit System
Initiate L
L = UN + PW
Initiate WMQ
#include<stdio.h>
#include<conio.h>
#define MAX 10
#define TEMP 0
#define PERM 1
#define infinity 9999
struct node
{int predecessor;
int dist; /*minimum distance of node from source*/
int status;
};
int adj[MAX][MAX];
int n;
void main()
{
int i,j;
int source,dest;
int path[MAX];
int shortdist,count;
clrscr();
create_graph();
printf(The adjacency matrix is :\n);
display();
while(1)
{
printf(Enter source node(0 to quit) : );
scanf(%d,andsource);
printf(Enter destination node(0 to quit) : );
scanf(%d,anddest);
if(source==0 || dest==0)
exit(1);
count =
findpath(source,dest,path,andshortdist);
if(shortdist!=0)
{
printf(Shortest distance is : %d\n,
shortdist);
printf(Shortest Path is : );
for(i=count;i>1;i--)
printf(%d->,path[i]);
printf(%d,path[i]);
printf(\n);
}
else
printf(There is no path from
source to destination node\n);
View QO
Activate QS
}/*End of while*/
}/*End of main()*/
```

IV. RESULTS AND DISCUSSION

A. Choice and Justification of Programming Language used

We implemented the Proposed System design with PHP, JavaScript Programming Language, Hypertext Markup Language, Cascading Style Sheet and MySQL Relational Database Management System. JavaScript is a server-side scripting language that is used for making web pages interactive.

B. Discussion of Results

Once the Waste Management System is launched, the user must log in with a unique username and password (see figure 4.1). We saw the need for an Improved Waste Management System using Deep Learning which will promote the organization and recycling of datasets and waste respectively for the long term. Waste Management recommendations are a powerful economic tool the user can leverage to drive significant returns for waste management. Not only does it encourage users to spend more time analyzing waste management datasets, but it also fosters a better user experience. Some of the biggest names in tech have differentiated themselves in the management of large datasets for waste management, thanks to their sophisticated recommendation algorithms. It is the recommender system that is considered one of the most powerful tools in the present digital world. Explanations are usually provided by it to their recommendations so that web users are helped to find its products, people and also their friends who are missing in social communities. In the field of recommender systems, there are various methods and approaches which have been implemented. There are two approaches that are most widely used. They are content-based and collaborative approaches. These personalized approaches should be studied so that the best recommendations are provided to the end-users. Originally, we defined Recommender systems as ones where ‘‘recommendations are provided by people as inputs, which are then aggregated and directed to appropriate recipients by the system’’. The clear main purpose of the current recommender systems is to guide the user to useful/interesting objects.

Due to this, evaluation of the proposed system shows to what extent this goal has been. Recommenders are being used in many applications and circumstances to make ease of social life by generating categorized and personalized recommendations to the individuals. These categories may be chosen by the users to get recommendations for movies, songs, products and various services etc. One of the challenges of a recommender system is to generate recommendations in real-time for many people by analyzing a huge amount of data. Recommendation systems are the type of information retrieval mechanisms used to predict users' interest in a given context on an item. Recommendation system found its applications in news personalization, product/item recommendations, in websites recommendation in online streaming websites and friend recommendation in social networking sites.

Fig. 4.1 IWMRS: Welcome Page

Secondly, the function of the proposed system involves two steps which include: the learning of data, also known as the model building step or offline step, and the generation predictions, also known as execution or online step. Residual connections make deeper and wider inception networks more efficient with lesser hyper-parameters. Earlier inception module implementation required more training resources and time, with residual connection improvement, requirements reduced, and the model turned out to be more efficient to train. Different from previous works, in inception-v4, batch normalization takes place on the top of traditional coevolutionary layers, not before residual blocks; due to this property, the inception block size is increased. Apart from inception-v3 for inception-v4 contains scaling of residuals before layer accumulation, these scaling results with more stable training and higher accuracy and eventually allows building an increased model size, deep supervision, and depth diversification. It is interesting to note that the proposed system also claimed to work better without data augmentation because of large margin properties. Due to the limited data number, our results seem to be confirming this claim.

Classification of real-world examples for waste classification is not an easy computer vision task. Apart from environmental factors such as lighting, Waste could be described as a shape-shifting material. For instance, one can compress a plastic bottle or tear a paperboard. These materials do not lose their material properties, but they lose their key properties to be identified as an intact objects. Besides, virtually any object can be an input to a waste sorting system, but the available training samples are limited. This requires the system to generalize extremely well when trained with a relatively small training set.

Fig. 4.2 IWMRS: System Client Login Page

Fig. 4.3 IWMRS: Recommended Waste Management Categories

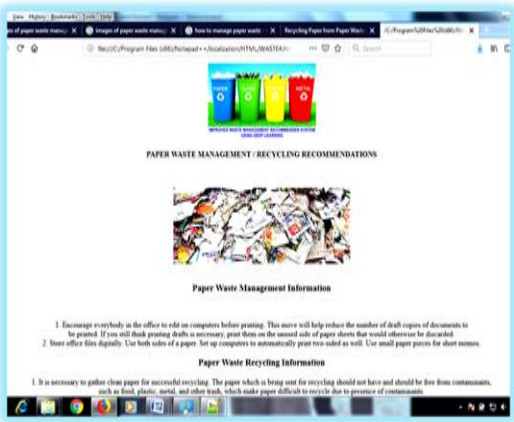

Fig. 4.4 IWMRS: Paper Waste Management / Recycling Recommendations

We believe that when the state-of-the-art deep learning neural networks are meticulously trained, they will be capable of producing industrial-grade results to solve these types of problems. This was the main motivation behind the Proposed System. The results of this research prove this claim. The common practice for household refuse disposal in the local areas is to dump solid wastes openly in backyard gardens or in an open space. Such indiscriminate disposal is an environmental hazard and can threaten human health and safety. Solid Waste that is improperly disposed of can result in a number of problems. It can create a breeding ground for pathogenic microorganisms and vectors of disease and cause a public nuisance due to unsightliness and bad smell. It can cause contamination of surrounding soil, groundwater and surface water, and it can also create fire hazards physical hazards and have poisoning effects (from pesticides and insecticides). The traditional approach where municipal authorities monopolize waste management, ignoring other stakeholders, using command-and-rule strategies, and ill-adapted imported technology is common in urban cities. The immediate health effects from hazardous wastes range from bad smells and simple irritation of eyes, skin, throat and breathing (lungs) to serious health conditions that affect the nervous system and could cause paralysis of the functional body parts. Categorizing the reviewed articles by their objects of investigation shows that many studies assessed entire waste management systems. The life cycle of a product ends with waste management, which includes the waste management system from waste generation, waste collection, recycling, and treatment to the final disposal. Therefore, the efficient planning of waste management systems requires an accounting of complete sets of effects caused by the entire life cycle of Waste. The output of the Proposed System also illustrated reviewed works assessed either one treatment plant or compared different treatment options to determine the best available alternative. Comparing system boundaries with the object of investigation shows that studies evaluating waste management systems, waste collection systems, and waste prevention options often used geographic boundaries (country, region, or city). The reason is that these boundaries most likely coincided with administrative boundaries. The functional unit to compare different treatment options was primarily one unit of a specific waste stream, and the evaluation of a single treatment often referred to the inputs and outputs of the investigated plant.

Fig. 4.5 IWMRS: Plastic Waste Management / Recycling Recommendations

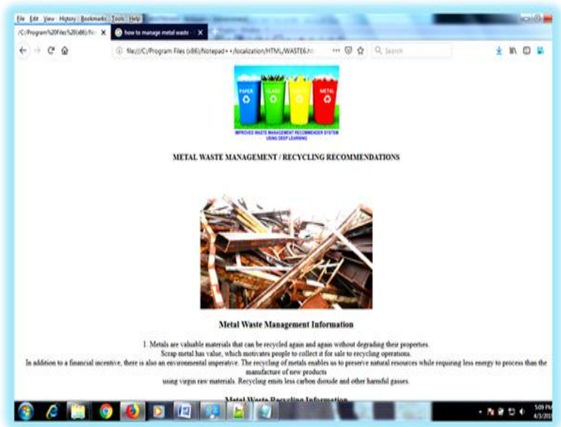

Fig. 4.6 IWMRS: Metal Waste Management / Recycling Recommendations

However, depending on the goal of a study, sometimes only one or two aspects were considered. Economic aspects are an important factor because money, in combination with available technology, is generally the limiting factor for a sophisticated, properly functioning waste management system. Economic aspects are mentioned on a business (microeconomic) level or on a public (macro-economic) level. In the reviewed articles, on the business level, the investment and operational costs were usually evaluated. Social sustainability can be classified under three different perspectives. Social acceptability (the waste management system must be acceptable); social equity (the equitable distribution of waste management system benefits and detriments between citizens); and social function (the social of waste management systems). Public health and safety are important factors within society, with a close link to the economy and to the environment. Social aspects of our proposed system also refer to recommendations of waste management information through structured programming. Taking this view, the complexity of the economic system is apparent. It becomes evident that sophisticated assessment methods are required. Only such methods are able to evaluate the economic, ecological, and social effects of a waste management system. The choice of the starting point and endpoint of an assessment can have a decisive impact on the results. The application of the mass balance principle is crucial for an impartial, comprehensible evaluation. As stated before, assessment methods can be divided into two groups: methods that are based on the mass balance principle and other methods that do not require this strict precondition.

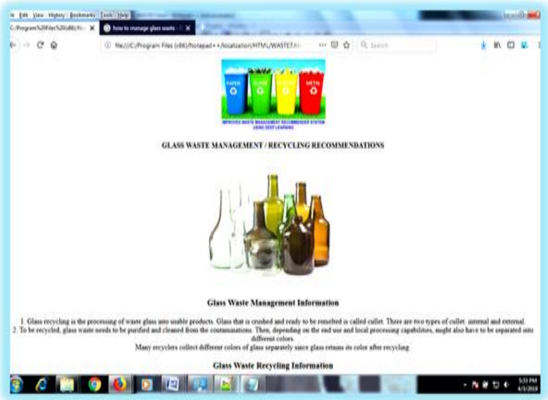

Fig. 4.7 IWMRS: Glass Waste Management / Recycling Recommendations

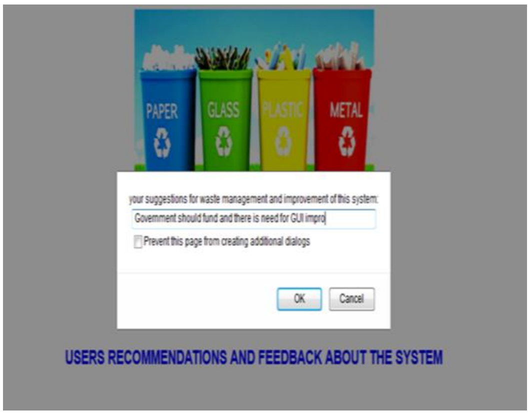

Fig. 4.8 IWMRS: User Recommendation and Feedback Page

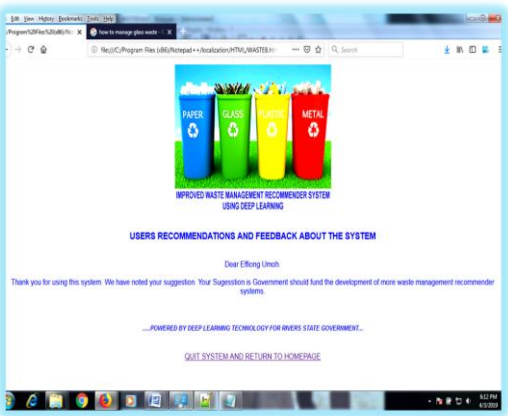

Fig. 4.9 IWMRS: User Recommendation / Feedback Page Confirmation

C. *Performance Evaluation*

Table 4.1 Existing System: Overview of the applied Waste Management Analytical Parameters N = 100

(where n is the overall total performance rate of the applied parameter)

Table 4.1

SN	PARAMETERS	ASSESSED PERFORMANCE RATE (%)
1.	Time Complexity (TC)	14
2.	Life-Cycle Assessment (LCA)	31
3.	Benchmarking (B)	14
4.	Multi-Criteria Decision-Making (MCDM)	10
5.	Risk Assessment (RA)	7
6.	Cost-Benefit Analysis (CBA)	2
7.	Speed	5

Assessed Parameters Summary:

B	=	14
TC	=	14
LCA	=	31
MCDM	=	10
RA	=	7
CBA	=	2
S	=	5
TOTAL	=	83%

Table 4.2: Proposed System (2020), Overview of the applied Waste Management Analytical Parameters N = 100 (where n is the overall total performance rate of the applied parameter)

Table 4.2

SN	PARAMETERS	ASSESSED PERFORMANCE RATE (%)
1.	Time Complexity (TC)	20
2.	Life-Cycle Assessment (LCA)	36
3.	Benchmarking (B)	14
4.	Multi-Criteria Decision-Making (MCDM)	10
5.	Risk Assessment (RA)	7
6.	Cost-Benefit Analysis (CBA)	2
7.	Speed	5

Assessed Parameters Summary:

B	=	14
TC	=	20
LCA	=	36
MCDM	=	10
RA	=	7
CBA	=	2
S	=	5
TOTAL	**=**	**94%**

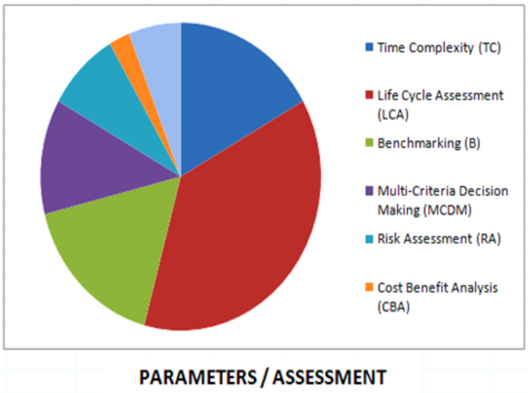

Fig. 4.10 Parameters/Assessment Chart for Existing System

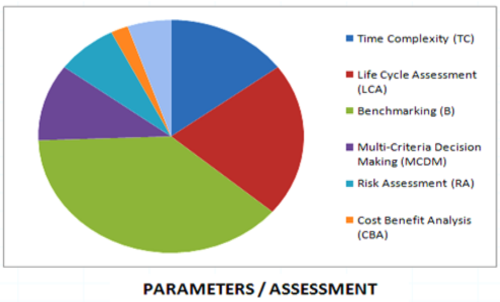

Fig. 4.11 Parameters/Assessment Chart for Proposed System

V. CONCLUSION

In conclusion, Waste Management is all about applying the right information on sorting, cleaning and transforming Waste to wealth for economic growth. Furthermore, Deep Learning has continued to play an important role in the design and development of various recommender systems. We live in a world of information and Big Data. Hence, we perceive the application of Recommender Systems as efficient tools for the management of Information and Big Data. Secondly, Recommender systems typically produce a list of recommendations in one of two ways through collaborative filtering or through content-based filtering (also known as the personality-based approach). Collaborative filtering approaches build a model from a user's past behaviour (items previously purchased or selected and/or numerical ratings given to those items) as well as similar decisions made by other users. In other words, we highly recommend the vital information from the study to seekers of waste management information through recommender systems that utilize Deep Learning Technique.

REFERENCES

[1] K. Alexander, Artificial Intelligence in Automated Sorting in Trash Recycling, an International Conference Paper Published at https://www.researchgate.net/publication/326994757, (2018).
[2] B. Glouche, A Smart Waste Management System with Self-Describing Objects, in the Second International Conference on Smart Systems, Devices and Technologies (SMART' 13), (2013).
[3] H. Raveesh, K. Lola, J. Goin, Waste Management Initiatives in India for Human Well-Being, European Scientific Journal, Special Edition: ISSN: 1857 – 7881, (2018) 105 -127.
[4] D. Cenk, RecycleNet: Intelligent Waste Sorting using Deep Neutral Networks, An International Conference Paper submitted at https://www.researchgate.net/325626219, (2018).
[5] J. Kate, Recommendation for Waste, Waste Reduction and Recycling, International Journal of Computer Applications (IJCA), 4(3) (2019)117 – 129.
[6] O. Ahmed, Solid Management Practices in two Northern Manitoba First Nations Communities: Community Perspective on the Issues and Solutions, a Thesis Submitted to the Faculty of Graduate Studies, University of Manitoba, (2016).
[7] J. Awomeso, Waste Management Disposal and Pollution Management in Urban Areas, A Workable Remedy for the Environment in Developing Countries, American Journal of Environmental Sciences, 6(1) (2016) 26 – 32.
[8] V. Danilo, Sustainable Solid Waste Management System: The CLSU International Journal of Science and Technology, 1(2) (2016) 15 – 25.
[9] R. Elena, Analysis and Measures to Improve Waste Management in Schools, an International Article for the University of Trento, (2019)
[10] A. Taiwo, Waste Management Disposal and Pollution Management in Urban Areas: A Workable Remedy for the Environment in Developing Countries, American Journal of Environmental Sciences, 6(1) (2014) 26 – 32.