AI-Powered Web-Based Household Waste Management System

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Abstract

Systems for managing household trash for The Internet of Things (IoT) and machine learning are at the heart of green smart societies. They use the newest technology to make garbage management more efficient in every room in the society. This study looks into smart trash gathering and breakdown, with the goal of getting more benefits while easily reducing real waste. This study looks at two levels of separating trash. The first level is based on a single family, and the second level is based on the whole society. Author, please explain more about how recyclable trash is composted. Using a machine learning method like KNN, a warning message is sent for different combos of three sensor data, such as the amount of biodegradable and non-biodegradable trash, the amount of toxic gas present, and so on. Long-term, this study will help green technologies move forward by reducing pollution, saving more resources, and reusing and recovering energy.

Keywords: IoT, smart city; waste management; biodegradable; sensor; machine learning

Introduction

Machine learning and the Internet of Things (IoT) enable every device to be uniquely identified (using an IP address) and to autonomously distribute data across networks, all without the need for human or computer intervention. Through the integration of electronic components like sensors, software, and networking gear, the Internet of Things (IoT) may encompass any physical object that can be addressed by an IP address, allowing for data transfer via a network.The Internet of Things (IoT) is defined by its concept of heterogeneity and offers enhanced connection of many types of equipment, services, protocols, and applications [1]. The Internet of Things (IoT) has shown to be useful in many areas, including smart city development, home automation, and social concerns [2].These days, the concept of a "smart city" is all the rage when it comes to bettering people's daily lives. One hundred "smart cities" will be established by the Indian government. Power, water, sanitation, recycling, transportation, and other essential services can be efficiently provided and managed in a smart city thanks to its cutting-edge technology, which includes a sensor network, cameras, wireless devices, fast networks like 5G, information technology

infrastructure, and data centers. In light of the growing importance of reimagining cities in a way that is environmentally sustainable, waste management has emerged as an essential component of city administration. A smart waste management system is an essential component of any smart city. A city is made up of many different types of residences and communities, both large and tiny, as well as markets, offices, and organizations. Collecting garbage from homes is the primary method. The many types of garbage, both organic and inorganic, that are generated by various economic and domestic activities [3]. While we wait for municipal companies to collect domestic waste, the only option is to utilize a trash can. Garbage cans and dustbins in urban areas are usually above capacity since daily trash production is significantly more than expected. Serious health risks, including the spread of infectious illnesses and environmental pollution, result from improper waste management [4]. The mixture of different biodegradable waste materials might release harmful gasses, such as methane, if the trash can is left unattended for an extended period of time. This situation demands prompt attention. The daily separation of biodegradable and non-biodegradable garbage, as well as trash management in order to maintain a healthy environment, is the primary concern with the fast rising metropolitan population. The proper authorities need to be notified in advance when the trash can is full so that they may pick it up in a timely manner and prevent pollution. In addition, a city may be considered smart if its residents are as adept at conserving resources such as water, energy, and trash. Smart green societies are the common term for these types of communities. Figure 1 depicts the green society component.

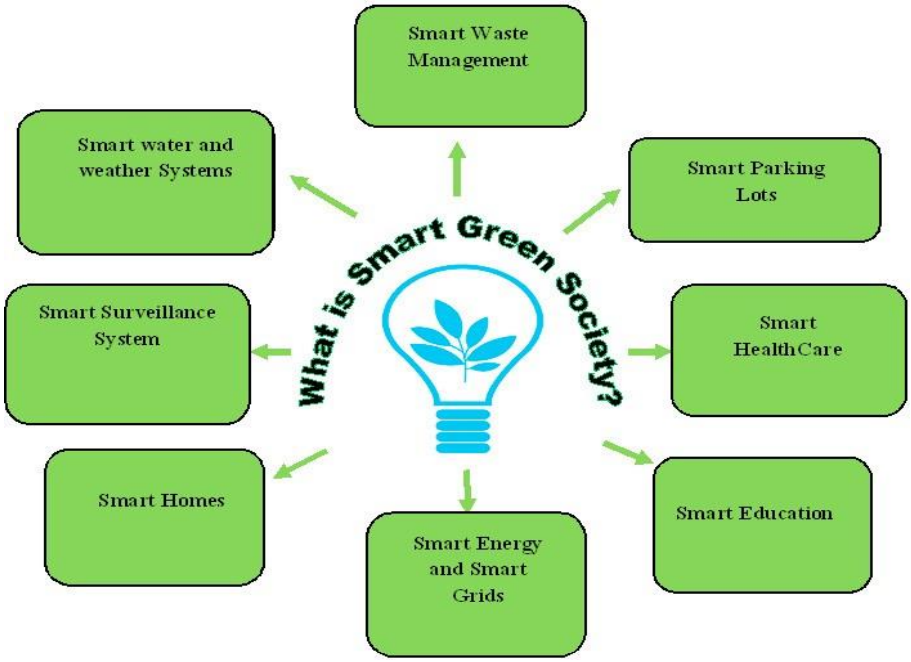


Fig. 1.components of green society

India has laws about how to deal with different kinds of trash, but they are not well enforced or kept up to date (Rewind 2018 [5]). Ten thousand metric tons of trash are made every day in Delhi alone, which makes it hard to find places to put them. The local company pays for all of the costs of picking up, transporting, treating, and getting rid of this trash. It is only possible for the community level in India to pick up trash; there is currently no system in place to sort, reuse, and recover household waste.The goal of making a "smart city" is pushing researchers to find ways to use machine learning and the internet of things to solve problems.More and more gadgets are connecting to the internet thanks to Internet of Things (IoT) apps that are used all over smart towns. Machine learning (ML) techniques can be used to make an app smarter and more useful as the amount of data it collects grows because of more devices being connected [6].

A smart trash can that sorts household trash into different types and turns them into biocompost is suggested in this study. It would use machine learning and internet of things technologies. The most important thing this paper adds is a way to make decisions that uses three sensor-collected factors together to send warning messages to the right people. The third factor is the amount of poisonous gases present, the second is the amount of trash that doesn't break down, and the first is the amount of trash that does break down. The decision of whether to send an alarm message or not is based on data from monitors. The guided machine learning algorithm KNN is used to sort sample data into groups and make predictions about alarm messages. The suggested model is made up of two parts. In module one, you can find a smart trash can with different areas for biodegradable and non-biodegradable trash. As a first step in keeping people away from each other, it is built into every house in the neighborhood.Module 2 is used at the societal level and deals with the second stage of segregation. This stage involves putting non-biodegradable trash from Level 1 into different groups and telling the local body about this. In addition to sending alarms to the city government, level 2 is used to make compost from level 1's recyclable trash that has been separated.

The rest of the document's parts are grouped in this way: In Section 2, we talk about the work that has been done on smart society garbage management systems based on the internet of things (IoT). In Section 3, we will talk about the parts of the suggested system. In Section 4, we talk about the parts that will be used in the planned study. Section 5 goes into more depth about the model's machine learning approach. In Section 7, the study's conclusion, we talk about what needs to be done in the future. The findings and conversation are in Section 6.

2. Related works

India's fast growth in cities, industry, and people over the past twenty years has made the problem of managing garbage even worse. It is used as a base for a study of a common trash management method [7]. [8]. The World Bank says that the total budget for solid waste handling by municipal companies is 20 to 50 percent of their total budget. The writer of the "ISWM plan" describes starting points, goals, worries, how the management system will respond, the plan's implementation, how it will be watched, and how it will be fed [9]. The automatic tracking system that has GSM built in [10] sends an SMS to the boss when the trash can is full, which lets the system plan a truck pick-up. The manager is once again told by SMS that the trash will be picked up. To find out how much trash was in the bin, the author of that study used a sound monitor. A GSM module sent messages that said the bin was full or empty.A similar way to collect trash was mentioned in [11], which uses an Arduino UNO board linked to a GSM module and an ultrasonic sensor. The author of that piece talked about issues with smart trash cans, like how much they cost, how easy they are to maintain, and how long they last.A camera, an Arduino UNO, and a Wi-Fi module are used in this garbage management system to get trash from city spots that are hard to get to. Using the Blynk app [2], the systems talk to each other. When the trash can is full, an ultrasonic monitor will make it clean right away [12, 13]. [14] suggested a smart trash can in 2017 based on a prototype for the Internet of Things (IoT).in the Indian state of Pune. The Internet of Things (IoT) can be used for many useful things outside of homes, such as in healthcare [15].

Machine learning is showing to be very useful for making decisions, finding patterns, and analyzing data in the Internet of Things (IoT), wearable tech, and smart tech businesses. In this way, machine learning is a way to use data to make decisions [16]. Machine learning methods, like KNN [17][18], are a simple way to group user "type" choices in wireless networks and other places. For the sake of people's health, Agarwal et al. gave a lot of information about India's trash control programs. The author pointed out that better garbage handling could be good for everyone [3]. Waste management is more than just picking up and getting rid of trash; it's necessary for building a smart city.To keep dangerous gases from escaping from home items, it's also important to know how to properly get rid of old batteries, pesticides, paints, motor oil, and other things.Waste that breaks down naturally, like food scraps, can release gases like methane into the air if they are not slowed down [19]. Garbage collection, sorting, reducing, reusing, and recycling are the five main parts of good waste management. The vast majority of written works on the subject have been about public smart trash cans. Even so, there is still a tough problem with dealing with household trash.

Surprisingly little research has been done on how to separate biodegradable trash from non-biodegradable trash and then recycle the biodegradable trash into compost. Toxic gases given off by everyday items are also a big problem for the environment. This forces us to create a system that can separate household trash

into two groups: biodegradable and non-biodegradable. The system will then use data from devices to set off alarms using a machine learning method. The Municipal Corporation picks up trash that doesn't break down and turns it into compost after more cleaning happens at the neighborhood level. Biodegradable trash is kept out of landfills.

3. A model for a green and smart society is put forward.

The idea of a smart city would stay just that: an idea without the will of people and neighborhoods. For a sustainable society, this study suggests a high-tech trash system with gas monitors to find dangerous gases and lids that open and close automatically when someone approaches the trash can. We will compost biodegradable household trash, sort biodegradable and non-biodegradable materials in two steps, and use Google Messenger to let the society supervisor and the local company know about it. The suggested smart trash can might be able to tell the difference between biodegradable and non-biodegradable trash using sensors built right in. Figure 2 shows that the green society's suggested plan for a waste management system works on two levels. The first level is for each family, and the second level is for the whole society.

3.1. Level 1: Adjoining Family

At the home level, the smart trash can is split into two parts. The steps you need to take to get to level one are shown below:

• Opens the trash can lid from a distance when someone approaches it.

• The green button means biodegradable trash and the red button means non-biodegradable trash. • The inner drum of the dust bin can be turned to separate biodegradable trash from non-biodegradable trash.

A message is sent to the site supervisor when the trash can is full to the amount set or when toxic gas is discovered.

You should take the trash can outside when the biodegradable or non-biodegradable part hits the reference level. You should use the line follower to bring it inside when it's empty.

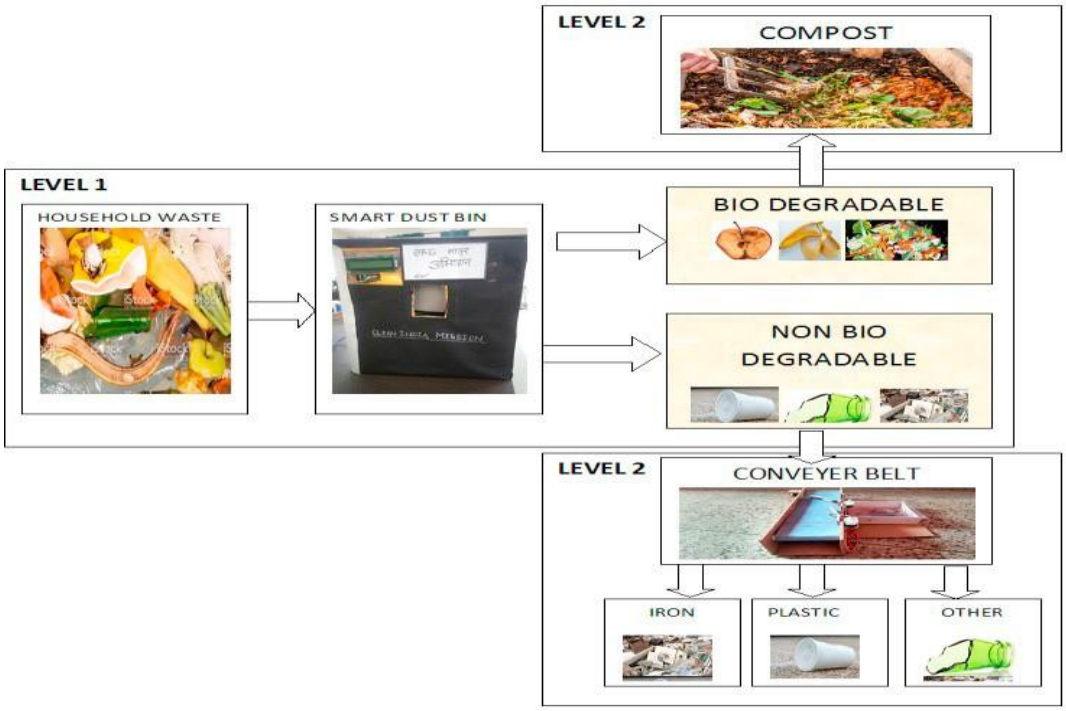


Fig. 2: A plan for managing garbage is proposed

3.2 The level of society

The conveyor belt separates non-biodegradable trash from level 1 into a second level. Level 1 has different types of non-biodegradable trash.

• An magnetic proximity sensor on the moving belt separates the trash that is made of metal. As soon as it finds metal, it sends it to the bin for receiving it. • A capacitance proximity sensor on the conveyor belt sorts recyclables like plastic and wood. When it finds plastic, it moves to the plastic container and then to the wooden container to be stored.

The rest of the trash is non-biodegradable trash that can't be sorted any further with this method.

• An alert message is sent to the city government when the amount of separated non-biodegradable trash goes over 90% full.

• To make compost, level 1 biodegradable trash from homes is mixed with leaves from the neighborhood green area, leftover roots, earthworms, and other organic materials.

3.3. The system's assumptions and a list of its parameters:

The model that is being offered is based on the following assumptions:

A word called "flag" is used to show whether the biodegradable or non-biodegradable part is now on the lid.At the very top, it says 1, which means there is a recyclable section.

Algorithm 1: Working of smart dustbin at Level1

1. Initialize flag=1 , th_{level} =20 cm ,th_{plevel}=0.3
2. If ir_{user}< 40mm
   "open the lid"
3. if b=1 then
   if flag=1
   "No Rotation"
   else
   "180 degree Rotation"
   flag=1
   endif
   endif
4. if nb=1 then
   if flag=1
   "180 degree Rotation"
   flag=0
   else
   "No Rotation"
   endif
   endif
5. "close the lid after delay of 30 sec"

The parameter 'b' will show biodegradable trash if the green button is pressed, and the parameter 'nb' will show nonbiodegradable trash if the red button is pressed.

We use the variable "iruser" to store the information from the "ir" sensor to keep track of how far away the user is from the trash can. If this number is less than or equal to 40 mm, we open the lid.

As our cutoff level, we use the same "thlevel" for both recyclable and non-biodegradable trash. It has a value of 20 cm to begin with.

• We use the terms blevel and nblevel to keep track of how much trash is biodegradable and how much is not biodegradable.

Use the variable "pglevel" to keep an eye on the current level of harmful gases like methane.

The work that should be done with level 1 and level 2 execution is shown in the simple flow charts in Figure 3(a) and (b).

3.4 Parts of the Proposed Model

By reusing and recycling household garbage, this model may help maintain a clean environment in the real world, ultimately leading to a Green and Smart society. The suggested architecture states that the smart dust bin's front-mounted infrared sensor automatically opens and closes the lid whenever it detects the user's approach. To open and close the smart dust bin's lids, actuators regulate the linear motion that is necessary.At level 1, two ultrasonic sensors on the inside of the lid keep an eye on the amount of trash in the biodegradable and non-biodegradable sections of the trash can.One way to determine how far away an object is from the sensor is to use A combination of the sonic speed (C) and the time it takes for the sonic waves to hit an item and return to the sensor (T) is given by (1).

Distance is equal to half of T times C times 1.

Located in the biodegradable container behind the lid at level 1, the MQ-4 gas sensor is utilized for the detection of toxic gases, such as methane.Under the level 2 conveyer belt, there are proximity inductive sensors and capacitance proximity sensors that are used to monitor the segregation of non-biodegradable materials.Under the conveyer belt on level 2, you'll find an inductive proximity sensor that can identify metal objects without touching them physically. Level 2 also has a capacitance proximity sensor that can sense plastic and wood.

The data is gathered by the Raspberry Pi and sent to the Adafruit IO free web service over Wi-Fi. This service links to the IFTTT (If This Then That) service and Facebook Messenger. Messages are sent according to the programming, and the necessary action is taken. The data is tracked on both the mobile and the adafruit IO GUI at different phases.You may access Adafruit.io from any Internet-connected device because it is a cloud service. Its primary function is to store information for later retrieval.It brings together the two online services.Plus, it makes data storage practical. The dashboard function allows us to see the data in a visual format. The alert message is sent to the concerned facility supervisor using the messenger service.

Fig. 3.(a) Rollout at the first level (b). The second level of implementation

4. The Suggested Model's Machine Learning Approach:

Gathering a dataset of three sensor values Si is the next step after executing the algorithm.The sensor readings are as follows: dustbin level (DL), metal level (ML), and poisonous gas value (PG), and they are provided in a comma-separated file (csv). Using equation 2 as a guide, we may normalize these values from 0 to 1 [17].

If S is a set, then N(S) is equal to Sa(S) minus S.

two (2)

i ~ a < max

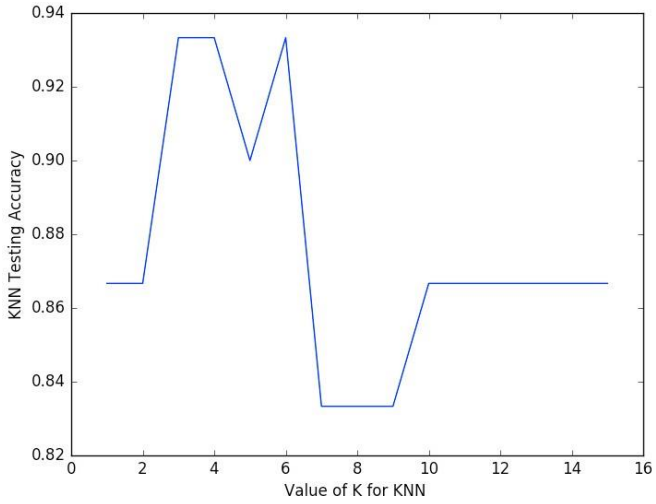
The highest predicted value of that parameter is Smax, while the actual value acquired by sensorvalue is Sa. Various service providers have the ability to establish the maximum anticipated value. An automated "decision" has been made about the transmission of weather alert messages based on combinations of N (Si). As a starting point, we'll pretend that a civilization has four trash cans, and we'll use supervised learning to determine which ones will send out warning signals. Author made "decision" prediction using K-nearest neighbor (KNN) method on training data set. The field of data mining makes use of KNN as a classification, estimation, and prediction method [20]. To forecast 'decision' straight from the training data set, the author of this research used the K-nearest neighbor (KNN) method.

The author utilized Python's sklearn or Scikit-Learn library to import csv files, and the panadas module to implement machine learning techniques like KNN classifier in the simulation environment. With Scikit-Learn, you can access a number of scientific and numerical libraries, including NumPy and SciPy, as well as a number of algorithms, such as SVM, KNN, random forest, and more. The author has used the following values for the KNN classifier's parameters [21].

Here is the code for the KNeighborsClassifier: n_jobs=1, n_neighbors=2, p=2, weights='uniform', algorithm='auto', leaf_size=30, metric='minkowski', metric_params=None.

One hundred examples of the 'Decision' class, which includes {'bleveli', 'nbleveli', pgleveli'}, make up the data set. There are 70 samples used for training and 30 samples used for testing out of a total of 100. Predicting 'decision' from the training data set is done using the KNN classifier.For a new instance A{'bleveli', 'nbleveli', 'pglevel i'}, predictions are formed by traversing the whole training set for the K examples that are most similar, known as neighbors, and then aggregating the output variable for those K instances. Only the 'n_neighbors' or 'K' parameter has been considered for comparative analysis in this study. For various values of n_neighbors (K), the KNN classifier's average accuracy has been plotted. For values of K ranging from 1 to 16, see Fig. 4. Figure 4 shows that the KNN classifier's performance is best at k=3, 4, and 6, in comparison to the other K values. Table 1 displays the data corresponding to figure 4.

K (n_neighbors)	Accuracy
1,2	0.87
3,4,6	0.93
5	0.90
7,8,9	0.83



5. Discussion and Results

The suggested model is a great machine learning tool for keeping communities clean, healthy, and well-maintained. The KNN model achieves an overall accuracy of 93.3% for K = 3, 4, and 6. Biocomposts made from municipal garbage have dual purposes: enhancing the aesthetic value of our built environment and bringing in much-needed funds through their sale. In addition to selling or collecting the separated non-biodegradable trash, the Municipal Corporation can do the same.At the societal level, the suggested framework is effective because it collects garbage, sorts it into biodegradable and non-biodegradable categories, and then uses the decomposition process to make compost. In an intelligent approach, this helps keep society clean, hygienic, and healthy. A green smart society is an asset to any city's development into a smart metropolis, and this contributes to that goal.

6. Conclusion

An ecologically sustainable and health-promoting "smart green society" is the ultimate goal of this study.In addition to tracking the concentration of toxic gasses, this model constantly checks the amount of garbage in the biodegradable and non-biodegradable trash can compartments. To notify relevant societal authorities, this model employs a machine learning approach (KNN) and achieves an accuracy rate of 93.3%. At level 1, this model separates the garbage from the recyclables and compostables. At level 2, it reduces the amount of garbage by recycling the biodegradable trash. When it comes to improving society's system for managing domestic garbage, this approach is an outstanding accomplishment.

To determine the model's appropriateness, subsequent work will involve simulating it. Instead of using a line follower to bring the trash can in and out, the suggested device might utilize GPS navigation. With the addition of additional sensors, the suggested model may be utilized in industries, public spaces, and multi-specialty hospitals to separate distinct sorts of garbage for further recycling or reusing.

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