IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# PREDICTION OF MEDICAL WASTE USING AI

[1] Dr.S.Pradeep, [2]P.Dharani, [3]S.Dinush, [4]V.JANANI, [5]R.Ashwin

[1]AP/ECE, [2] , [3], [4], [5]Final year students

[1]Electronics and Communication Engineering,

[1]SNS College of Technology, Coimbatore, *India*

***ABSTRACT***— The primary goal of the proposed system is to mitigate the impact of medical waste contamination by employing advanced deep learning techniques. Through waste management practices such as recycling and landfilling, the deconstruction of medical waste is addressed. The system's architecture utilizes the RESNET framework for feature extraction, facilitating the intelligent categorization of garbage into digestible and indigestible categories through convolutional neural networks (CNN). Transfer learning enhances the model's ability to detect specific waste categories. Performance analysis, conducted with the KNN algorithm, ensures the effectiveness of the waste classification. The system's real-time data tracking capabilities enable continuous monitoring and adaptation to evolving waste management needs. By leveraging these technologies, the proposed system not only streamlines waste sorting processes but also contributes to a more sustainable and environmentally conscious approach to medical waste management. Ongoing refinement of the model can address emerging challenges and further enhance its efficiency in handling diverse medical waste scenarios

## I.INTRODUCTION

Waste management results in the destruction of waste through landfilling and recycling. Both the Internet of Things and deep learning provide adaptable ways to track and sort data in real time. This study presents a deep learning and IoT-based trash management system architecture that is competent. The suggested technique consists of two components: the architectural layout of smart trash cans, which facilitates IoT-enabled real-time data monitoring, and the garbage sorting process utilizing convolutional neural networks. Outstanding outcomes in the area of waste management are obtained by combining two structural models. Recognizing recoverable trash is made easier by classifying wastes into appropriate groups. By learning to identify recyclables, we can save them from going to waste. When it comes to image classification, deep learning algorithms perform better than anything else. Because there is a chance that we can cut down on the utilization of recyclable parts, the authors are interested in using deep learning to sort garbage and identify recyclables. This article primarily divides waste into two categories: digestible and indigestible. We have utilized refined models to classify garbage instead of having enough data to do so. The utilization of deep learning technology for waste categorization facilitates the extraction of waste types from photographs. Trash boxes' construction allows for the use of several sensors to collect data and transmit it for monitoring.

Classification of waste

A scientific management technique for efficient garbage disposal is waste categorization. Classification facilitates the recycling and use of valuable materials while also improving trash quality. This is advantageous for landfills and incinerators as it leads to treatment that poses less of a risk to the environment and public health.


Fig.1.1. Waste Management Flow

Issues with Waste Management in Smart Cities

One of the main issues that cities deal with is trash management Fig 1.1 . In smart cities, trash management is handled by a sizable workforce of garbage workers, including recyclers, scrap dealers, and waste collectors. Garbage collectors, who make up the majority of the unorganized sector in the nation, are the most impacted segment of the waste disposal system. These garbage collectors often work in villages of 50–70 families, where every family member participates in the nationwide waste collection process. About 15–20% of the garbage in the city is managed by these waste collectors, and every member of their family works in this industry.

## II. LITERATURE SURVEY

The paper identifies the significance of medical waste management challenges and emphasizes the role of deep learning, particularly ResNeXt architecture, in addressing the urgent need for automatic detection and classification of medical waste. It reviews the evolution of convolutional neural network architectures, including AlexNet, VGG, GoogLeNet, and ResNet, highlighting their contributions to image classification tasks. The survey underscores the growing concern for environmental protection and health risks associated with improper medical waste disposal, advocating for advanced artificial intelligence solutions to enhance waste sorting and recycling[1].

Explores the challenges in global waste management and highlights the transformative role of artificial intelligence (AI). It covers practical AI applications, such as smart bins and waste-sorting robots, addressing issues from logistics optimization to treatment methods like recycling and incineration. The review underscores AI's potential for efficient, economic, and intelligent waste management, envisioning a sustainable future[2].

It assesses advancements in leveraging deep learning techniques to enhance environmental monitoring and waste management. The survey discusses challenges associated with waste detection and classification, explores the integration of convolutional neural networks (CNNs) and other deep learning architectures, and identifies emerging trends in the field. By summarizing key findings and methodologies, the paper contributes to the growing body of research aimed at optimizing waste-related processes through deep learning technologies[3].

This real-time classification and object detection model, built upon the YOLO architecture, is designed specifically for waste management applications. Lin's work addresses the growing need for efficient waste detection by leveraging advanced computer vision techniques. The YOLO-Green model is tailored for real-time performance, aligning with the contemporary trend in waste management research to enhance operational efficiency[4].

The paper addresses the need for more effective frameworks in computer vision tasks by incorporating super-class guidance, showcasing its potential impact on improving accuracy and efficiency. This contribution aligns with the broader trend in research, emphasizing the significance of incorporating higher-level information for more robust image analysis. SGNet's innovative approach signifies a step forward in advancing the capabilities of networks for both image classification and object detection, marking a valuable addition to the evolving landscape of computer vision methodologies[5].

The integration of machine learning techniques underscores the growing trend of leveraging advanced analytics for waste prediction and management. This research emphasizes the importance of tailoring predictive models to specific healthcare contexts, offering potential solutions for optimizing resources and implementing targeted waste reduction strategies in medical facilities. The paper aligns with the broader goal of enhancing sustainability in healthcare waste management through data-driven approaches[6].

The paper addresses the implementation of an intelligent machine learning model for the efficient handling and segregation of biomedical waste[7].

The paper delves into the utilization of blockchain technology to enhance the efficiency of solid waste management systems[8].

The paper addresses the establishment of sustainable solid medical waste management in general hospitals through the implementation of Enterprise Resource Planning (ERP)[9].

The paper addresses the design of an environmentally friendly non-medical waste management system for hospitals, incorporating Enterprise Resource Planning (ERP)[10].

An innovative solution for medical waste management—an ROS-based Voice Controlled Robotic Arm employing YOLOv3. The proposed system aims to enhance efficiency and precision in waste segregation processes[11].

The implementation of Enterprise Resource Planning (ERP) for the management of liquid medical waste in an Indonesian public hospital. Presented at the 2022 International Conference on Software Engineering and Information Technology in Bandung, the study likely discusses how ERP systems enhance efficiency and organization in handling liquid medical waste, providing valuable insights for healthcare waste management practices. The case study approach offers practical implications for optimizing liquid medical waste processes in hospital settings[12].

## III. EXISTING SYSTEM

To avoid the transmission of germs and the possibility of cross-contamination, it is essential that various types of medical waste be carefully separated and disposed of. But paying someone to sort that trash is just not going to happen. It is feasible to construct a Deep Learning algorithm to classify the many forms of medical waste, given the apparent prominence of deep learning in conjunction with picture classification systems. Consequently, employing a deep learning-based categorization approach that involves choosing a suitable pre-trained model for real-world application.

- Insufficient Knowledge on Waste Management

  The majority of people are unaware that improper garbage management and collection practices can contaminate the environment. It is exceedingly challenging to handle such a massive volume of garbage because of the recent fast increase in population throughout the world. We may raise awareness among the general public by holding seminars. The program is crucial because it raises awareness among the populace of a nation. In India, the majority of people are ignorant of the differences between dry and moist garbage. These individuals are primarily from shantytown regions, so they are unaware of segregation. It is crucial to provide workshops and seminars about effective waste management in order to raise awareness of cleanliness, rubbish segregation in all cities, and community issues. Raising awareness among the public would help ensure effective garbage management.

- Inaccurate categorizing municipal waste

  It may be exceedingly dangerous to improperly classify and dispose of municipal refuse. It not only has an impact on the health of people and animals, but it can also impede plant development. Appropriate municipal trash categorization, disposal, and treatment are the only options.

- The Organized Sector's Involvement in Performing Effective Waste Management

  People in that nation must participate in various garbage collecting and disposal procedures as the implementation of an effective waste management system becomes imperative. It is also evident that the rag-pickers who gather trash from various parts of cities or towns do not value recognition from the community. Thus, it's crucial to provide them with the appropriate guidance. Any nation or city may become pollution-free when all sectors engage equally in waste management.

- Lack of a Public-Private Partnership and Technical Solution

  An efficient waste management system must be implemented using new technical solutions, such as machine learning-based technology, the Internet of Things, and other cutting-edge innovations.

In this discipline, a few novel technologies may turn out to be the finest. Therefore, in order to develop this kind of system—which we discovered to be far less prevalent in the current situation—a public-private cooperation is required.

- Transportation of Waste

  The primary tool utilized to manage garbage across the nation is transportation. Trucks, tractors, as well as many other kinds of vehicles are used to transport the gathered rubbish. The majority of Indian cities lack a reliable transportation system, and those that have may still use antiquated cars that are inefficient at moving garbage. These are the issues that arise most frequently while handling trash. An optimum approach may be provided by efficient transportation, saving a significant amount of time and money.

## IV. PROPOSED METHOD

Deconstruction of garbage occurs as a result of waste management practices including recycling and landfilling. When it comes to categorization with real-time data monitoring, deep learning provides a quick fix, correspondingly. An effective deep learning-based waste management system architecture is presented in this research. The suggested approach intelligently uses convolutional neural networks (CNN), a well-liked deep learning paradigm, to distinguish between garbage that can be digested and garbage that cannot. In our proposed work we use resnet for extract features and transfer learning for classification.

The following items are categorized:

- Band-aid
- Gloves
- Mask
- Test tubes
- Glucose Bottle
- Cotton

Advantages :

- High Accuracy
- Increase the number of categories.

## V. SOFTWARE DESCRIPTION

### MATLAB:

Matrix LABoratory is the acronym for the term MATLAB. The initial intention of MATLAB was to facilitate the use of matrix programs created by the LINPACK and EISPACK initiatives. When it comes to tackling technical difficulties, MATLAB is much superior to more traditional computer languages like C and FORTRAN. An interactive environment and fourth-generation a high-level programming language for numerical computing, visualization, and programming, MATLAB stands for matrix laboratory. MathWorks is the company that created MATLAB. Matrix manipulation, function and data charting, algorithm implementation, UI design, data analysis, algorithm development, model and application construction, and interfacing using programs written in languages such as C, C++, Java, as well as FORTRAN are all possible with this language.

## VI.BLOCK DIAGRAM

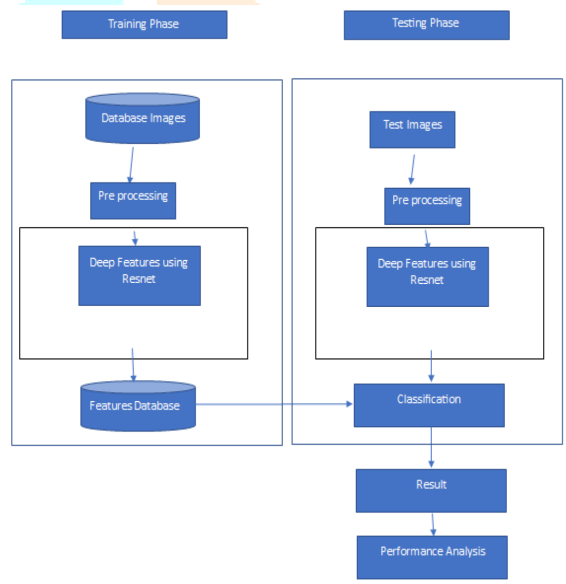


Fig.6.1. Block diagram of system

## VII.PROPOPSED METHODOLOGY

### 1. DATA ACQUSITION

Get the input dataset

### 2. PREPEOCESSING

When pictures undergo operations at the most basic level of abstraction, the goal is to improve the image data in some way—for example, by enhancing certain characteristics or suppressing unwanted distortions. This process is called image pre-processing. It has no effect on the amount of data included in images. Image redundancy is a key component of its algorithms. In real-life photographs, adjacent pixels that represent the same item often have a comparable or same brightness value. This makes it possible to recover a distorted pixel by averaging its brightness with that of its nearby pixels. It has been found via preprocessing that distinct photos of the same kind of tissue may have signal intensities scaled differently.

Operations often needed before principal data analysis and information extraction are known as preprocessing functions, and they are typically classified as either geometric corrections or radiometric corrections. In our proposed work do the image resizing.

## 3. FEATURE EXTRACTION :

Feature extraction is a step in pattern recognition, machine learning, and image processing that takes a dataset of measured data and uses it to construct informative and non-redundant derived values (features). These features then help with learning and generalization, and in some cases, they even help humans make better interpretations. One aspect of dimensionality reduction is feature extraction.

Reduced sets of features, sometimes called feature vectors, may be used when an algorithm's input data is too big and likely contains duplicate information, such as identical measurements in feet and meters or pictures shown as pixels. The process of feature selection involves deciding which of the original features to use. In order to accomplish the intended job utilizing this shortened representation rather than the whole starting data, it is assumed that the chosen features will include what is needed from the input data.

Feature extraction is a step in pattern recognition, machine learning, and image processing that takes a dataset of measured data and uses it to construct informative and non-redundant derived values (features). These features then help with learning and generalization, and in some cases, they even help humans make better interpretations. One aspect of dimensionality reduction is feature extraction.

Reduced sets of features, sometimes called feature vectors, may be used when an algorithm's input data is too big and likely contains duplicate information, such as identical measurements in feet and meters or pictures shown as pixels. The process of feature selection involves deciding which of the original features to use. In order to accomplish the intended job using this reduced representations instead of the whole starting data, it is assumed that the chosen features will include the essential information from the input data.Using residual architecture, we extract features in this.

An effective machine learning paradigm called "transfer learning" takes use of prior knowledge to enhance performance on a related but distinct job. The use of transfer learning may help address issues with sparsely labeled datasets in the context of artificial intelligence-based medical waste prediction. The feature extractors may make good use of the pre-trained models, which are often trained on big and varied datasets. Models may be fine-tuned to the intricacies of medical waste prediction by applying the general information gained from the larger domain to a smaller dataset that is dedicated to this purpose.

When gathering large amounts of labeled data for a particular job is not feasible, transfer learning may speed up training and improve models' prediction capabilities.

Medical waste prediction aims to maximize model accuracy, which is of utmost importance, and the transferability of information from one domain to another is in line with these objectives. Implementation success depends on meticulous planning of model architecture, selection of pre-trained models, and domain adaption methods. Adaptable models that can handle the intricacies of healthcare waste management are becoming more important in the field of medical waste prediction, and transfer learning Fig.7.1 is showing great promise as a tool for this process.

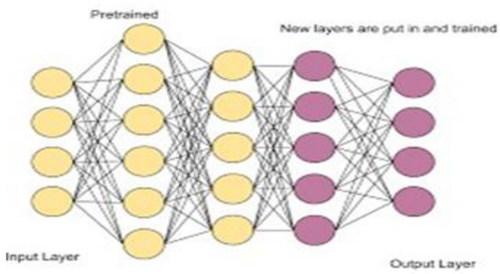


Fig. 7.1. Transfer learning

**Residual Network:**

A method known as skip connections is used in this network. The skip connection bypasses certain levels in between to link activations of one layer to subsequent ones. A residual block Fig.7.2 is formed by this. A resnet is constructed by stacking these blocks of residuals.

We let the network fit the remaining mapping as its strategy, rather than having layers learn the underlying mapping. Therefore, allowing the network to fit, rather than stating H(x), initial mapping,

F(x) := H(x) - x which gives H(x) := F(x) + x.

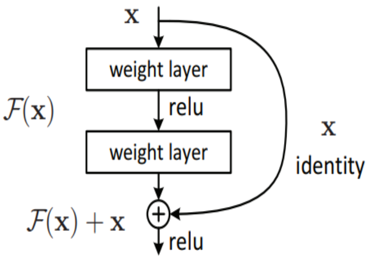


Fig.7.2. Residual network

**Skip (Shortcut) connection:**

Including this kind of skip connection has the benefit of allowing regularization to bypass any layer that degrades the architecture's speed. As a consequence, a deep neural network may be trained without the issues caused by disappearing or explosion gradient.  A related method is known as "highway networks," and it too makes use of skip connection. These skip connections use parametric gates in a manner similar to LSTM. The amount of data that may traverse the skip connection is controlled by these gates. To yet, nonetheless, this design has not outperformed ResNet in terms of accuracy.

**Deep Neural Networks in Computer Vision:**

Experts in machine learning often overlay additional layers on top of convolutional neural networks with deep learning when tackling computer vision problems. These supplementary layers allow for the efficient solution of complicated problems by allowing the individual layers to be trained for specific tasks, resulting in extremely accurate predictions. While increasing the stacking depth may improve the model's characteristics, a deeper network might reveal the deterioration problem. Put simply, there may be a saturation point at which the accuracy levels begin to gradually decline in relation to the total number of layers in the neural network. The model's performance in both the testing and training phases suffers because of this. Overfitting is not to blame for this decline. Problems with optimization functions, disappearing or ballooning gradients, or even network setup might be the blame.

**Deep Residual Learning:**

This same situation inspired the creation of ResNet. To enhance the models' accuracy, deep residual nets use residual blocks. The key feature of this neural network type is the idea of "skip connections," which is crucial to the residual blocks.

**Skip Connections in ResNet:**

There are two ways these skip connections function. To start with, they fix the disappearing gradient problem by creating a new path for the changing gradient to take. They also make it possible for the model to pick up on an identity function. This checks that the model's upper layers aren't underperforming relative to their lower counterparts. To sum up, the layers learn identity functions much more easily with the help of the residual blocks. Consequently, ResNet maximizes efficiency and minimizes error percentage in deep neural networks that include more neural layers. To rephrase, training deeper networks is now feasible thanks to skip connections, which combine the outputs of earlier layers with those of stacked layers..

Advantages:

- The training error % remains constant even when training networks with hundreds or thousands of layers. The vanishing gradient issue may be effectively addressed with the use of ResNets and identity mapping.
- They're useful for keeping the network's error rate low at higher levels.
- One benefit of using this kind of skip link is that regularization will bypass any layer that degrades the architecture's speed.

## 4. CLASSIFICATION

Both organized and unstructured data may be used for classification. The process of classifying data into a predetermined number of groups is known as classification. Finding the correct category or class for fresh data is the primary objective of any classification challenge. categorization is a method of supervised learning in statistics and machine learning whereby a computer program learns to categorize new observations based on its previous learning from the data input. In certain cases, such as when determining whether an email is spam or not, the data set may only include two classes; in others, it may have more than two classes. Recognition of spoken language, handwriting, biometric data, documents, etc., are all instances of categorization issues. Although humans find item classification to be a simple activity, robots have found it to be an incredibly challenging challenge. Object classification algorithms have recently attracted a lot of attention because to the proliferation of powerful computers, the accessibility of affordable, high-quality video cameras, and the growing need for automated video analysis. One basic categorization method uses a camera mounted far above the target area to take pictures, which are then analyzed. identifying objects, object segmentation, feature extraction, object classification, picture preprocessing, and image sensors are all components of classification. In order to properly categorize objects, a classification system compares them to a database that has predetermined patterns. Classifying images is a difficult but crucial work in many different fields, such as remote sensing, industrial visual inspection, robotic navigation, vehicle navigation, biomedical imaging, video surveillance, and biometry.

In order to classify data, image classification examines the numerical qualities of different picture features. The two main processing steps used by classification algorithms are training and testing. During the first round of training, we identify the most important qualities of common picture features and use them to build a one-of-a-kind description of each categorization class. These features-space partitions are used for feature classification in the testing phase that follows.

The goal of classification in statistics and machine learning is to assign new observations to one of many preexisting subpopulations based on the characteristics of existing observations in the training set of data. Sorting emails into "spam" as well as "non-spam" categories is one example; another is making a diagnosis for a patient based on their physical symptoms, gender, blood pressure, and other relevant demographic information. Pattern recognition applications include classification. Classification, in machine learning parlance, is an example of supervised learning, the process of learning with access to a training set of properly recognized observations. Clustering is the equivalent unsupervised technique; it entails dividing data into groups according to their degree of intrinsic similarity or distance.

Variables or traits that may be measured and used to explain the data are often derived from the individual observations. The attributes in question might be of several types: categorical (like "A", "B", "AB" nor "O" for blood type), ordinal (like "large", "medium" nor "small"), integer-valued (like the frequency of a certain term in an email) nor real-valued (like a blood pressure reading). Similarity or distance functions are used by other classifiers to compare new data to old ones. A classifier is an algorithm that uses classification, often in a more practical sense. The mathematical function that assigns a category to incoming data is frequently also referred to as a "classifier" when discussing classification algorithms.

One basic categorization method uses a camera mounted far above the target area to take pictures, which are then analyzed. Recognition of objects, object segmentation, feature extraction, object classification, picture preprocessing, and image sensors are all components of classification. In order to properly categorize objects, a classification system compares them to a database that has predetermined patterns. Classifying images is a difficult but crucial work in many different fields, such as remote sensing, industrial visual inspection, robotic navigation, vehicle navigation, biomedical imaging, video surveillance, and biometry.

A thorough understanding of the connection among the data as well as the classifications it is categorized into is necessary for data classification. The computer needs training in order to do this task automatically.

- The development of classification techniques originated in the field of pattern recognition.
- Computer categorization of images captured remotely entails the program's learning the connection among the data as well as the information classes.
- Training is crucial to the achievement of classification.
- Aspects of learning methods and feature sets that are crucial for precise categorization

Features are characteristics of data pieces that are used to categorize them. Knowing this, we can determine how many classes there are and which pixels will serve as prototypes for each class.

**Role of Image Classifier:**

1) Function of the image classifier is discrimination, or the practice of favoring one set of data over another.
2) Maximum discriminant value for a single class, decreasing for all other classes combined (multiclass).
3) One class has a positive discriminant value while the other class has a negative one (two class).

There are two parts to every classification:

(1) Training

(2) Testing.

The K-nearest neighbour (KNN) technique is a transfer learning approach that we employ for classification.

One of the most popular artificial intelligence algorithms used for medical waste prediction is K-Nearest Neighbors (KNN). Here, KNN is useful because it uses the agreement of nearby instances in the feature space to decide whether a medical waste instance should be classified or regressioned. Using similarities between distinct cases in the dataset, KNN fig 4.5 may be used to medical waste management to forecast waste types or volumes. In cases when the connections in the medical waste data are adequately represented by the closeness of comparable instances, the algorithm's accessibility is enhanced by its simplicity and convenience of implementation.

While doing so, it is essential to think about things like picking the right distance measure and finding the sweet spot for 'k,' the number of closest neighbors studied. Tuning the algorithm meticulously is necessary to get the best possible predicted accuracy, since its performance could be affected by various characteristics. In conclusion, KNN is a powerful tool for medical waste prediction because it offers an easy-to-understand method for finding patterns and extrapolating from the features of nearby cases in the feature space.

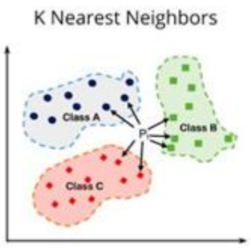


Fig.7.3. KNN

K-Nearest Neighbors (KNN) provides a simple and understandable method for predicting medical waste. Part of its power comes from the fact that it uses proximity-based decision-making, which means that the features of nearby instances have an impact on the forecast for a specific medical waste case. When there are localized patterns and correlations in the underlying structure of medical waste data, KNN Fig 4.4 becomes very effective. Nevertheless, its efficacy may be affected by the dimensionality of the feature space, therefore picking the right distance measure and optimum value for 'k' requires considerable thought. With its clear and easy-to-understand technique, KNN is a great tool for predictive modeling in medical waste management scenarios that focus on local pattern analysis for correct classification or regression.

## VIII. RESULT

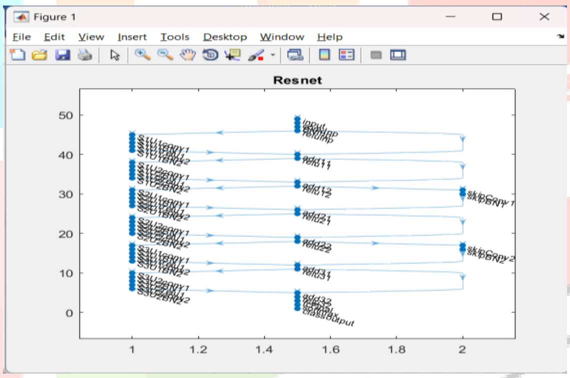


Fig.8.1 Resnet analysing

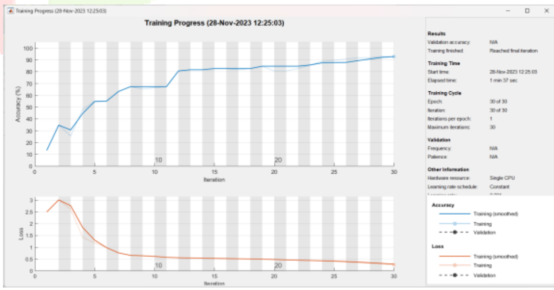

Fig.8.2.Training phase


Fig.8.3.Feature extraction

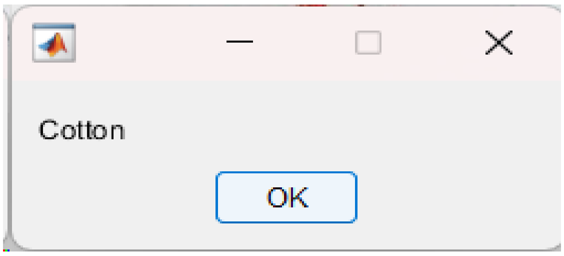


Fig.8.4.Expected output

The algorithm begins with the collection and preprocessing of a labeled dataset of garbage images. Utilizing the Fig.8.1 RESNET50 pre-trained model, features are extracted from these images. Next, the dataset is divided into testing and training sets.. A transfer learning model, incorporating the RESNET features, is built and trained for waste category detection. The model's performance is evaluated using metrics such as accuracy on the testing data.

In real-time, the trained model Fig.8.2 is employed for garbage categorization. Simultaneously, a KNN algorithm is applied for performance analysis. Features extracted Fig.8.3 by RESNET are flattened, and a KNN classifier is trained on the flattened training data. The classifier predicts waste categories Fig.8.4 for the flattened testing data, and its accuracy is evaluated. The final step involves printing the accuracy of both the transfer learning model and the KNN algorithm, providing a comprehensive assessment of the garbage categorization system. Fine-tuning and adjustments can be made to cater to specific project requirements, including hyperparameter tuning and addressing class imbalances.

## IX.CONCLUSION

This allowed the system to effectively sort medical waste as it was disposed of separately. This concept makes it easy to recover recyclable materials and may be utilized for household uses. Consequently, the goal of this study is to sort medical waste using machine learning as well as image processing.

## X. REFERENCES

[1] A deep learning approach for medical waste classification Haiying Zhou, XiangyuYu, AhmadAlhaskawi, Yanzhao Dong, Vishnu Goutham Kota Scientific.Reports volume 12, Article number: 2159 (2022)

[2] Artifcial intelligence for waste management in smart cities: a review Bingbing Fang1 · Jiacheng Yu1 · Zhonghao Chen1 · Ahmed I. Osman2 · Mohamed Farghali3,4 · Ikko Ihara3 · Essam H. Hamza5 · David W. Rooney2 · Pow Seng Yap1 Springer Received: 15 April 2023 / Accepted: 24 April 2023 / Published online: 9 May 2023

[3] A Survey on Waste Detection and Classification Using Deep Learning Haruna Abdu; Mohd Halim Mohd Noor IEEE Access ( Volume: 10) 05 December 2022

[4] In the 2021 IEEE International Conference on Big Data (Big Data), Orlando, FL, USA, W. Lin, "YOLO-

Green: A Real-Time Classification and Object Detection Model Optimized for Waste Management," pp. 51-57, doi: 10.1109/BigData52589.2021.9671821.

[5] SGNet: A Super-class Guided Network for Image Classification and Object Detection Kaidong Li; Nina Y. Wang; Yiju Yang; Guanghui Wang 2021 18th Conference on Robots and Vision (CRV)

[6] Predicting the amount of medical waste using kernel-based SVM and deep learning methods for a private hospital in Turkey panel Fatma Gül Altin , İbrahim Budak , Fatma Ozcan Science direct Volume 33, June 2023

[7] B. Gupta, P. Sreelatha, M. Shanmathi, J. Philip Bhimavarapu, P. John Augustine and K. Sathyarajasekaran, "A Smart Handling of Bio-Medical Waste and its Segregation with Intelligant Machine Learning Model," 2023 International Conference on Disruptive Technologies (ICDT), Greater Noida, India, 2023, pp. 73-78, doi: 10.1109/ICDT57929.2023.10150547.

[8] O. J. Oyebode, S. Chhabra, G. Thakur, N. D, W. K. Ibrahim and M. B. Alazzam, "Improvement of Solid Waste Management by Using Blockchain Technology," 2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), Greater Noida, India, 2023, pp. 621-625, doi: 10.1109/ICACITE57410.2023.10182424.

[9] "Developing Sustainable Solid Medical Waste Management Based on Enterprise Resource Planning in General Hospital," by I. P. Dharma Yudha, A. Y. Ridwan, and L. Septianingrum, papers presented at the 10th International Conference on Information and Communication Technology , 2022, Bandung, Indonesia, pp. 140–145, doi: 10.1109/ICoICT55009.2022.9914904.

[10] A. Fitriani, A. Y. Ridwan and L. Septiningrum, "Designing Green Hospital Non-Medical Waste Management System Based on ERP," 2022 International Conference on Data Science and Its Applications (ICoDSA), Bandung, Indonesia, 2022, pp. 137-142, doi: 10.1109/ICoDSA55874.2022.9862867.

[11] S. Tasnim, M. Z. Hasan, T. Ahmed, M. T. Hasan, F. J. Uddin and T. Farah, "A ROS-based Voice Controlled Robotic Arm for Automatic Segregation of Medical Waste Using YOLOv3," 2022 2nd International Conference on Computer, Control and Robotics (ICCCR), Shanghai, China, 2022, pp. 81-85, doi: 10.1109/ICCCR54399.2022.9790152.

[12] D. Fitriani, A. Y. Ridwan, L. Septiningrum and K. P. Kusumahstuti, "Liquid Medical Waste Management Based on ERP: The Case of An Indonesian Public Hospital," 2022 1st International Conference on Software Engineering and Information Technology (ICoSEIT), Bandung, Indonesia, 2022, pp. 138-143, doi: 10.1109/ICoSEIT55604.2022.10030057.

[13]Shah, K. B., Visalakshi, S., Khatri, K. C., and Panigrahi, R., "Current scenarios, obstacles, possibilities, and innovations for sustainable municipal solid waste management following COVID-19 pandemic in Kathmandu valley, Nepal," in Second International Conference on Computer Science, Engineering and Applications (ICCSEA), 2022, Gunupur, India, pp. 1-6, doi: 10.1109/ICCSEA54677.2022.9936305.

[14] H. M. M. Rashid, S. R. M. Yatim, S. Abdullah, M. Y. A. F. Pejabat, I. A. Nazim and Z. Ahmad, "Forecasting Medical Waste Generation In Hospital Taiping, Perak Using Nonlinear Autoregressive (NAR) Neural Network Method," 2022 3rd International Conference on Artificial Intelligence and Data Sciences (AiDAS), IPOH, Malaysia, 2022, pp. 243-247, doi: 10.1109/AiDAS56890.2022.9918794.

[15]In 2022, Paramita, A. Y. Ridwan, and L. Septiningrum presented a case study at the 9th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE) in Semarang, Indonesia. The paper, "Developing Radioactive Medical Waste Management System of Nuclear Medicine Units Using Open-Source Enterprise Resource Planning: Case Study in Indonesian Public Hospital," was published. doi: 10.1109/ICITACEE55701.2022.9924140.

[16] K. Wang and W. Nai, "Application of 5G Wireless Communication Technology in Hazardous Medical Waste Treatment," 2021 IEEE International Conference on Software Engineering and Artificial Intelligence (SEAI), Xiamen, China, 2021, pp. 87-90, doi: 10.1109/SEAI52285.2021.9477538.

[17] "IOT Monitoring System of Medical Waste Based on Artificial Intelligence," C. Wang, Y. Ma, and G. Zhong, 7th Annual International Conference on Network and Information Systems for Computers (ICNISC), Guiyang, China, 2021, pp. 139-143, doi: 10.1109/ICNISC54316.2021.00034.

[18] Z. S. Mazhandu, M. Belaid, T. Nhubu and E. Muzenda, "Potential Impact of the Covid-19 Pandemic on Plastic Medical Waste Management in South Africa: A Narrative Review," 2021 9th International Renewable and Sustainable Energy Conference (IRSEC), Morocco, 2021, pp. 1-8, doi: 10.1109/IRSEC53969.2021.9740733.

[19]"Waste to energy: Recovery of alternative energy source from thermal pyrolysis of medical waste in Khartoum, Sudan," 2020 International Conference on Computer, Control, Electrical and Electronics Engineering (ICCCEEE), Khartoum, Sudan, 2021, pp. 1-5, doi: 10.1109/ICCCEEE49695.2021.9429575, were written by M. E. H. M. Ahmed, S. A. T. Muawad, A. K. A. Ahmed, and A. A. A. Abuelnuor.

[20]X. Wang, C. Wang and H. Jia, "Research on Source Monitoring System of Medical Waste Recycling Smart Device," 2021 7th Annual International Conference on Network and Information Systems for Computers (ICNISC), Guiyang, China, 2021, pp. 315-320, doi: 10.1109/ICNISC54316.2021.00063.