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Computer Vision Based Automatic Medical Waste Classification Using Machine Learning

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ABSTRACT: We know demand for health facilities are growing day by day. In this last two years because of CORONA COVID 19 pandemic importance of medical field is also get increased. Usages of medicine, masks, biomedical chemicals, and medical equipment's also get increased. But ultimately at the end of day we are using this all facilities and creating too much biomedical west. As we know this biomedical west is very dangerous to the atmosphere and it not get decomposed properly. Collecting this biomedical west by using manual operation can contaminate labours with dangerous diseases. As we know COVID19 is infectious disease, if we come closer to this biomedical west which is generated during COVID 19 patients' treatment. Then the risk of getting contaminated by this virous is high. To eliminate this type of risks we have to identify biomedical west in first step where human intervention is not necessary. To solve this problem, computer vision based automatic medical waste classification using machine learning and deep learning approach. Thus, this system aims to eliminate the need for manual Labouré to segregate hazardous medical waste and avoids harmful exposure to contaminated waste.

KEYWORDS: Medical Waste, Computer Vision, Machine Learning, Deep Learning, Waste Classification, image processing, CNN.

I. INTRODUCTION

As the demand for health grows, the increase in medical waste generation is gradually outstripping the load. Proper disposal of medical waste is of utmost importance as hospitals and medical centres across the globe are producers of extremely dangerous waste materials. To solve this problem, computer vision based automatic medical waste classification using machine learning and deep learning approach. Thus, this system aims to eliminate the need for manual labour to segregate hazardous medical waste and avoids harmful exposure to contaminated waste. At present, country has comprehensively carried out garbage classification. The garbage classification plays a very important rolein garbage recycling. However, many residents lack classification knowledge and lack of classification awareness. The classification effect is not significant. If not classified, it will not only cause waste of reusable resources, and for hazardous waste such as biomedical west, if not properly handled, it will cause environmental pollution and endanger people's health. In the early days, manual sorting or sensors were often used for identification. Later, it was proposed to identify images based on existing models and then complete garbage classification through pre-completed labels or recollect data sets to train a new garbage classification model. For existing models, the recognition results of the same kind of objects may be different, and the classification method is also different from garbage classification. In practical applications, most of the data does not have labels. Labelling data and building a complete model for classification are required with a lot of time and workload. Image classification has very high requirements on data set and model performance. These two methods not only take a lot of time, but also have low accuracy. An electronic copy can be downloaded from the website. Medical waste (MW) refers to directly or indirectly infectious, toxic, or otherwisehazardous waste generated by medical institutions during medical or preventative care and related activities, and specifically includes infectious, pathological, damaging, pharmaceutical, and chemical waste1. These wastes contain a large number of bacteria and viruses, and have the potential to cause space pollution, acute viral infection, and latent infection.

If they are not properly managed, they can contaminate the surrounding environment, where they pollute the land, water, plants, animals, and air, causing the spread of disease. MW also poses a great threat to the physical and mentalhealth and the quality of life of medical staff and patients3. Currently, MW in China is generally collected and processed centrally by a unified acquisition department, and faces challenges such as inadequate use of waste bins, lackof detailed classification of medical waste or even stacking randomly, and insufficient training of waste classification personnel4. High expenses are also one of the reasons for improper disposal of medical waste. Because moreprocessing costs have to be paid to external agencies, the cost of medical waste disposal for hospitals has risen accordingly. The increase in expenditure has caused hospitals to deploy waste disposal facilities and human resources more casually, and in turn, hospitals' medical waste disposal has steeply declined in quality, which greatly increases the potential for medical waste to contaminate the environment and harm the associated staffs, while reducing the chancesof its recycling. In the new edition of the National Hazardous Waste List, which was implemented on August 1, 2016 in China, clinical medical waste is regarded as No. 1 Hazardous substance. For disposable medical supplies and drugpackaging, non-infectious waste should be disposed of as domestic waste. For disposable syringe nipples and transfusion pipes, waste should be disposed of harmlessly before discarding. For disposable syringes, transfusion needles, blood collection needles and other blood-contaminated waste, in order to prevent medical personnel from occupational exposure and infection must be directly put into instrument collection box. However, this classification method cannot distinguish between recyclable and non-recyclable medical waste, and still involves manual sorting. Therefore, medical personnel involved in sorting cannot completely avoid the risk of virus infection. In recent years, in order to solve the problem of secondary infection of medical waste virus, the government has started to focus on the study of automatic waste classification system. In 2016, Abhimanyu Singh and his team proposed a waste collection system based on infrared sensors, which collects real-time waste data through infrared sensors and transmits theinformation to waste managers in real time so that waste managers can effectively use the information to optimize the collection process. This method optimizes the waste treatment process to a certain extent, but it cannot accuratelyclassify waste. It can only identify the types of waste by the parameters of waste volume, cross-sectional area and transmittance. In 2018, Misra and his team proposed an intelligent waste bin based on ultrasonic liquid level sensorsand various gas sensors to automatically detect harmful gases and wastes to the maximum extent, and combined with the Internet of Things technology to achieve a mobile platform for comprehensive monitoring of waste volume and odour. This method improves the process of waste disposal through olfactory detection, but it cannot classify the types of waste accurately. Most of the global waste classification systems only can classify domestic waste, and there is nosolution for medical waste that needs to be classified and treated immediately because of the risk of virus infection. Even now, in numerous parts of India, garbage segregation is done by rag pickers. This can prove to be extremely harmful as medical waste is a carrier of infectious germs and radioactive substances which can gravely harm a person's life and in some cases, it could also be the reason for the spread of infectious diseases. In a country like India, due to the fact that a large amount of our population cannot afford proper treatment at well-equipped private hospitals, the majority of the medical facilities are government organizations and are usually incapable of according industrialized automatic garbage segregation machines and often employ manual labour for this job.Machine Learning (ML) refers to a significant function of Artificial Intelligent (AI) that allows a system the ability to learn and make the decision automatically without being explicitly instructed. Machine learning is a scientific study of some statistical models and algorithms. Due to offering the most exceptional features in computing, the popularity of ML has reached the highest peak. According to recent statistics by Tactical shows that the market growth of ML and AI-based technology was $1.4 billion in 2016, and the growth will be increased $59.8 billion by the year 2025. These statistics clearly show the popularity of ML-based applications. Similarly, deep learning is an essential part of machine learning.

Limitations of existing system

Nowadays, clinical medical waste is regarded as No. 1 Hazardous substance. For disposable medical supplies and drug packaging, non-infectious waste should be disposed of as domestic waste. For disposable syringe nipples and transfusion pipes, waste should be disposed of harmlessly before discarding. For disposable syringes, transfusion needles, blood collection

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needles and other blood-contaminated waste, in order to prevent medical personnel from occupational exposure and infection must be directly put into instrument collection box. However, this classification method cannot distinguish between recyclable and non-recyclable medical waste, and still involves manual sorting. Therefore, medical personnel involved in sorting cannot completely avoid the risk of virus infection. In recent years, in order to solve the problem of secondary infection of medical waste virus, various researchers have implemented automatic waste classification system. The most of the authors detect the waste based on sensors, but it is unable to detect the waste properly, its classified into dry and wet. Also, some authors have implemented waste classification based on general waste or specific medical waste into particular items. So, considering these limitations, we will implement automatic classification of medical waste-based machine learning which effectively classify the waste into several types or degradable or non-degradable.

BASIC BLOCK DIAGRAM FOR MAXIMUM BIOMEDICAL WEST CLASSIFICATION AND IDENTIFICATION

The proposed system architecture of automatic classification of waste is as shown in figure. 1

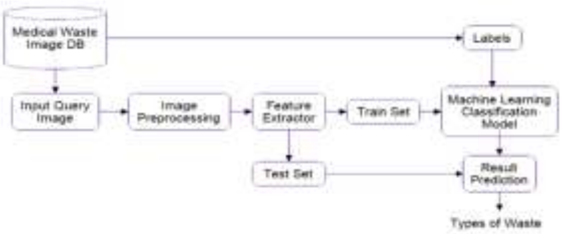

Figure 1: Proposed Block Diagram

Medical Waste Image DB

We are applying our methodology to standard benchmark image database, publicly available dataset, is applied and observed under several aspects. The dataset has a collection of several medical waste images. For experimental evaluation, we will split the dataset into 70-30% ratio for training and testing set of images.

Image Pre-processing

The input images are provided as input to the presented model. In the initial stage, the pre-processing takes place by the use of image resizing as per the size of trained model.

Feature Extraction

At the next stage, a collection of important features gets extracted from the segmented image using pre-trained deep learning model. The pre-trained deep learning model that used is Resnet101 which is based on a convolutional neural network that is 101 layers deep. We chose this model because of its high classification performance.

Classification

Then, the classification of images carried out using machine learning classification model which finally provides the output as classified image into types of medical waste or degradable or non-degradable waste. In our case, we use random forest classifier. Training and testing of computer aided diagnosis models for classifying medical waste performed in proposed approach. The process of extracting features takes place using image processing and classifier operation is carried out utilizing machine learning which helps to develop the trained prediction approaches from the filtered features in an easier way and rapid way.

Various approaches mainly categorized into two phases: Training and Testing. First, retinal fundus image dataset needs to split for two phases in 70-30% ratio of total dataset in train and test image set. In training phase, first train image set need to be processed before feature extraction in which noise removal, image enhancement and image resizing operation is carried out. In feature extraction we are going to extract the low level to high level features using automated feature extraction technique using pre-trained deep convolutional neural network. Later input and output data is collected as feature dataset from train image set and labels from its equivalent train image set respectively. Same data is given to train and validate the machine learning model, in which we have used classifier. After successful validation, we save the trained model. In testing phase, test image set need to apply same operation up to feature extraction as in training phase. After getting test feature set, we load the trained model and predict the results of medical waste image.

Aim

The main aim of the proposed system is to classify the medical waste using computer vision and machine learning approach.

Objectives

- To study the various techniques related to medical waste classification and related technologies.

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- To develop an intelligent model to classify bio waste and non-bio waste through image classification using deep learning.
- To simulate the proposed model using MATLAB software with machine learning and image processing toolbox.
- To evaluate and compare the performance of proposed models in terms of accuracy.

II. LITARATURE REVIEW

Related Work

H. Abdu et.al. survey contributes by reviewing various image classification and object detection models, and their applications in waste detection and classification problems, providing an analysis of waste detection and classification techniques with precise and organized representation and compiling over twenty benchmarked trash datasets. Also, we backed up the study with the challenges of existing methods and the future potential in this field. This will give researchers in this area a solid background and knowledge of the state-of-the-art deep learning models and insight into the research areas that can still be explored.

Xia W et.al. summarizes the application of ML algorithms in the whole process of MSWM, from waste generation to collection and transportation, to final disposal. Through this comprehensive review, the gaps and future directions of ML application in MSWM are discussed, providing theoretical and practical guidance for follow-up related research.

Md. Wahidur Rahman et.al. proposed architecture of the waste management system based on deep learning and IoT. The proposed model renders an astute way to sort digestible and indigestible waste using a convolutional neuralnetwork (CNN), a popular deep learning paradigm. The scheme also introduces an architectural design of a smart trash bin that utilizes a microcontroller with multiple sensors. The proposed method employs IoT and Bluetooth connectivityfor data monitoring. IoT enables control of real-time data from anywhere while Bluetooth aids short-range data monitoring through an android application.

Yinghao Chu et.al. proposes a multilayer hybrid deep-learning system (MHS) to automatically sort waste disposed of by individuals in the urban public area. This system deploys a high-resolution camera to capture waste image andsensors to detect other useful feature information. The MHS uses a CNN-based algorithm to extract image features and a multilayer perceptron's (MLP) method to consolidate image features and other feature information to classify wastesas recyclable or the others. The MHS is trained and validated against the manually labelled items, achieving overall classification accuracy higher than 90% under two different testing scenarios, which significantly outperforms a reference CNN-based method relying on image-only inputs.

Haiying Zhou et.al. propose a deep learning approach for identification and classification of medical waste. Deep learning is currently the most popular technique in image classification, but its need for large amounts of data limits itsusage. In this scenario, we propose a deep learning-based classification method, in which ResNet is a suitable deep neural network for practical implementation, followed by transfer learning methods to improve classification results.We pay special attention to the problem of medical waste classification, which needs to be solved urgently in the current environmental protection context. We applied the technique to 3480 images and succeeded in correctly identifying 8 kinds of medical waste with an accuracy of 97.2%; the average F1-score of five-fold cross-validation was 97.2%. This study provided a deep learning-based method for automatic detection and classification of 8 kinds of medical waste with high accuracy and average precision.

X. Bian et.al. designed a medical waste automatic identification and classification system, which adopt technology of machine vision and deep learning algorithm. The system firstly detects and locates medical waste by cross-platform computer vision library (Open CV), then applies SSD-Mobile Net model to train and classify medical waste. The existing background subtraction algorithm and SSD-Mobile Net model structure are improved. Examples of haemostatic forceps, gloves, infusion bags and syringes are tested. Experimental results show that recognition accuracy of medical waste classification system is more than 98.5%, and average recognition time is 52 milliseconds, and the system has strong robustness. The application of the proposed method in actual medical waste classification is of great significance in reducing manual input and reducing the risk of virus infection for medical personnel involved in sorting.

J. Chen et.al. propose a system named I WASTE to detect and classify medical waste based on videos recorded by a camera-equipped waste container. In this pilot study, we collected a video dataset of 4 waste items (gloves, hairnet, mask, and shoe cover) and designed a motion detection based pre-processing method to extract and trim useful frames. We propose a novel architecture named

R3D+C2D to classify waste videos by combining features learnt by 2D convolutional and 3D convolutional neural networks. The proposed method obtained a promising result (79.99% accuracy) on our challenging dataset. Clinical Relevance—I Waste enables consistent and effective real-time monitoring of solid waste generation in operating rooms, which can be used to enforce medical waste sorting policiesand to identify waste reduction strategies.

Guo, D. et.al. applied the ResNet-50 convolutional neural network based on the transfer learning method to design the image classifier to obtain the domestic refuse classification with high accuracy. By comparing the method designed inthis paper with back propagation neural network and convolutional neural network, it is concluded that the CNN based on transfer learning method applied in this paper with higher accuracy rate and lower false detection rate. Further, underthe shortage situation of data samples, the method with transfer learning and ResNet-50 training model is effective to improve the accuracy of image classification.

A. Sharma et.al. proposed Architecture for Waste Management in Indian Smart Cities (AWMINS). This uses smart bins for garbage classification and collection. The smart bins are fitted with sensors and other necessary hardware equipment. These are then integrated with the IoT environment for efficient waste management thereby reducing the wastage of the city's resources.

Ninad Mehendaleet.al. aimed to build an automatic computer vision based medical waste separator that detects the presence of medical waste and categorizes them into one of the four categories namely gloves, mask, syringe andcotton. This embedded system uses transfer learning on the AlexNet deep learning network to train a model which classifies medical waste. The hardware set up is designed to detect the movement of the lid of the input bin and thencapture an image of the waste object dropped into the bin. This image is then fed to our trained model which classifies the object with a 86.17\% validation accuracy. Once the model classifies it, the waste object is dropped into the correct bin with the help of servo motors. This embedded system has been tested with different types of gloves, mask, syringe and cotton samples and presents a convenient way to segregate medical waste successfully. Thus, this system aims to eliminate the need for manual labour to segregate hazardous medical waste and avoids harmful exposure to contaminated waste.

S M Cheena et.al. propose a real-time smart waste management and classification mechanism using a cutting-edge approach (SWMACM-CA). It uses the Internet of Things (IoT), deep learning (DL), and cutting-edge techniques to classify and segregate waste items in a dump area. Moreover, we propose a waste grid segmentation mechanism, which maps the pile at the waste yard into grid-like segments. A camera captures the waste yard image and sends it to an edgenode to create a waste grid. The grid cell image segments act as a test image for trained deep learning, which can make a particular waste item prediction. The deep-learning algorithm used for this specific project is Visual Geometry Groupwith 16 layers (VGG16). The model is trained on a cloud server deployed at the edge node to minimize overall latency. By adopting hybrid and decentralized computing models, we can reduce the delay factor and efficiently use computational resources. The overall accuracy of the trained algorithm is over 90%, which is quite effective. Therefore, our proposed (SWMACM-CA) system provides more accurate results than existing state-of-the-art solutions, which isthe core objective of this work.

Feature Extraction – Resnet 101

ResNet-101 is a convolutional neural network that is 101 layers deep. A residual neural network (ResNet) is an artificial neural network (ANN) of a kind that builds on constructs known from pyramidal cells in the cerebral cortex. Residual neural networks do this by utilizing skip connections, or shortcuts to jump over some layers. Typical ResNet models are implemented with double- or triple- layer skips that contain nonlinearities (ReLU) and batch normalization in between. An additional weight matrix may be used to learn the skip weights; these models are known as Highway Nets. Models with several parallel skips are referred to as Dense Nets. In the context of residual neural networks, a non-residual network may be described as a plain network. A reconstruction of a pyramidal cell. Soma and dendrites are labeled in red, axon arbor in blue. (1) Soma, (2) Basal dendrite, (3) Apical dendrite, (4) Axon, (5) Collateral axon.There are two main reasons to add skip connections: to avoid the problem of vanishing gradients, or to mitigate the Degradation (accuracy saturation) problem; where adding more layers to a suitably deep model leads to higher training error.During training, the weights adapt to mute the upstream layer [clarification needed], and amplify the previously-skipped layer. In the simplest case, only the weights for the adjacent layer's connection are adapted, with no explicit weights for the upstream layer. This works best when a single nonlinear layer is stepped over,

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or when the intermediate layers are all linear. If not, then an explicit weight matrix should be learned for the skipped connection (a Highway Net should be used).

You can load a pretrained version of the network trained on more than a million images from the ImageNet database. The pretrained network can classify images into 1000 object categories, such as keyboard, mouse, pencil, and many animals. As a result, the network has learned rich feature representations for a wide range of images. The network has an image input size of 224-by-224. For more pretrained networks.

Need for ResNet

Mostly in order to solve a complex problem, we stack some additional layers in the Deep Neural Networks which results in improved accuracy and performance. The intuition behind adding more layers is that these layers progressively learn more complex features. For example, in case of recognising images, the first layer may learn to detect edges, the second layer may learn to identify textures and similarly the third layer can learn to detect objects and so on. But it has been found that there is a maximum threshold for depth with the traditional Convolutional neural network model. Here is a plot that describes error% on training and testing data for a 20-layer Network and 56 layers Network.

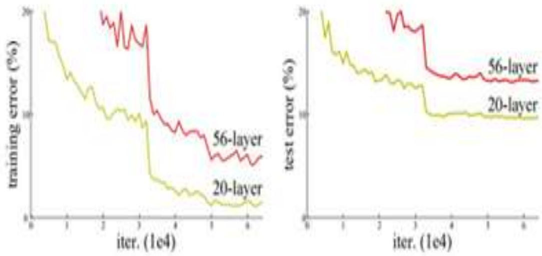

Figure 2. Graph Plot for error% on training and testing data

We can see that error% for 56-layer is more than a 20-layer network in both cases of training data as well as testing data. This suggests that with adding more layers on top of a network, its performance degrades. This could be blamed on the optimization function, initialization of the network and more importantly vanishing gradient problem. You might be thinking that it could be a result of overfitting too, but here the error% of the 56-layer network is worst on both training as well as testing data which does not happen when the model is overfitting.

ResNet architecture

ResNet network uses a 34-layer plain network architecture inspired by VGG-19 in which then the shortcut connection is added. These shortcut connections then convert the architecture into the residual network as shown in the figure below:

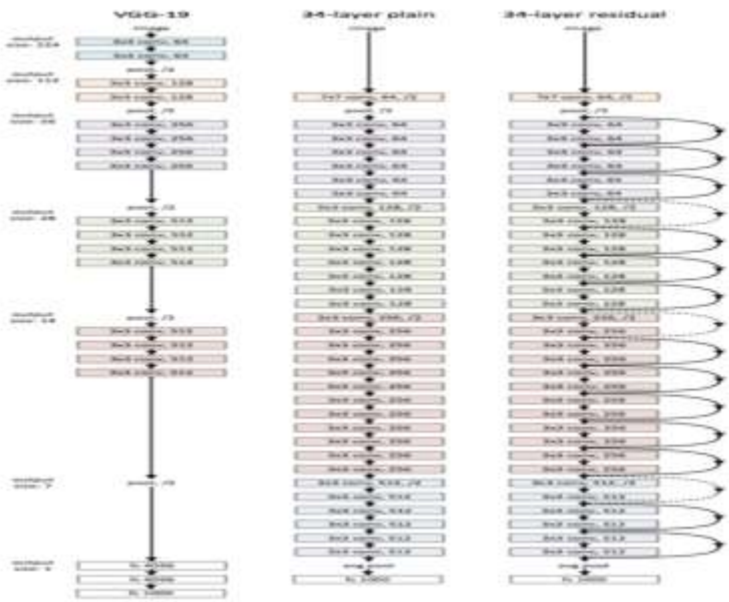

Figure 2. ArsNet Architecture

III. METHODOLOGY

Classifier – Random Forest Classifier

Random forests or random decision forests are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees. It is a supervised learning algorithm which is used for both classification as well as regression. But however, it is mainly used for classification problems. As we know that a forest is made up of trees and more trees means more robust forest. Similarly, random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result.

Working of Random Forest Algorithm

To understand and use the various options, further information about how they are computed is useful. Most of the options depend on two data objects generated by random forests. When the training set for the current tree is drawn by sampling with replacement, about one-third of the cases are left out of the sample. This oob (out-of-bag) data is used to get a running unbiased estimate of the classification error as trees are added to the forest. It is also used to get estimates of variable importance.

After each tree is built, all of the data are run down the tree, and proximities are computed for each pair of cases. If two cases occupy the same terminal node, their proximity is increased by one. At the end of the run, the proximities are normalized by dividing by the number of trees. Proximities are used in replacing missing data, locating outliers, and producing illuminating low-dimensional views of the data.

Step 1 − First, start with the selection of random samples from a given dataset.
Step 2 − Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree.
Step 3 − In this step, voting will be performed for every predicted result.
Step 4 − At last, select the most voted prediction result as the final prediction result.

Features of Random Forests

- It is unexcelled in accuracy among current algorithms.
- It runs efficiently on large data bases.
- It can handle thousands of input variables without variable deletion.
- It gives estimates of what variables are important in the classification.
- It generates an internal unbiased estimate of the generalization error as the forest building progresses.
- It has an effective method for estimating missing data and maintains accuracy when a large proportion of the data are missing.
- It has methods for balancing error in class population unbalanced data sets.
- Generated forests can be saved for future use on other data.
- Prototypes are computed that give information about the relation between the variables and the classification.
- It computes proximities between pairs of cases that can be used in clustering, locating outliers or (by scaling) give interesting views of the data.
- The capabilities of the above can be extended to unlabelled data, leading to unsupervised clustering, data views and outlier detection.
- It offers an experimental method for detecting variable interactions.

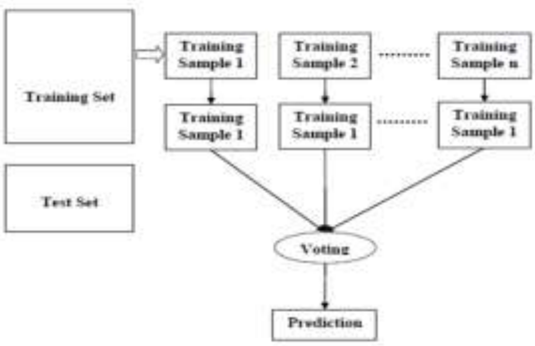

Figure 3. Working of Random Forest

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MATLAB:

MATLAB is a matrix-based language. Since operations may be performed on each entry of a matrix, "for" loops can often be bypassed by using this option. As a consequence, MATLAB programs are often much shorter and easier to read than programs written for instance in C or FORTRAN.MATLAB is a software program that allows doing data manipulation and visualization, calculations, math and programming. It can be used to do very simple as well as very sophisticated tasks. MATLAB is a high-performance language for technical computing. MATLAB is useful because it simplifies the analysis of mathematical models, it frees you from coding in high-level languages (saves a lot of time - with some computational speed penalties), provides an extensible programming/visualization environment, provides professional looking graphs.In our proposed system we will be using Image processing toolbox due to its user-friendly nature.

Typical uses of MATLAB:

A. Mathematical computations
B. Algorithmic development
C. Model prototyping (prior to complex model development)
D. Data analysis and exploration of data (visualization)
E. Scientific and engineering graphics for presentation

Complex analysis using MATLAB toolboxes (i.e., statistics, neural networks, fuzzy logic, H-infinity control, economics, etc.)

MATLAB Environment

MATLAB is a software program that allows you to do data manipulation and visualization, calculations, math and programming. It can be used to do very simple as well as very sophisticated tasks. We will start very simple. The name 'MATLAB' comes from two words: matrix and laboratory. According to The Math Works (producer of MATLAB), MATLAB is a technical computing language used mostly for high-performance numeric calculations and visualization. It integrates computing, programming, signal processing and graphics in easy-to-use environment, in which problems and solutions can be expressed with mathematical notation. Basic data element is an array, which allows for computing difficult mathematical formulas, which can be found mostly in linear algebra. But MATLAB is not only about math problems. It can be widely used to analyse data, modelling, simulation and statistics. Mat-lab high-level programming language finds implementation in other fields of science like biology, chemistry, economics, medicine and many more.

Most important feature of MATLAB is easy extensibility. This environment allows creating new applications and becoming contributing author. It has evolved over many years and became a tool for research, development and analysis. MATLAB also features set of specific libraries, called toolboxes. They are collecting ready to use functions, used to solve particular areas of problems. MATLAB System consist five main parts. First, Desktop Tools and Development Environment are set of tools helpful while working with functions and files. Examples of this part can be command window, the workspace, notepad editor and very extensive help mechanism. Second part is The MATLAB Mathematical Function Library. This is a wide collection of elementary functions like sum, multiplication, sine, cosine, tangent, etc. Besides simple operations, more complex arithmetic can be calculated, including matrix inverses, Fourier trans-formations and approximation functions. Third part is the MATLAB language, which is high-level array language with functions, data structures and object-oriented programming features.Itallows programming small applications as well as large and complex programs. Fourth piece of MATLAB System is its graphics. It has wide tools for displaying graphs and functions. It contains two and three-dimensional visualization, image processing, building graphic user interface and even animation. Fifth and last part is MATLAB's External Interfaces. This library gives a green light for writing C and FORTRAN programs, which can be read and connected with MATLAB.

Data representation

Data representation in MATLAB is the feature that distinguishes this environment from others. Everything is presented with matrixes. The definition of matrix by Math Works is a rectangular array of numbers. MATLAB recognizes binary and text files. There is couple of file extensions that are commonly used, for example *.m stands for M-file. There are two kinds of it: script and function M-file. Script file contains sequence of mathematical expressions and commands. Function type file starts with word function and includes functions created by the user. Different example of extension is *.mat. Files *.mat are binary and include work saved with command File/Save or Save as.
Since MATLAB stores all data in matrixes, program offers many ways to create them. The easiest one is just to type values.

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There are three general rules:

- The elements of a row should be separated with spaces or commas;
- To mark the end of each row a semicolon ';' should be used;
- Square brackets must surround whole list of elements.

After entering the values matrix is automatically stored in the workspace. To take out specific row, round brackets are required. In the 3x3 matrix, pointing out second row would be (2, :) and third column (:3). In order to re-call one precise element bracket need to contain two values. For example (2,3) stands for third element in the second row. Variables are declared as in every other programming language. Also, arithmetic operators are represented in the same way certain value is assigned to variable. When the result variable is not defined, MATLAB creates one, named Ans, and placed in the workspace. Ans stores the result of last operation. One command worth mentioning is plot command. It is responsible for drawing two dimensional graphs. Although this command belongs to the group liable for graphics, it is command from basic MATLAB instructions, not from Image Processing toolbox. It is not suitable for processing images; therefore, it will not be described.

Wide selection of toolboxes

MATLAB offers very wide selection of toolboxes. Most of them are created by Math works but some are made by advanced users. There is a long list of possibilities that this program gives. Starting from automation, through electrical engineering, mechanics, robotics, measurements, modelling and simulation, medicine, music and all kinds of calculations. Next couple of paragraphs will shortly present some toolboxes available in MATLAB. The descriptions are based on the theory from Mrozek&Mrozek (2001, 387 – 395) about toolboxes and Mathworks.com.

Communication Toolbox provides mechanisms for modelling, simulation, designing and analysis of functions for the physical layer of communication systems. This tool-box includes algorithms that help with coding channels, modulation, demodulation and multiplexing of digital signals. Communication toolbox also contains graphical user interface and plot function for better understanding the signal processing. Similarly, Signal Processing Toolbox deals with signals. Possibilities of this MATLAB library are speech and audio processing, wireless and wired communications and analogy filter designing.

Another group is math and optimization toolboxes. Two most common are Optimization and Symbolic Math toolboxes. The first one handles large-scale optimization problems. It contains functions responsible for performing nonlinear equations and methods for solving quadratic and linear problems. More used library is the second one. Symbolic Math toolbox contains hundreds of functions ready to use when it comes to differentiation, integration, simplification, transforms and solving of equations. It helps with all algebra and calculus calculations.Image processing toolboxes and Map-ping Toolbox is one of which is responsible for analysing geographic data and creating maps. It provides compatibility for raster and vector graphics which can be imported. Additionally, as well two-dimensional and three-dimensional maps can be displayed and customized. It also helps with navigation problems and digital terrain analysis.Image Acquisition Toolbox is a very valuable collection of functions that handles receiving image and video signal directly from computer to the MATLAB environment. This toolbox recognizes video cameras from multiple hardware vendors. Specially designed interface leads through possible transformations of images and videos, acquired thanks to mechanisms of Image Acquisition Toolbox.

Statistics and Machine Learning Toolbox

Statistics and Machine Learning Toolbox™ provides functions and apps to describe, analyse, and model data. You can use descriptive statistics, visualizations, and clustering for exploratory data analysis; fit probability distributions to data; generate random numbers for Monte Carlo simulations, and perform hypothesis tests. Regression and classification algorithms let you draw inferences from data and build predictive models either interactively, using the Classification and Regression Learner apps, or programmatically, using AutoML.

For multidimensional data analysis and feature extraction, the toolbox provides principal component analysis (PCA), regularization, dimensionality reduction, and feature selection methods that let you identify variables with the best predictive power. The toolbox provides supervised, semi-supervised, and unsupervised machine learning algorithms, including support vector machines (SVMs), boosted decision trees, k-means, and other clustering methods. You can apply interpretability techniques such as partial dependence plots and LIME, and automatically generate C/C++ code for

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embedded deployment. Many toolbox algorithms can be used on data sets that are too big to be stored in memory.

Statistical System

A statistical model is a mathematical model that embodies a set of statistical assumptions concerning the generation of sample data. A statistical model represents, often in considerably idealized form, the data-generating process.

Confusion Matrix

A confusion matrix contains information about actual and predicted classifications done by a classification system. Performance of such systems is commonly evaluated using the data in the matrix.

The following table shows the confusion matrix for a two-class classifier.

The entries in the confusion matrix have the following meaning in the context of our study:

a is the number of **correct** predictions that an instance is **negative,**

b is the number of **incorrect** predictions that an instance is **positive,**

c is the number of **incorrect** of predictions that an instance negative, and

d is the number of correct predictions that an instance is **positive.**

		Predicted	
		Negative	Positive
Actual	Negative	a	b
	Positive	c	d

Several standard terms have been defined for the 2-class matrix:

The accuracy (AC) is the proportion of the total number of predictions that were correct. It is determined using the equation:

$$AC = \frac{a+d}{a+b+c+d}$$

The false positive rate (FP) is the proportion of negatives cases that were incorrectly classified as positive, as calculated using the equation:

$$FP = \frac{b}{a+b}$$

The true negative rate (TN) is defined as the proportion of negatives cases that were classified correctly, as calculated using the equation:

$$TN = \frac{a}{a+b}$$

The false negative rate (FN) is the proportion of positives cases that were incorrectly classified as negative, as calculated using the equation:

$$FN = \frac{c}{c+d}$$

Precision (P) is the proportion of the predicted positive cases that were correct, as calculated using the equation:

$$P = \frac{d}{b+d}$$

F-Measure, as defined in equation

$$F = \frac{(\beta^2+1) * P * TP}{\beta^2 * P + TP}$$

IV. RESULT

Training Images

Medical Waste Dataset

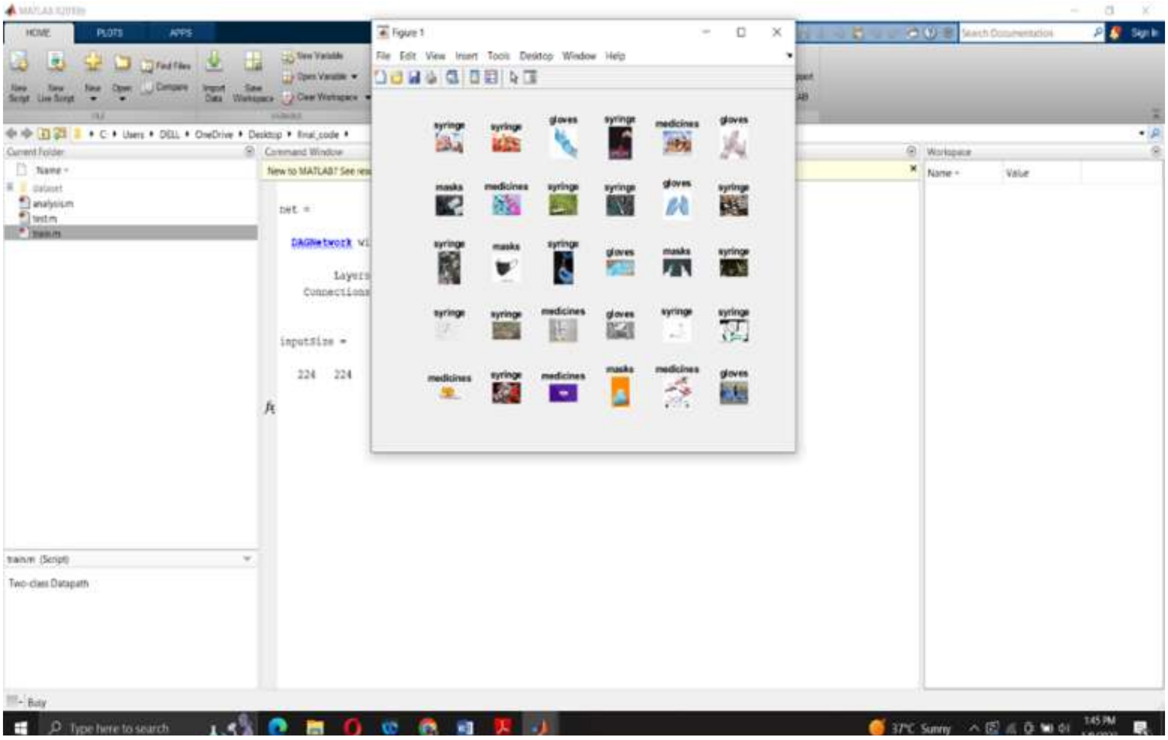

Figure 4. Medical Waste Dataset

Deep learning network analyser

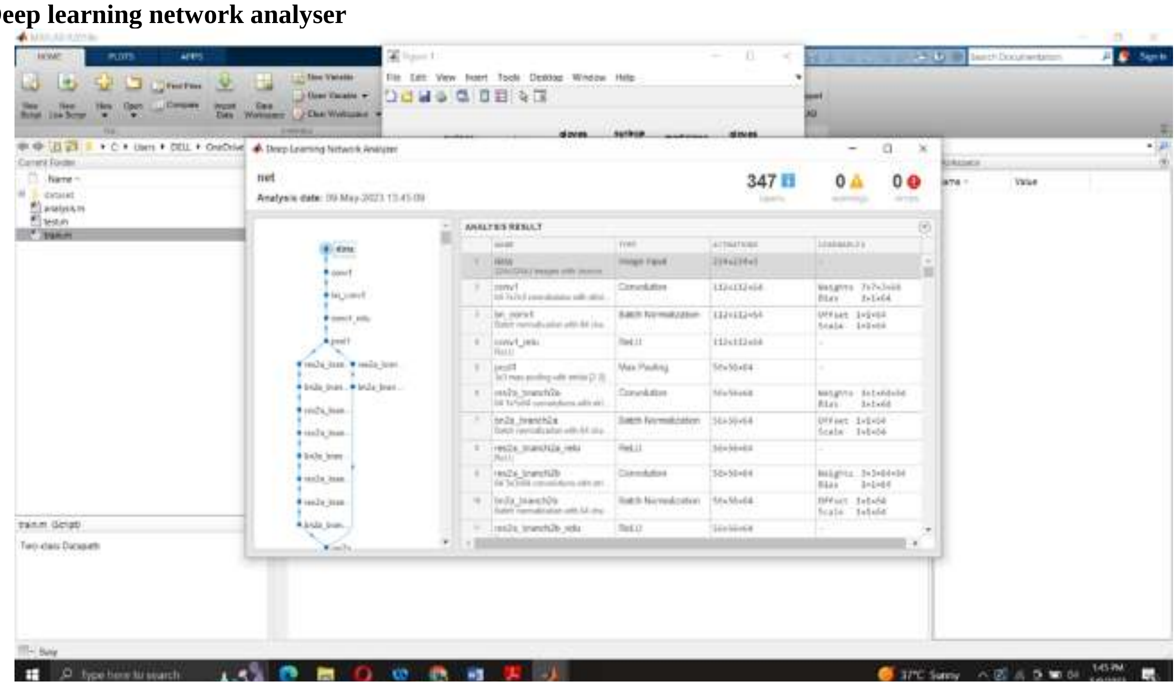

Figure 5. Deep learning network analyser

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Confusion Matrix

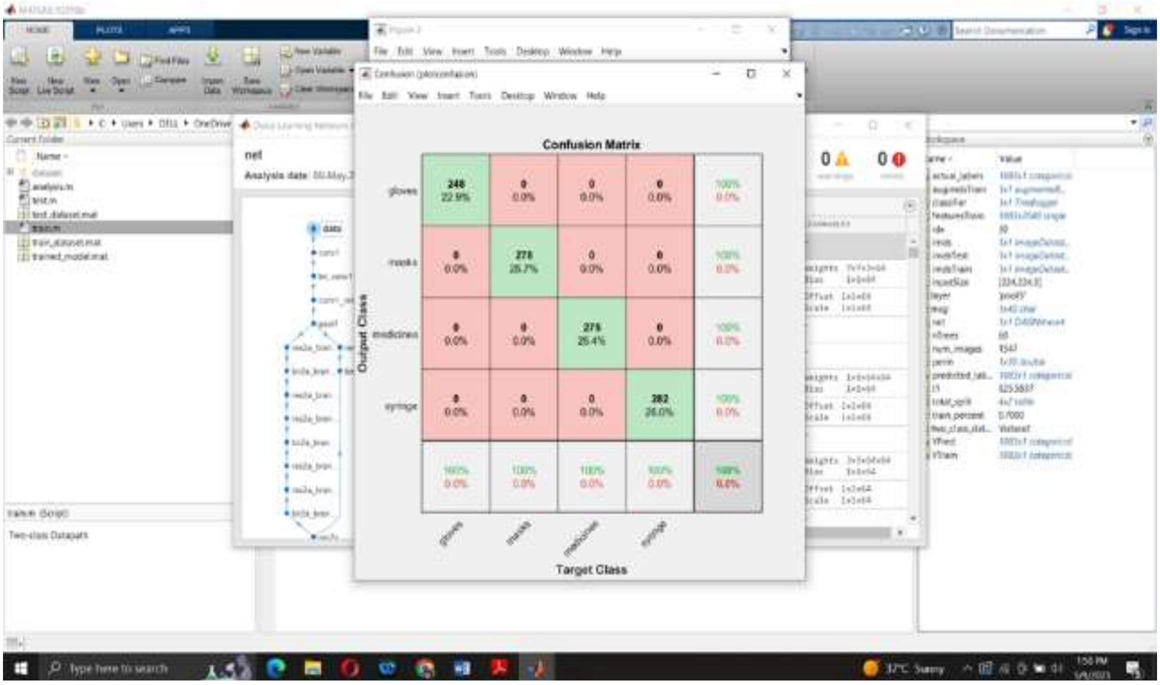

Figure 6. Confusion Matrix

Evaluation Time of Training

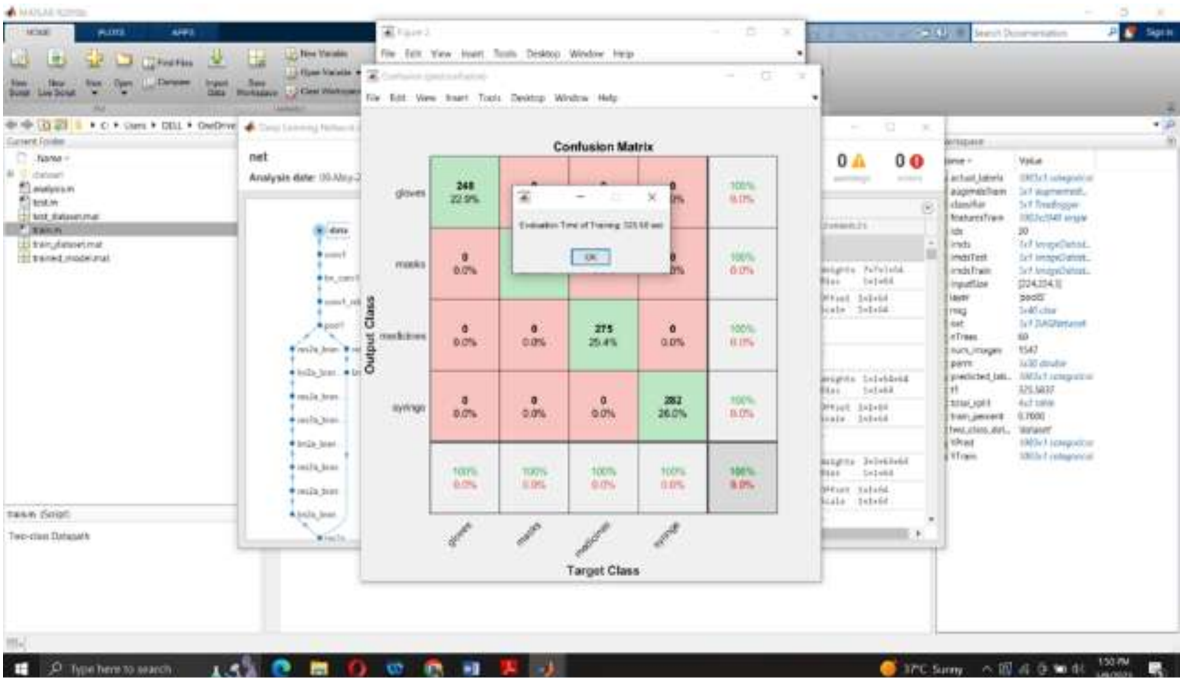

Figure 7. Evaluation Time of Training

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Testing Images:
Input Image

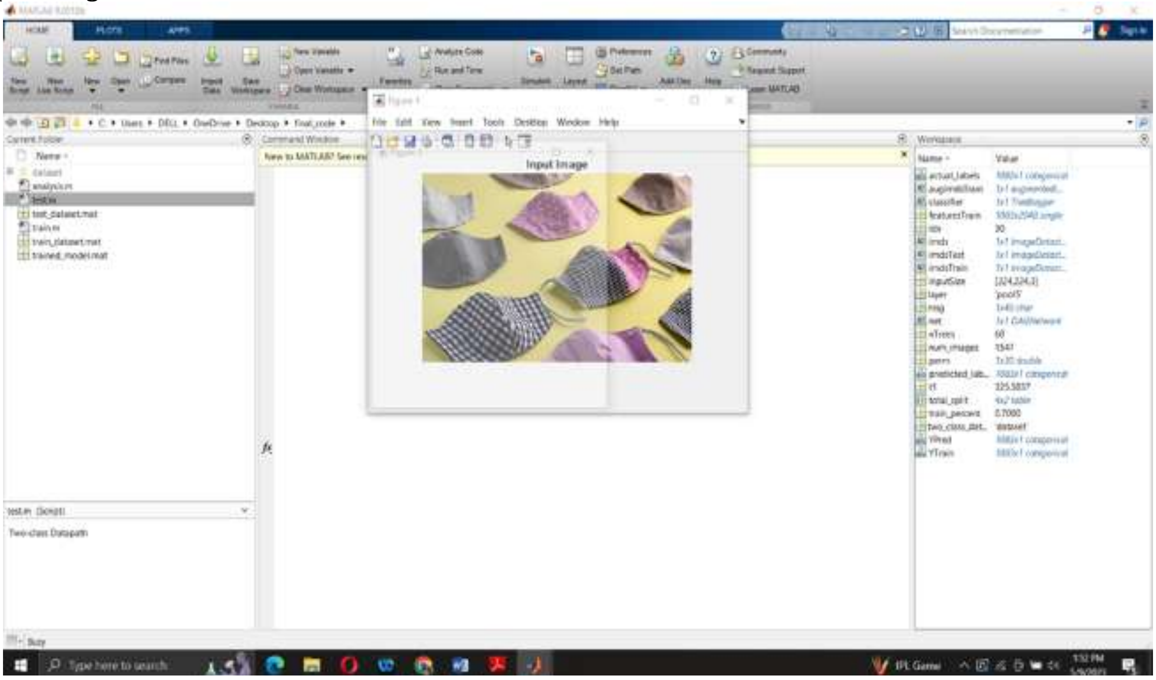

Figure 8. Input Image

Pre-process Input Image

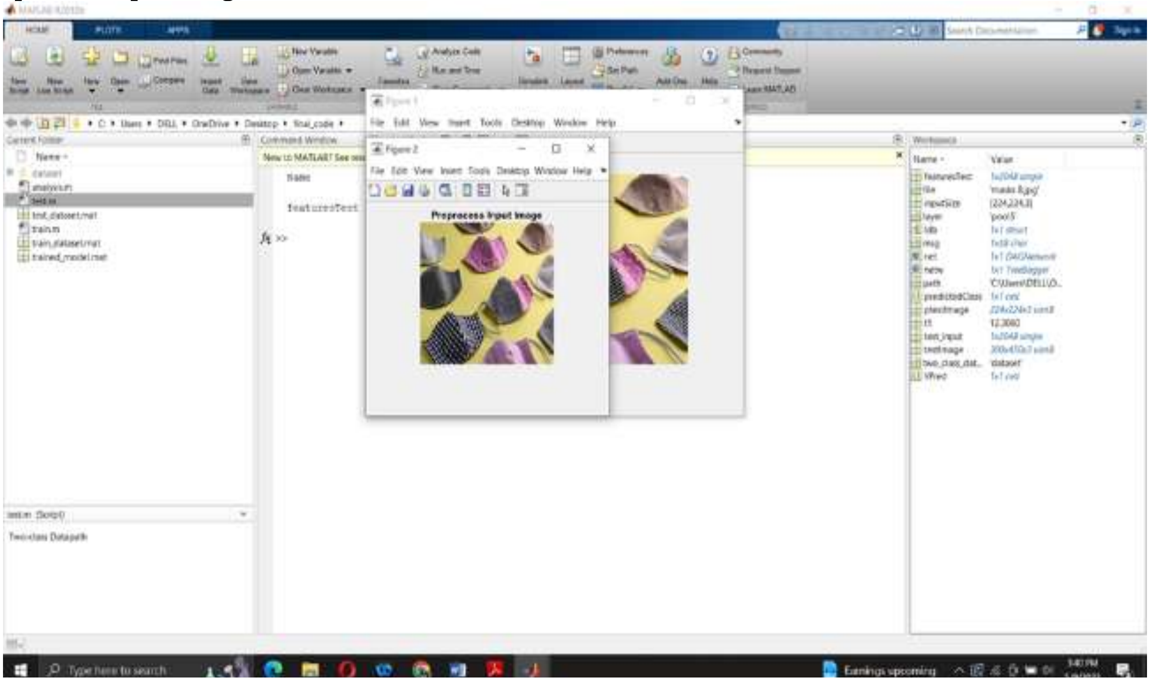

Figure 9. Pre-process Input Image

Evaluation Time of Testing

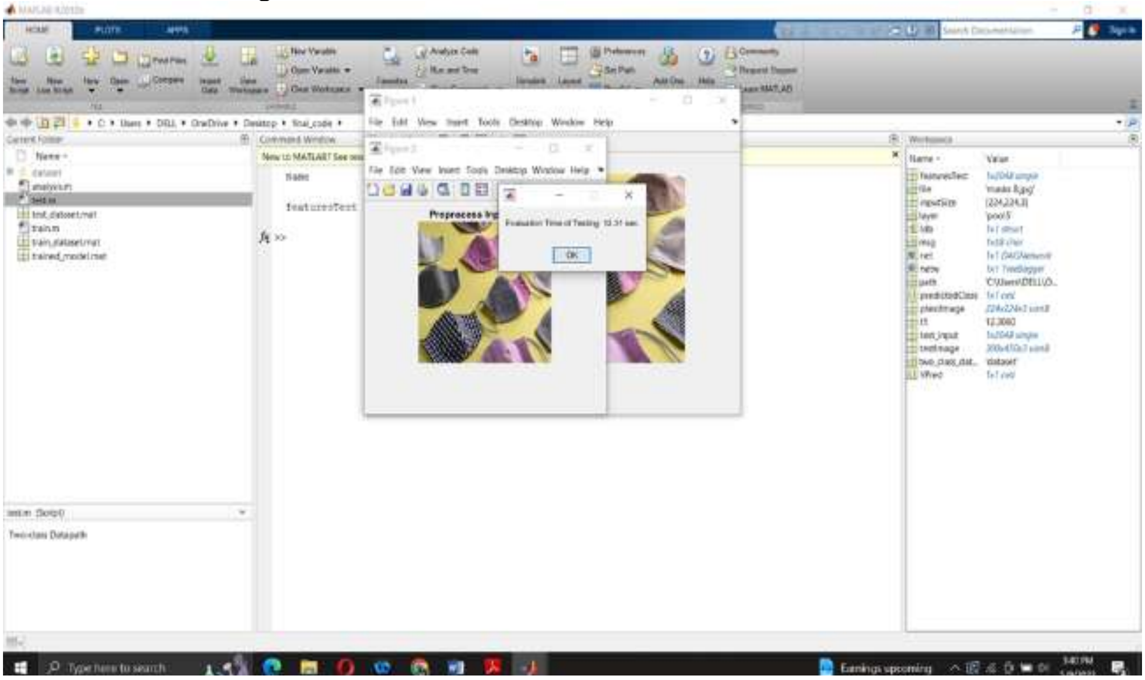

Figure 10. Evaluation Time of Testing

Medical waste Identification

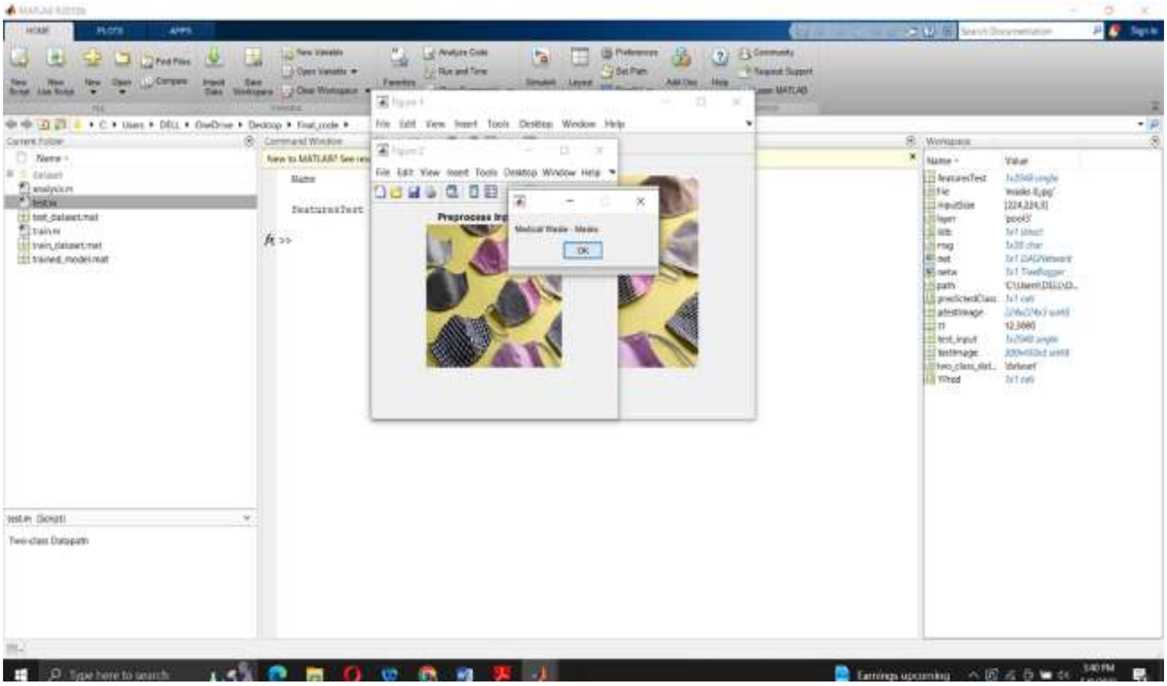

Figure 11. Medical waste Identification

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Analysis:

Figure 12. Medical Waste Dataset

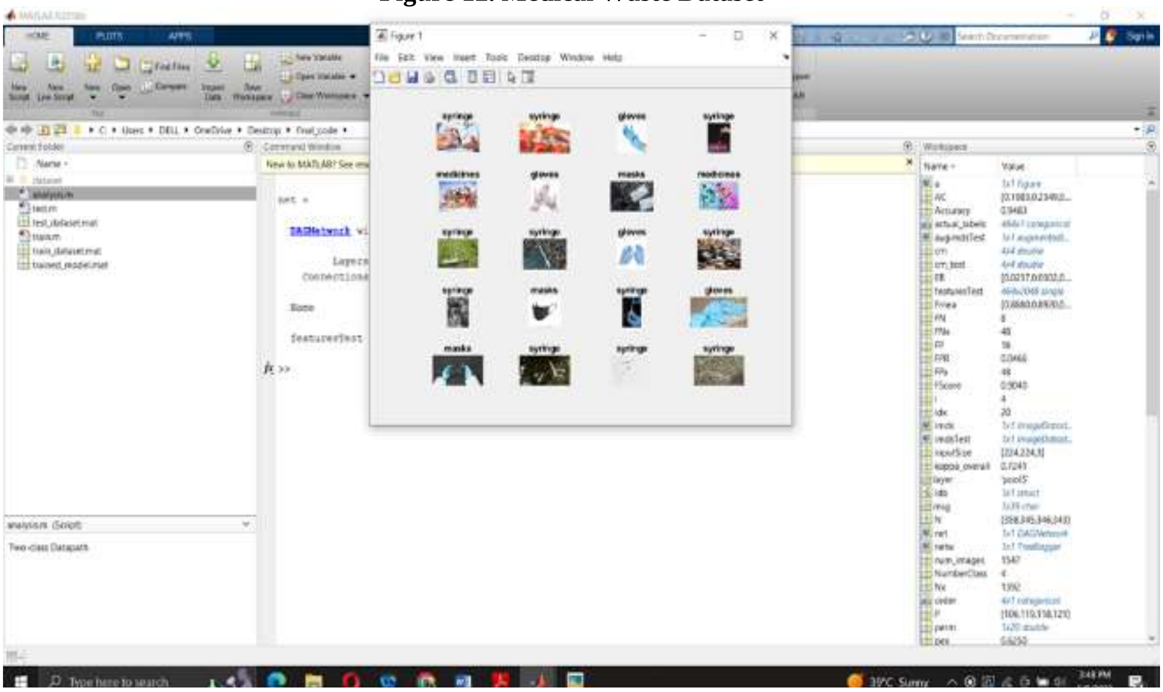

Figure 12. Medical Waste Dataset

Evaluation Time

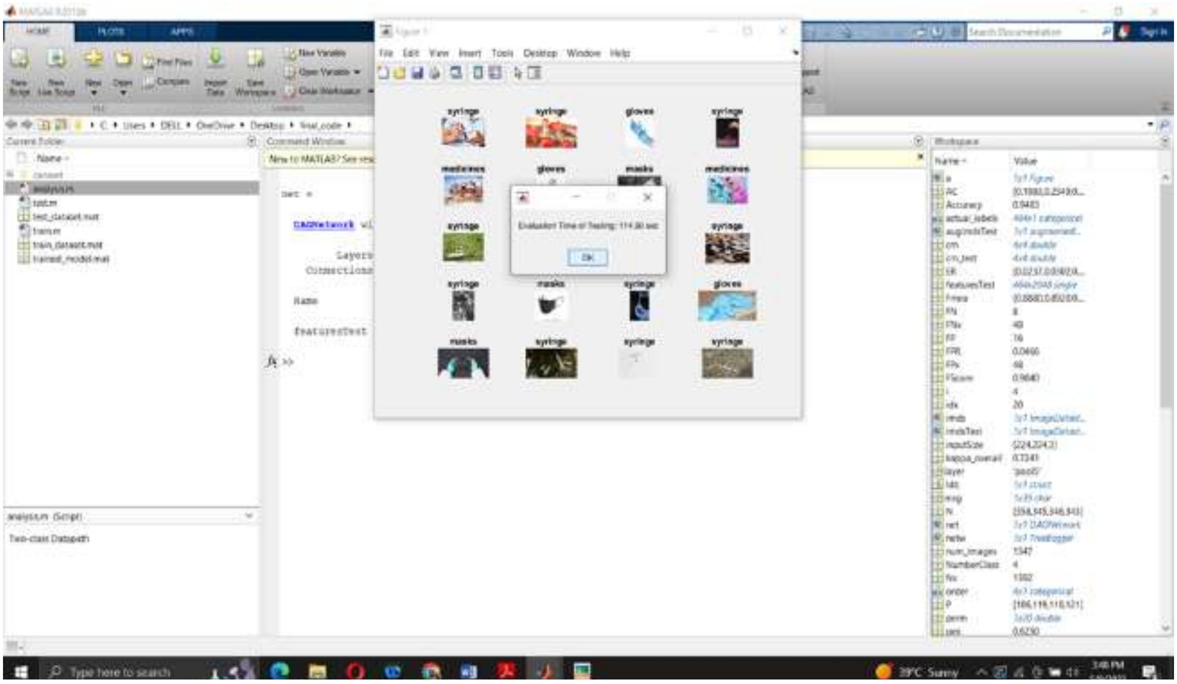

Figure 13. Evaluation Time

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Confusion Matrix

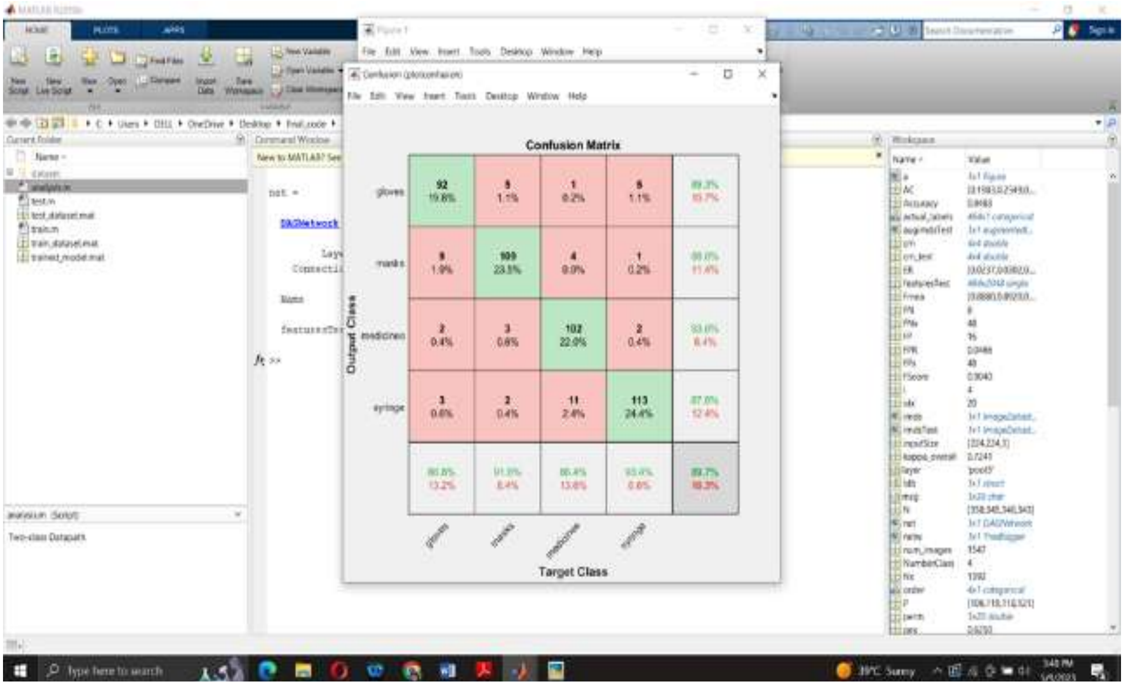

Figure 14. Confusion Matrix

Figure Result Accuracy, Error rate, Sensitivity, Specificity of image

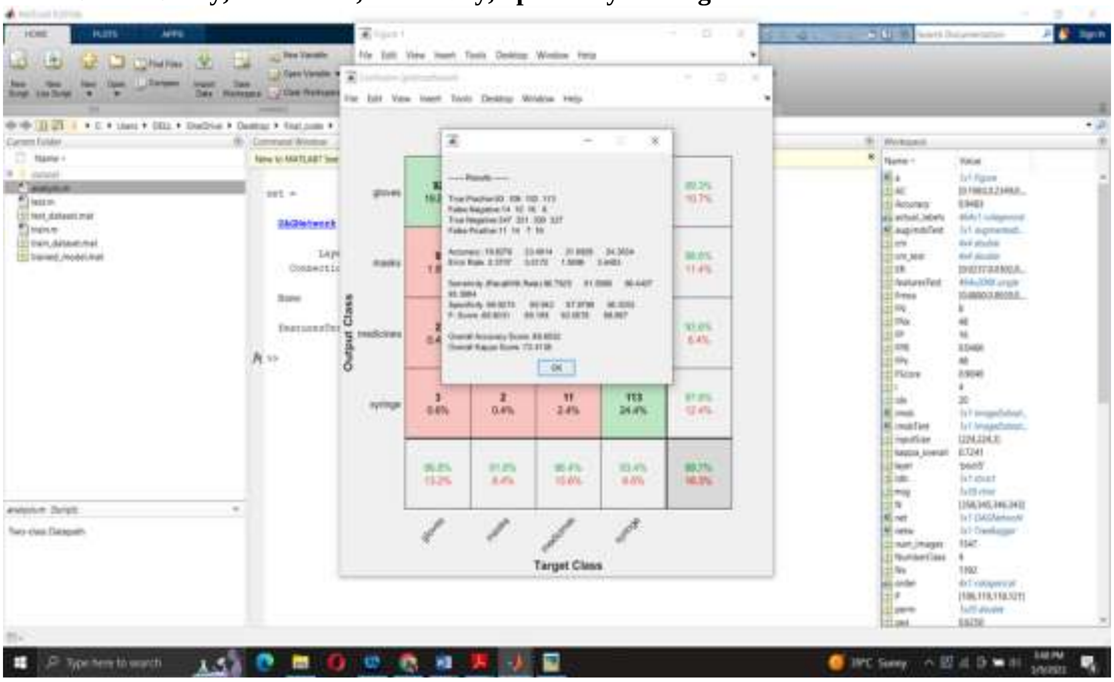

Figure 15. Figure Result Accuracy, Error rate, Sensitivity, Specificity of image

V. CONCLUSION

As we know biomedical waste is very dangerous and waste management of biomedical garbage is very necessary to protect environment. Manual collection of this hazardous biomedical waste can cause various contamination diseases tolabours. To protect them from this dangerous situation number of researchers dose a work in garbage and biomedical waste identification techniques. In this article we have studied about

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various techniques of biomedical west identification. According to this review of various techniques we can conclude that the necessity of biomedical waste identification and classification is very important to improve manual garbage collection system.

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