IWASTE: Medical Waste Classification

Let the waste of "the sick" not contaminate the lives of "healthy"

Raghu Vamsi Sai Rangannagari
Anish Sarla

Department of Electronic and Telecommunication Engineering
Blekinge Institute of Technology
Karlskrona
Sweden

2021

in association with

This report is submitted to the Department of Mathematics and Natural Sciences at Blekinge Institute of Technology in partial fulfilment of the requirements for the degree of Bachelor of Science in Telecommunication. The Report is equivalent to 8 weeks of full-time studies.

Contact Information: Author(s):

Anish Sarla

Raghu Vamsi Sai Rangannagari

E-mail: ansr21@student.bth.se

E-mail: rara21@student.bth.se

University advisor:

Prof. Wlodek Kulesza

Dept. Mathematics and Natural Sciences

Dept. Mathematics and Natural Science   Internet: www.bth.se/didd

Blekinge Institute of Technology   Phone: +46 455 38 50 00

SE–371 79 Karlskrona   Sweden Fax: +46 455 38 50 57

Abstract

In this work, we will detect and classify the medical waste from the input video with is nearly 5 seconds in duration. The collected video contains 4 number of medical waste things such as, gloves, hairnet, mask, shoe cover. Waste monitoring is necessary for the efficient reduction of medical waste in operation theatre. We suggest a framework known as IWASTE (Intelligent Waste Auditing System for Tracking Emissions) to detect and classify medical waste based on video records by a camera placed on waste container to improve the previous time-consuming and unsafe manual waste assessment process. For detection and classification process, we propose a new architecture based on deep Learning Techniques. The proposed method will obtain a promising result when compared to pre-existing methods.

Keywords: Classification, Detection, Deep Learning Techniques, iWASTE, Video-Processing.

Acknowledgements

We would like to express our sincere gratitude to our Professor Wlodek Kulesza for supporting us and guiding us throughout this project in every possible way. Which also helped us in doing lot of research and we came to know about so many things.

We would like to thank our parents and friends who helped us a lot in finishing this project.

Raghu Vamsi Sai Rangannagari
Anish Sarla

Contents

List of figures

List of acronyms

Acronym	**Unfolding**
MATLAB	Matrix Lab
GMM	Gaussian Mixture Model

1 Chapter: Introduction

Waste production and the concept of an ‘ecological footprint’ have increasingly become a global issue as there has been a renewed awareness of the lack of storage space for the accumulating waste.

We propose iWASTE [1], a camera-equipped waste container, which records and classifies video clips of waste as it enters and lands in the waste bin. Our dataset currently includes 4 classes (gloves, hairnet, mask, and shoe cover).

A reliable waste auditing system can help hospitals quantify and characterize waste generation among surgical teams. Data-driven resource scheduling strategies can then be developed to reduce waste.

For example, knowing the resource consumption variations among surgical teams can help hospitals standardize clinical practices of low waste generating clinics.

2 Chapter: Survey of related work

Due to the pandemic the number of persons using medical equipment like facemask, gloves, shoe cover, have increased rapidly. Due to which the medical waste produced by these medical things also increased rapidly.

So, we proposed a project, to develop a program that will detect the medical waste in trash bin. Which helps to detect easily the medical waste and humans can separate the detected waste.

In this project we used programs like MATLAB Alexnet Image processing which produce efficient results and can be implemented in any device

This project helps to identify different objects. It can also be used to classify different objects and identify what the object is.

We collected different data required for the program to execute. We collected different videos of that contain medical waste and used them for research purpose.

3 Chapter: Problem statement, objectives and main contribution

3.1 Problem Statement :

We all know that in today's world due to pandemic millions of medical equipment like mask, gloves, hairnet, shoe cover are purchased, they will inevitably create a tide of hazardous "Medical-Waste" that will be dumped illegally in developing countries. This medical waste disposed should be recycled whenever possible. Can we use latest deep learning models and image processing to overcome this problem?

3.2 Objectives :

The main objective of this project is to identify and classify different types of medical waste in trash bins with a MATLAB program. Using a video of a trash bin as input data, the program must identify whether the object is a medical waste or not. If it is a medical waste, what type of medical waste it is.

3.3 Main Contribution :

The main contribution of this paper is to use MATLAB program to identify and classify medical waste. This program may play a vital role in identifying the medical waste by the government officials or hospitals, due to which they can take necessary actions to decrease the medical waste. As the program can be run in different devices, it can be used anywhere. This program can be useful to decrease the medical by identifying the medical waste and classifying it.

4 Chapter: Solution

4.1 Modeling

Our proposed implementation is used to detect and classify the waste objects from bin by using deep learning network. We take the dataset of videos and converted into frames. By applying the morphological operations, we can de-noise the videos. In order to detect the motion of the object we are taking absolute difference between the frame and reference image. The object detection in the frame can be done by using the gaussian mixture model (GMM), after that bounding boxes are formed for the detected objects.

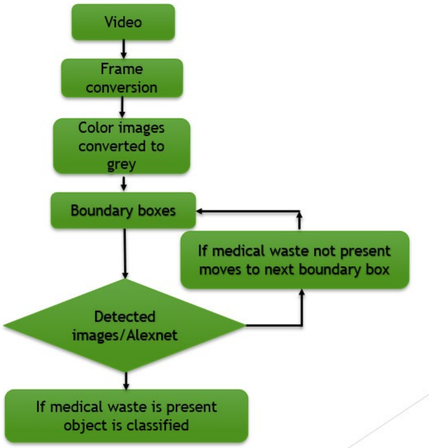

Figure 4-1. Block diagram of proposed method.

For that detected objects we can classifies that object is valid or not which is done by using an Alex Net. For valid objects we can again classifies the type of object using Alex Net. In our implementation we classify four items (mask, gloves, hairnet and shoe cover). Finally, we calculate the parameters such as accuracy, precision, sensitivity and specificity. The following figure represents the block diagram of the proposed implementation.

To study about this project iWASTE, we collected our dataset with a camera-equipped waste bin. Medical waste falling into a waste bin is captured as short videos using a waste container equipped with web-camera clipped on the rim of the metal frame. The camera is positioned to look down so that it can see the bottom of the plasticbag hanging around the metal frame. Four classes of medical waste are collected: shoe cover, gloves, hairnet and masks, which are common medical wastes. We choose these four items for our study in part because they are amorphous and similar in appearance and colour

Figure 4-2. Bin with camera attached.

GMM:

Adaptive GMM (Gaussian Mixture Model)[2] background modelling is applied to detect the motion of falling waste we use the motion detected by GMM. Basic morphological operations including erosion and dilation are applied to post-process the mask generated by GMM for denoising.

DIGITAL IMAGE PROCESSING:

Digital Image Processing[3] includes image processing techniques using a computer program. We could also assume that machine learning algorithms are used to retrieve some helpful information in terms of accuracy and speed image.

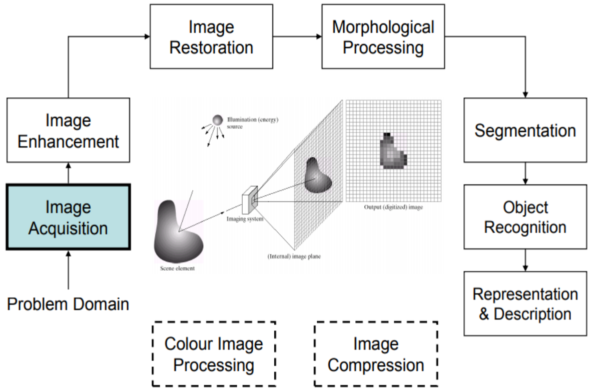

Figure 4-3. Digital image processing.

ALEX NET:

Alex Net convolutional neural network to perform classification on a new collection of images. Alex Net[4] has been trained on over a million images and can classify images into 1000 Object categories (such as keyboard, coffee mug, pencil, and many animals). The network[5] has learned rich feature representations for a wide range of images. The network takes an image as input and outputs a label for the object in the image together with the probabilities for each of the object categories. Transfer learning is commonly used in deep learning applications.

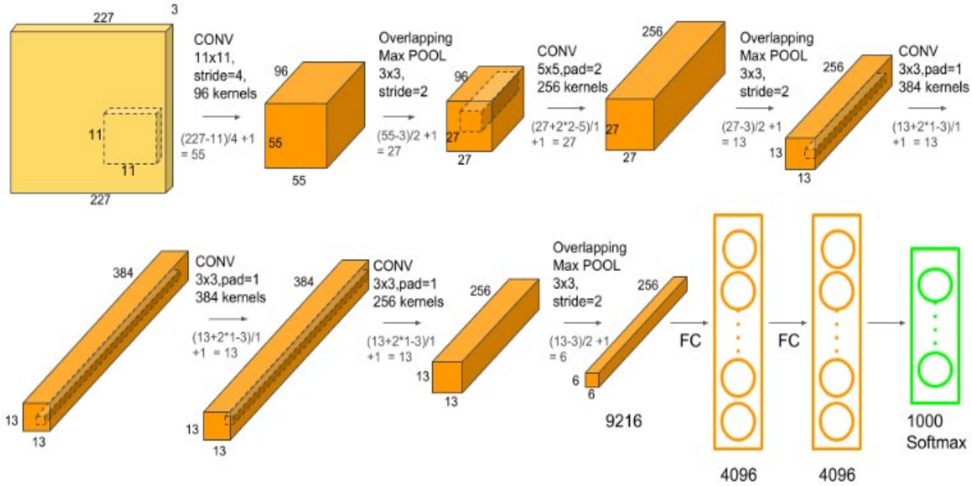

Figure 4-4. Alex Net

4.2 Implementation or Application

MATLAB CODE:

```
clc;
clear all;
close all;
warning off all;

[filename, pathname] = uigetfile({'*.*'},'Select A Video File');
org_video = VideoReader([filename]);
nFrames = org_video.numberofFrames;
vidHeight =  org_video.Height;
vidWidth =  org_video.Width;
mov(1:nFrames) = ...
    struct('cdata', zeros(vidHeight, vidWidth, 3, 'uint8'),...
           'colormap', []);
```

```
% % % frame conversion
for i=20:40
    frames=read(org_video,i);
    frm_name=frame2im(mov(i));
    mov(i).cdata=frm_name;
    mov(i).cdata=imresize(mov(i).cdata,[256 256]);
    filename1=strcat(strcat(num2str(i)),'.png');
    figure(1);imshow(frames);
    title(sprintf('Frame %d',i));
    cd('Frames');
    imwrite(frames,filename1);
    cd ..
end
for k=20:40
    frames1=read(org_video,k);
    c=rgb2gray(frames1);
    img=imread('23.png');
    x=rgb2gray(img);
    a=imabsdiff(x,c);
    g=imbinarize(a);
    se=strel('disk',1);
    h=imdilate(g,se); % % % morphological operations
    d=imerode(h,se);
    filename1=strcat(strcat(num2str(k)),'.png');
    figure(2);imshow(d);
    title(sprintf('Frame %d',k));
    cd('binary');
```

```
    imwrite(d,filename1);
    cd ..
end

% % % object recognition using gaussian mixture model
blobAnalysis = vision.BlobAnalysis('BoundingBoxOutputPort', true, ...
    'AreaOutputPort', false, 'CentroidOutputPort', false, ...
    'MinimumBlobArea', 150);
bbox = step(blobAnalysis, d);

result = insertShape(frames, 'Rectangle', bbox, 'Color', 'green');
objects = size(bbox, 1);
result = insertText(result, [10 10], objects, 'BoxOpacity', 1, ...
    'FontSize', 14);
figure; imshow(result); title('Detected objs');

% % % crop all the detected bounding boxes
for i=1:objects
obj=imcrop(img,bbox(i,:));
handles.obj=obj;
obj=imresize(obj,[256,256]);
figure;imshow(obj);
filename2=strcat(strcat(num2str(i)),'.jpg');
% imwrite(obj,filename2);

matlabroot=pwd;
digitDatasetPath = fullfile(matlabroot,'dataset');
imds1 = imageDatastore(digitDatasetPath, ...
```

```
    'IncludeSubfolders',true,'LabelSource','foldernames');
size(obj);
net=alexnet;
layers1 = net.Layers;
layers1(23) = fullyConnectedLayer(2,'Name','fc');
layers1(25) = classificationLayer('Name','CcL');

imageSize1 = net.Layers(1).InputSize;
augmentedTrainingSet1 = augmentedImageDatastore(imageSize1, imds1);

options = trainingOptions('sgdm', ...
    'InitialLearnRate',3e-4, ...
    'MaxEpochs',20, ...
    'MiniBatchSize',32,...
    'ExecutionEnvironment','cpu');
convnet1 = trainNetwork(augmentedTrainingSet1,layers1,options);

I11=imresize(obj,[227,227]);
YPred = classify(convnet1,I11);
output=char(YPred);
msgbox(output);

x='valid';
if contains (x,output)
    matlabroot=pwd;
digitDatasetPath = fullfile(matlabroot,'items');
imds = imageDatastore(digitDatasetPath, ...
    'IncludeSubfolders',true,'LabelSource','foldernames');
```

```
size(obj);
net=alexnet;
layers = net.Layers;
layers(23) = fullyConnectedLayer(4,'Name','fc');
layers(25) = classificationLayer('Name','CcL');

imageSize = net.Layers(1).InputSize;
augmentedTrainingSet = augmentedImageDatastore(imageSize, imds);

options = trainingOptions('sgdm', ...
   'InitialLearnRate',3e-4, ...
   'MaxEpochs',20, ...
   'MiniBatchSize',32,...
   'ExecutionEnvironment','cpu');
convnet2 = trainNetwork(augmentedTrainingSet,layers,options);

I11=imresize(obj,[227,227]);
YPred = classify(convnet2,I11);
output=char(YPred);
msgbox(output);
else
end
end

aaa=obj;
aa=imresize(aaa,[256 256]);
u_bw_filename =im2bw((aa));
```

```
b=I11;
 bb=imresize(b,[256 256]);
u_GT_filename = uint8(im2bw(bb));

temp_obj_eval=
objective_evaluation_core(u_bw_filename,u_GT_filename);
disp('Accuracy--');
disp(temp_obj_eval.Accuracy*100);

disp('Precision--');
disp(temp_obj_eval.Precision*100);

disp('Recall--');
disp(temp_obj_eval.Recall*100);

disp('Fmeasure--');
disp(temp_obj_eval.Fmeasure*100);

disp('sensitivity--');
disp(temp_obj_eval.Sensitivity*100 );

disp('specificity--');
disp(temp_obj_eval.Specificity*100);
```

4.3 Validation or Verification

We collected our dataset from waste bin. The following figure represents the input video.

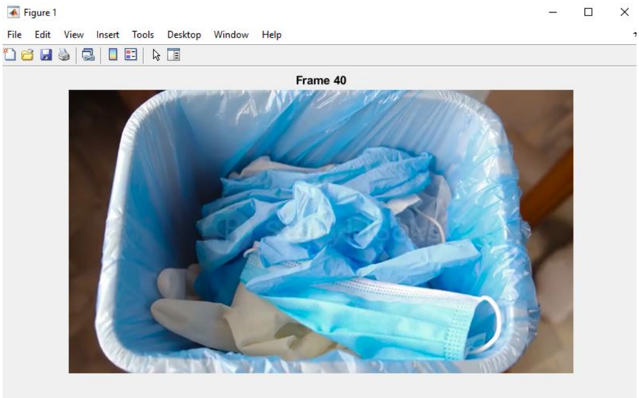

Figure 4-5.video of bin.

The below figure represent the motion objects in video.

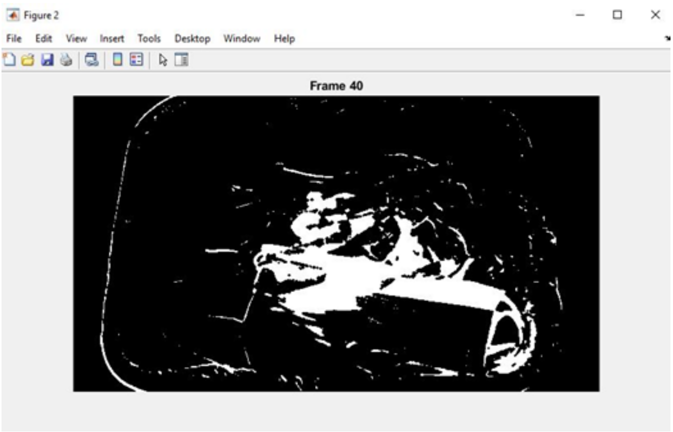

Figure 4-6. Gray code image of bin.

This shows how to use the foreground detector and blob analysis to detect and count objects in a video sequence. The following figure shows the detected objects in a single frame

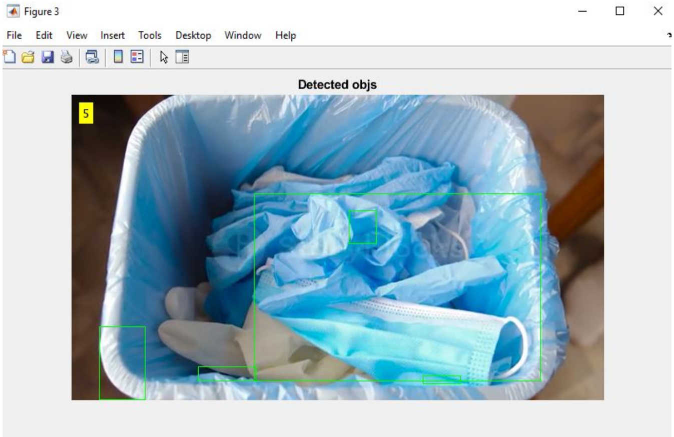

Figure 4-7. Boxing of image.

In the next step, we crop all the detected bounding boxes and that images are taken into two categories. The following figure shows the images of bounding boxes. The following figure represent the detected bounding box image is invalid.

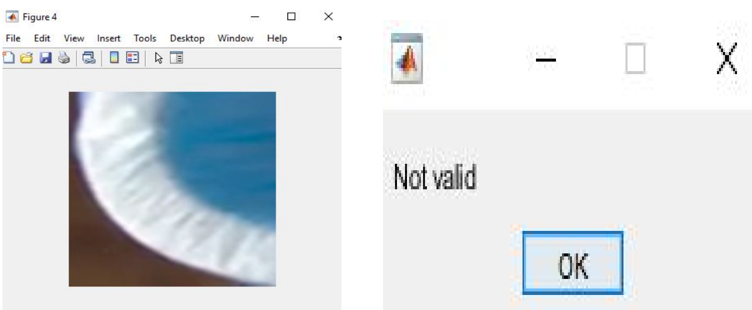

Figure 4-8. image identification and result of image.

For valid images by using a deep learning network further we classify the type of the object. the following figure shows that the classified output as mask. The following figure represent the detected bounding box image is valid. For valid images by using a deep learning network further we classify the type of the object. The following figure shows that the classified output as mask.

Figure 4-9. Detection and Identification of object.

5 Chapter: Conclusion and future work

It was concluded that our proposed implementation, a video dataset of 4 medical waste classes was gathered with a variety of backgrounds. Alex Net network was proposed to classify the detected image is valid or not and for valid output again this network classifies the item. This led us to main conclusion is motion-based pre-processing can help the network to focus on the moving object, which may be particularly important when the training data is limited. Our proposed implementation shows the better object detection and classification with high accuracy than existing approaches. In future work we could use a camera equipped (live) waste container. Which records and classifies video clips of waste as it enters and lands in the waste bin. And we detect a greater number of classes or items.

Reference

[1] J. Chen, J. Mao, C. Thiel, and Y. Wang, “iWaste: Video-Based Medical Waste Detection and Classification,” in 2020 42nd Annual International Conference of the IEEE Engineering in Medicine Biology Society (EMBC), Jul. 2020, pp. 5794–5797. doi: 10.1109/EMBC44109.2020.9175645.

[2] J. Zuo, Z. Jia, J. Yang, and N. Kasabov, “Moving Target Detection Based on Improved Gaussian Mixture Background Subtraction in Video Images,” IEEE Access, vol. 7, pp. 152612–152623, 2019, doi: 10.1109/ACCESS.2019.2946230.

[3] A. McAndrew, “An introduction to digital image processing with matlab notes for scm2511 image processing,” School of Computer Science and Mathematics, Victoria University of Technology, vol. 264, no. 1, pp. 1–264, 2004.

[4] “A Closer Look at Spatiotemporal Convolutions for Action Recognition | IEEE Conference Publication | IEEE Xplore.” https://ieeexplore-ieee-org.miman.bib.bth.se/document/8578773 (accessed Sep. 18, 2021).

[5] Z. Qiu, T. Yao, and T. Mei, “Learning Spatio-Temporal Representation with Pseudo-3D Residual Networks,” in 2017 IEEE International Conference on Computer Vision (ICCV), Oct. 2017, pp. 5534–5542. doi: 10.1109/ICCV.2017.590.