International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST

A Novel Enhancement and Detection Algorithm for Detecting Hazardous Products

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Article Info
Volume 9, Issue 6
Page Number : 293-299

Publication Issue
November-December-2022

Article History
Accepted : 15 Nov 2022
Published : 01 Dec 2022

ABSTRACT

To solve the issue of colour distortion in CLAHE enhanced airport security X-ray images, an X-ray image enhancement technique incorporating USM+CLAHE+HAZEREMOVAL and YOLOV2 for object recognition is provided. The X-ray image's R, G, and B channels' grayscale pictures will be calculated, subjected to CLAHE enhancement, and then the enhanced R, G, and B grayscale images will be combined. The CLAHE-enhanced X-ray image is next subjected to the USM sharpening operation, and according to the weight, it is combined with the original and USM-sharpened photos. To the data obtained afterwards, a haze removal procedure is incorporated. Utilized for detection is YOLOV2. Results of the experiments show that the USM+CLAHE+ HAZEREMOVAL algorithm can successfully enhance the security X-ray image while also suppressing colour distortion in the enhanced image.

Keywords :- Airport security, X-ray image, USM, CLAHE, Image enhancement, Atmospheric haze removal, Object detection, YOLOV2.

I. INTRODUCTION

Articles or substances that can endanger health, safety, property, or the environment and are listed as dangerous goods in the Technical Instructions or are categorized in accordance with those Instructions. Since the 1970s, when hijackings and bombs turned into the weapon of choice for militant, subversive groups all over the world, terrorism has been an issue for airlines and air travelers. Although airport security has always been rigorous, the 9/11 attacks brought into sharp focus the fact that it wasn't tight enough. Men commandeered four passenger jets that day and turned them into flying bombs while armed only with basic box cutters. What safety precautions could have prevented them? How has security at airports altered since then? Over 700 million pieces of passengers' luggage are searched for explosives and other dangerous things each year while 730 million people fly on passenger jets, according to the Department of Homeland Security. In this post, we'll see how cutting-edge approaches are being used to make flying as safe as possible and examine whether what we're doing is sufficient. For a moment, put yourself in the shoes of a terrorist who plans to blow up or hijack a plane. You are aware that you will have to go through metal detectors, bomb-sniffing dogs, and potentially a search of your belongings once you enter the airport. How were you able to get around all those safety precautions? To get to a vulnerable region of the airport, you may drive a truck or scale a barrier. Because of this, fences, obstacles, and walls serve as the first line of defense in airport security. The entire airport grounds are surrounded by high barriers that are challenging to scale. Security patrols frequently check the perimeter to look for attempts to scale the fence. The terminals and luggage processing facilities, which are particularly critical places, are considerably more protected, with extra fencing and security checkpoints. A guard station or security cameras keep an eye on all entrance gates. Another danger is that someone might approach the airport terminal entry in a vehicle or truck carrying a bomb and simply detonate it there. To stop this, airports have taken number of actions. If a threat is identified, substantial concrete barriers with the ability to obstruct vehicles the size of huge moving trucks can be set up. The areas where individuals used to park their automobiles to load or unload their trunks are now maintained clear of traffic. Parking close to the terminal is not permitted.

II. RELATED WORKS

In this study [1] for enhancing input X-ray images contrast using different image enhancement techniques and compares their results. The methods used for enhancing contrast Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE), Histogram Equalization (HE), and Contrast Limited Adaptive Histogram Equalization (CLAHE). The increased lumbar spine X-ray data from this experiment demonstrate that the CLAHE approach is a technique that, when compared to other procedures, provides great details and contrast. X-ray image enhancement techniques for enhancing the contrast and details.

In this article [2] for improving X-ray image enhancement and restoring the degraded quality in an X-ray. In this the author of this study introduced a technique which uses boundary division techniques for identifying the noises and wavelets concept for combining or which is also called as fusion that the image blocks or divisions into image. By this proposed approach will successfully merge the advantages of the wiener filter and sharpening in the enhancement of degraded X-ray images. Usage of wiener filter approach to restore corrupted pixels

In this article [3] studying about difficulties in studying an X ray i.e., scanned bag or luggage in which the detection of components with uneven thickness by X-ray, the problems of low contrast or uneven contrast and low illumination often occur, which make it difficult to observe and analyze some details of components in the images obtained. To solve this problem, an X-ray image enhancement algorithm based on gradient field was proposed. The algorithm takes gradient field enhancement as the core and is divided into two steps. Experimental results show that the proposed algorithm has more obvious enhancement effect and can better display the detailed information of the components.

In this article [4] the author has studied about image enhancing based on the high-frequency emphasis filtering and adaptive histogram algorithm, the digital image enhancement technology is introduced into the X-ray images of the cultural relics with reference to the medical X-ray image processing method. After image enhancement, the edges and details of the X-ray image of an artifact are enhanced, the contrast is stretched, and the useful information is clear. Enhancing of edges and details of the X-ray image

In this research paper [5] in general, according to research, a raw X-ray image obtained straight from a digital flat detector has low image quality and may not be appropriate for diagnosis or treatment planning.

This study uses the so-called N-CLAHE approach, which is based on global and local enhancement, to demonstrate improved picture enhancement on digital chest radiography. The suggested method entails two primary steps: the Contrast Limited Adaptive Histogram Equalization (CLAHE) method is used to enhance fine details, textures, and local contrast in the images, and the log-normalization function, which dynamically adjusts the intensity contrast of the image.

In this research paper [6] studied about Contrast enhancement the author proposes this research presents a revolutionary global mapping augmentation algorithm. First, number of sub-histograms are adaptively created from the histogram based on the idea of heat conduction. By creating a metric known as AHV, the background and non-background sub-histograms are separated, enhanced individually, and more grayscales are assigned to the non-background sub-histograms than the background sub-histograms. The grayscale redistribution also takes into account the characteristic of the human visual system defined by Weber's law. The advantages of our suggested strategy are illustrated by qualitative and quantitative comparisons with cutting-edge techniques on various databases.

III. METHODS AND MATERIAL

This section will elaborate on the security inspection Xray image enhancement algorithm process: (1) CLAHE enhancement. First, calculate the grayscale images on the R, enhancement respectively, and then merge the enhanced R, G, and B grayscale images. (2) USM sharpening. This algorithm uses an improved USM (Unsharp Mask) algorithm to sharpen the CLAHE-enhanced image to highlight details such as image edges and shapes. The USM algorithm combines the sharpened image with the original image according to the superposition coefficient for the second level image fusion. Haze causes problems in various computer vision and image processing-based applications as it diminishes the scene's visibility. The air light and attenuation are two main phenomena responsible for haze formation. The air light enhances the whiteness in the scene and contrast get reduced by attenuation. Haze removal techniques helps in recovering the contrast and color of the scene.

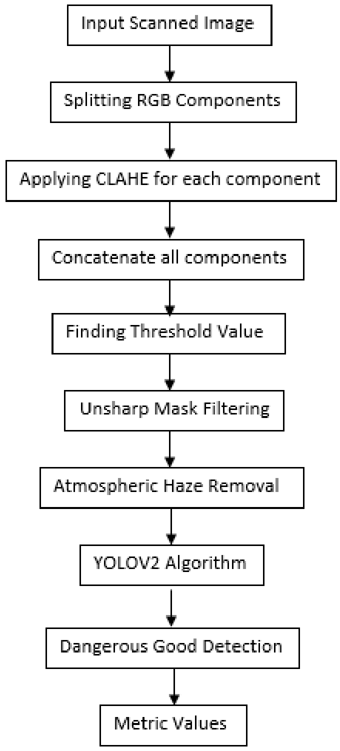

Fig. 1 Block Diagram of Proposed Method

Here we are proposing a new method for image enhancement and detection of dangerous goods in X-Ray images using image enhancement techniques and YOLO V2 object detector. First the input image is taken and apply preprocessing for the image then apply CLAHE to the input the image after that applies unsharp mask. After image enhancement if any dangerous good in that scanned image which detects dangerous goods in that image using object detector.

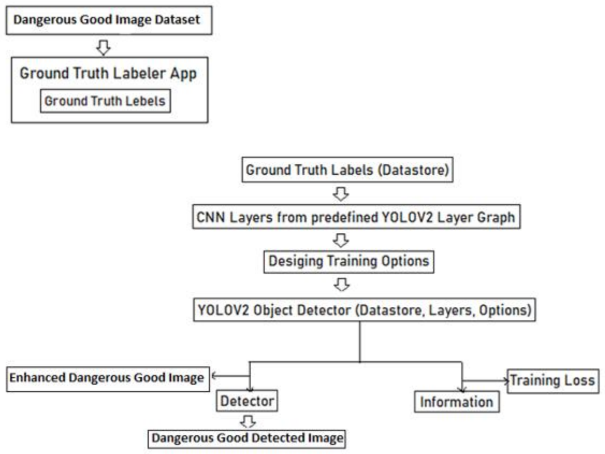

Fig. 2 Yolo V2 Architecture

YOLOV2: Yolo is now processing data quickly and effectively. To make predictions, a single network made up of item locations and classes is used. Accuracy may be fully learned and developed. In YOLOv2, by hovering over a block, you can learn more about it. With the exception of the last convolution block, each convolution block goes through BatchNorm normalization before Leaky Relu activation. YOLO creates an SS grid from the provided image. A single object is predicted by each grid cell. To illustrate, the "person" item in the yellow grid cell below, whose centre (the blue dot) is inside the grid cell, is attempted to be anticipated.

A predetermined number of border boxes are projected for each grid cell. Using two predictions from the border boxes, the yellow grid cell in this image determines where the person is (blue boxes). The one-object rule imposes a distance constraint on the proximity of detected items.

For each grid cell,

- The box confidence score for each box forecasts the B boundary boxes.
- No matter how many boxes B there are, it only picks up one thing.
- Regardless matter how many boxes B there are, it only detects one object.

For the C conditional class, it projects probability (one per class for the likeliness of the object class). The boundary boxes contain the box confidence score. The precision of the boundary box and the chance that an object is present in the box are represented by the confidence score (or is objectless). We subtract the bounding box's width and height from the image's width and height. X and Y are offsets to the important cell. As a result, x, y, w, and h are all between 0 and 1. Each cell contains 20 conditional class probabilities. The conditional class probability represents the possibility that the detected object belongs to a particular class (one probability per category for each cell).

The class confidence score for each prediction box is determined as follows:

The conditional class probability of the class confidence score is equal to the box confidence score time.

It evaluates the degree of certainty for the location and the classification (where an object is located). Those terms "score" and "probability" are simple to mix up. The following is a list of the mathematical definitions for your future use.

box confidence score $= P_r(object).IoU$

conditional class probability $=$

$\mathrm{P}_r\left(class_i \middle| object\right).IoU$

$class\ confidence\ score = P_r(class_i).IoU$

$=$ box confidence score $\times$

conditional class probability

Where $P_r(object)$ is the probability, the box contains an object

IoU is the IoU (intersection over union) between the predicted box and the ground truth.

$\mathrm{P}_r\left(class_i \middle| object\right)$ is the probability the object belongs to $class_i$ given an object is presence.

$\mathrm{P}_r(class_i)$ is the probability the object belongs to $class_i$

For each grid cell, YOLO predicts multiple bounding boxes. To compute the loss for the true positive, one of them needs to be in charge of the object. The one with the highest intersection over union (IoU) with the real data is the one we pick for this. This strategy results in forecasts for the bounding box that are specialized. Accuracy in predicting certain sizes and aspect ratios improves with each forecast.

YOLO uses the sum-squared error to calculate loss between the forecasts and the actual data. The loss function is made up of:

- The loss of categorization.
- a loss in localization (the anticipated boundary box's errors compared to the actual boundary box).
- lack of confidence (the box's objectivity).

Classification loss

The classification loss in each cell, provided an object is found, is equal to the squared error of the class conditional probability for each class:

$$\sum_{i=0}^{s^2} \mathbb{1}_i^{obj} \sum_{c \in classes} \left(p_i(c) - \hat{p}_i(c)\right)^2$$

Were

$\mathbb{1}_i^{obj} = 1$ if an object appears in cell *i*, otherwise 0.

$\hat{p}_i(c)$ denotes the conditional class probability for class *c* in cell *i*.

The projected border box sizes and locations are measured by the localization loss. We only include the box that detects the object in our count.

$$\lambda_{coord} \sum_{i=0}^{s^2} \sum_{j=0}^{B} 1_i^{obj} \left[\left(x_i(c) - \hat{x}_i(c)\right)^2 + \left(y_i(c) - \hat{y}_i(c)\right)^2 \right] + \lambda_{coord} \sum_{i=0}^{s^2} \sum_{j=0}^{B} 1_i^{obj} \left[\left(\sqrt{x_i} - \sqrt{\hat{x}_i}\right)^2 + \left(\sqrt{h_i} - \sqrt{\hat{h}_i}\right)^2 \right]$$

Where $\mathbb{1}_i^{obj} = 1$ if the *j* th boundary box in cell *i* is responsible for detecting the object, otherwise 0.

For the loss in the boundary box coordinates, λ_{coord} raise the weight.

There should not be a weight difference between absolute errors in large boxes and small ones. A 2-pixel error, for instance, has the same impact whether it occurs in a large or small box. To partially address the issue, Yolo predicts the bounding box's square root, not just its width and height. To further emphasize the need of the border box precision, we double the loss by λcoord (default: 5).

IV. RESULTS AND DISCUSSION

The below figures are the experimental outputs of the proposed method

First, we take X-ray image and apply enhancement techniques then we will detect if any dangerous goods in that scanned image.

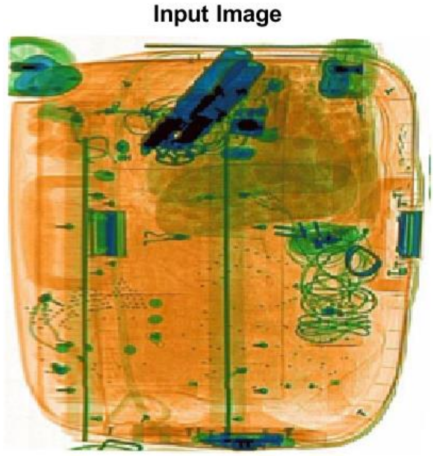

Fig. 3 Input Image

Above image is an X-ray image which it taken as input and then for input image enhancement techniques are applied.

Fig. 4 CLAHE Enhanced image

Here we are applying CLAHE algorithm for enhance edges and details of the X-ray image.

Fig. 5 The above figure shows the X-ray image after applying USM – Un Sharp Mask.

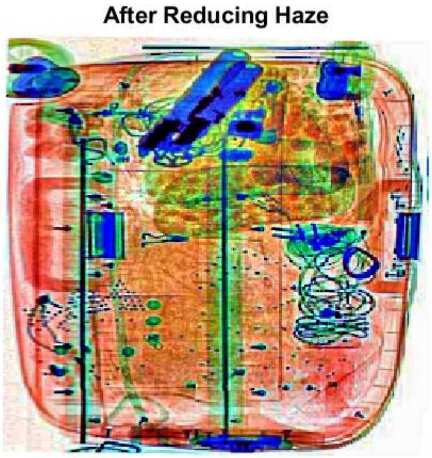

Fig. 6 Image output After reducing haze

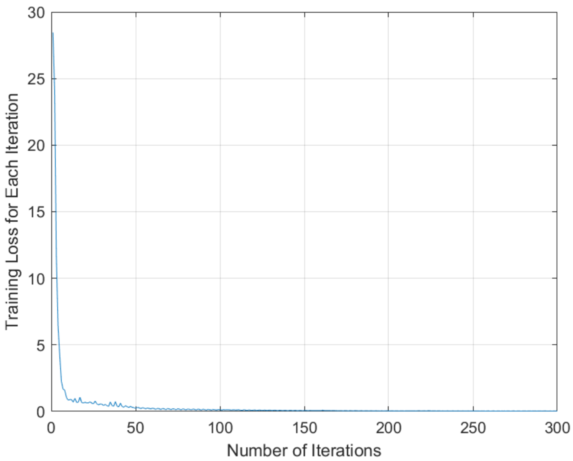

Fig. 7 Training Loss

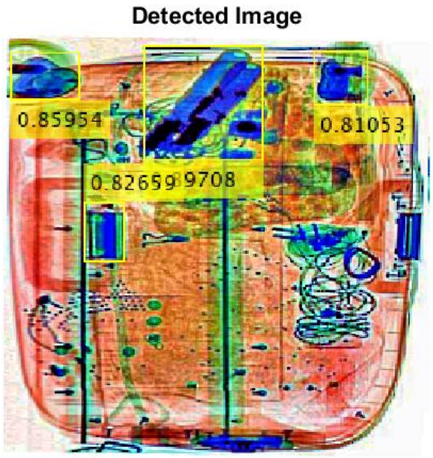

Fig 8 Dangerous Goods Detected - YOLOV2 Detection Image

The goods that were detected in the image with the boundary box are shown in the figure above.

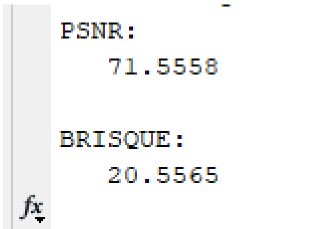

Fig 9: Enhanced Image Metrics in Command window

Image enhancement will be improved and PSNR value increases and BRISQUE values reduces.

S.NO	Existing Method		Proposed Method	
	PSNR	BRISQUE	PSNR	BRISQUE
1	64	22.01	71.55	20.55
2	66.68	25.77	70.13	26.93
3	65.32	24.9	72.08	27.13
4	64.28	45.62	65.13	19.16
5	64.98	32.88	68.13	34.08
6	65.84	36.2	69.74	28.2

Table. 1 Accuracy Comparison Table

The suggested system has better accuracy than the present system, as seen in the comparison table above.

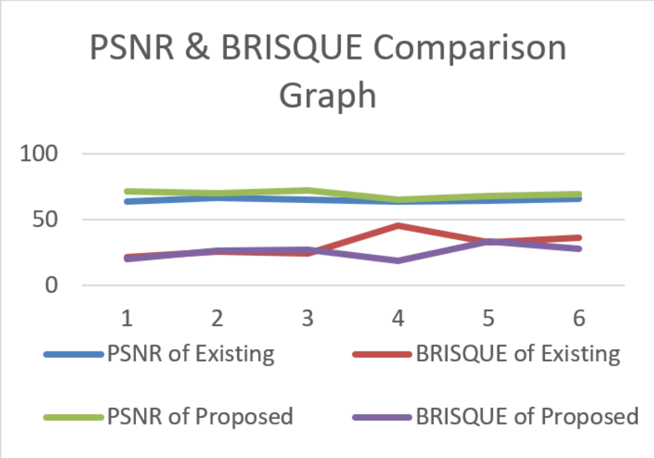

Fig. 9 Accuracy Comparison Graph

The graph shown above compares the proposed and existing systems, with the suggested approach having better accuracy as shown graphically.

V. CONCLUSION

This study uses MATLAB as an analytical framework to investigate the topic of "In airport security inspection, an X-Ray image enhancement & detection algorithm for dangerous goods." To address the issue of color distortion in CLAHE enhanced airport security X-ray images, an X-ray image enhancement technique incorporating USM+CLAHE+HAZEREMOVAL and YOLOV2 for object recognition is offered. Calculated grayscale images on the R, G, and B channels of the X-ray image will then have CLAHE enhancement added to each before the enhanced R, G, and B grayscale images are combined. Following the USM sharpening process, the CLAHE-enhanced X-ray image is combined with the original and USM-sharpened images according to weight. The obtained data is then put through a haze removal process. YOLOV2 is used to perform the detection. The trials' findings show that the USM+CLAHE+ HAZEREMOVAL algorithm may successfully enhance security X-ray images while minimizing color distortion in the enhanced images.

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Cite this article as :

Gurram Sivarani, D. Poorna Chandra Reddy, "A Novel Enhancement and Detection Algorithm for Detecting Hazardous Products", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 9 Issue 6, pp. 293-299, November-December 2022.

Journal URL : https://ijsrst.com/IJSRST229642