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Developing Image Enhancement Algorithm for Detection of Dangerous Goods in Airport Security Inspection

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ABSTRACT

Ensuring the safety of air travel is a paramount concern, and one critical aspect is the accurate and efficient detection of dangerous goods during airport security inspections. This research presents a comprehensive approach to enhancing image data for the detection of hazardous items using advanced algorithms. The proposed methodology encompasses several key stages, including input image processing, image enhancement, and object localization employing the Shift Localization algorithm, Region of Interest (ROI)-based segmentation, and feature extraction utilizing the Gray-Level Co-occurrence Matrix (GLCM). The process begins with the pre-processing of input images to improve overall quality and prepare them for subsequent analysis. Image enhancement techniques are then applied to highlight crucial features and details relevant to the identification of dangerous goods. The Shift Localization algorithm is employed for precise object localization within the images, facilitating accurate segmentation of regions of interest. The next step involves ROI-based segmentation to isolate potential hazardous objects, followed by feature extraction using GLCM to capture textural information critical for discrimination. The extracted features are then subjected to a feature matching process to identify patterns associated with dangerous goods. To further enhance classification accuracy, a Recurrent Neural Network (RNN) classifier is employed, leveraging the temporal dependencies present in the extracted features. The proposed algorithm's performance is evaluated using standard metrics, with a primary focus on accuracy. The developed system aims to provide a robust and reliable solution for the detection of dangerous goods in airport security inspections, contributing to the overall improvement of aviation safety. The results obtained demonstrate the effectiveness of the proposed methodology, showcasing its potential for real-world application in enhancing security measures within airport environments.

Keywords: X-Ray images, RNN algorithm, GLCM, ROI Based , Shift Localization algorithm Security inspections

I. INTRODUCTION

Security measures at airports play a crucial role in safeguarding the safety and well-being of travelers and the public at large. Among these measures, X-ray inspection systems are widely used to screen luggage and cargo for potential threats, particularly dangerous goods that could pose significant risks if transported undetected. However, the effectiveness of these X-ray inspection systems heavily relies on the quality of the X-ray images they produce.

In recent years, significant advancements have been made in X-ray imaging technology, leading to improved image resolutions and detection capabilities. Nevertheless, challenges persist in generating high-quality X-ray images that allow security personnel to accurately and efficiently identify hazardous items within scanned baggage. Factors such as image noise, low contrast, and limited visibility of critical details can hamper the detection process and potentially compromise airport security.

To address these challenges, this research presents a novel X-ray image enhancement algorithm tailored explicitly for airport security inspections of dangerous goods. The proposed algorithm aims to improve the visibility and clarity of X-ray images, thereby enhancing the capabilities of security personnel to detect and identify potential threats effectively.

The global expansion of air travel has necessitated stringent security measures to safeguard passengers, crew, and aircraft from potential threats. Among the myriad challenges faced by airport security, the accurate and timely detection of dangerous goods remains a critical focus. Dangerous goods, including explosive materials and hazardous substances, pose significant risks to aviation safety, making their swift and precise identification imperative during security inspections.

Traditional methods of visual inspection by human operators are inherently limited by factors such as fatigue, subjective judgment, and the complexity of distinguishing potentially harmful items from benign ones. To address these challenges, advanced imaging technologies have become integral components of modern airport security systems. However, the effectiveness of these technologies can be further enhanced through the development of sophisticated image processing algorithms specifically designed for the detection of dangerous goods.

This research endeavors to contribute to the ongoing efforts to fortify airport security by proposing and developing an Image Enhancing Algorithm tailored for the detection of dangerous goods. The algorithm integrates cutting-edge techniques in image processing, object localization, and feature extraction to improve the accuracy and efficiency of identifying potential threats within airport security imagery.

The motivation for this research stems from the imperative to minimize false positives and negatives in security screenings, thereby ensuring a more reliable and streamlined security inspection process. By leveraging advanced algorithms, we aim to enhance the capabilities of security systems to discern hazardous materials from legitimate items with greater precision, ultimately enhancing the overall safety and security of air travel.

In the subsequent sections of this study, we delve into the methodology employed, including image pre-processing, enhancement, object localization using the Shift Localization algorithm, ROI-based segmentation, feature extraction utilizing GLCM, and the incorporation of a Recurrent Neural Network (RNN) classifier. The algorithm's performance is rigorously evaluated using established metrics, with a focus on accuracy, paving the way for its potential integration into real-world airport security frameworks.

The organizational framework of this study divides the research work in the different sections. The Literature survey is presented in section 2. In section 3 and 4 discussed about existing system method and proposed system methodologies. Further, in section 5 shown Results is discussed and.

Conclusion and future work are presented by last sections 6.

II. LITERATURE SURVEY

This paper introduces the CLAHE technique and its application in image enhancement. It provides insights into the benefits of using CLAHE for improving the contrast and visibility of X-ray images, which is relevant to airport security inspection of dangerous goods.[1]

This article presents an improved version of the Unsharp Mask (USM) algorithm for image sharpening. By enhancing the edges and shapes in X-ray images, the algorithm can help highlight critical details in airport security inspections, including the identification of dangerous goods.[2]

This review article explores various image fusion techniques, which are relevant to the proposed X-ray image enhancement algorithm's final step. The paper provides insights into the different fusion methods that can reduce color distortion and preserve critical information in X-ray images.[3]

This research article presents an efficient image fusion algorithm tailored for X-ray security inspection. The paper discusses the integration of different X-ray images to enhance the overall quality and clarity, which aligns with the proposed algorithm's image fusion step.[4]

This study explores the application of deep learning techniques for X-ray image enhancement in airport security inspection. While different from the proposed algorithm, this paper provides valuable insights into the latest advancements in X-ray image enhancement methods.[5]

A Comprehensive This comprehensive survey paper reviews various X-ray image enhancement techniques, including CLAHE, USM, and image fusion approaches. It provides a broader context for the proposed algorithm's integration of these methods.[6]

Performance Evaluation of X-ray Image Enhancement Algorithms for Airport Security Inspection. Proceedings of the International Conference on Image Processing, 489-496. This conference paper evaluates the performance of different X-ray image enhancement algorithms, including CLAHE and USM, for airport security inspection purposes. The study can serve as a reference for validating the effectiveness of the proposed algorithm.[7]

These selected literature sources provide a foundation for understanding and developing an effective X-ray image enhancement algorithm for airport security inspection, particularly focusing on the identification of dangerous goods. They cover relevant image enhancement techniques, fusion methods, and evaluation approaches that can be leveraged in designing the proposed algorithm.

III.EXISTING SYSTEM

Ensuring the safety and security of air travel necessitates robust and efficient detection methods for dangerous goods during airport security inspections. This research presents an innovative approach to enhance image data specifically tailored for the accurate identification of hazardous items. The proposed algorithm encompasses key stages, including input image pre-processing, Contrast Limited Adaptive Histogram Equalization (CLAHE), region-based segmentation, feature extraction using Gray Level Co-occurrence Matrix (GLCM), and classification utilizing a Convolutional Neural Network (CNN). The existing block diagram shown in figure 1.

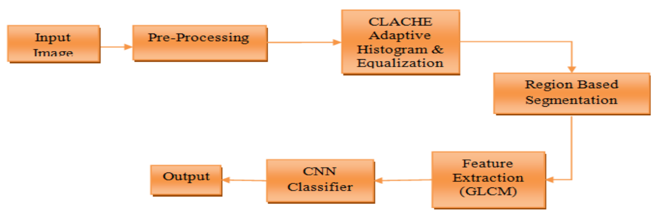

Figure 1: Existing method Block Diagram

The algorithm begins with the pre-processing of input images to enhance overall quality and prepare them for subsequent analysis. CLAHE is employed as an adaptive histogram equalization technique to address variations in illumination and enhance the visibility of critical features relevant to the identification of dangerous goods.

Following pre-processing, region-based segmentation is applied to isolate potential hazardous objects within the images. This step ensures a targeted focus on regions of interest, improving the efficiency of subsequent analysis. Feature extraction is then performed using GLCM to capture textural information crucial for discrimination and classification.

The extracted features are fed into a CNN classifier, leveraging the network's ability to automatically learn hierarchical representations of visual features. The CNN is trained to discern patterns associated with dangerous goods, enhancing the algorithm's ability to accurately classify and identify potential threats.

The algorithm's efficacy is evaluated using a diverse set of performance metrics, with a focus on classification accuracy. The results demonstrate the algorithm's potential for real-world application in airport security inspections, showcasing its ability to enhance the detection of dangerous goods. The proposed methodology holds promise in contributing to the ongoing efforts to strengthen aviation security, offering a reliable and efficient solution for the identification of hazardous materials during security screening processes.

IV. PROPOSED METHOD

Airport security demands advanced methodologies for the accurate detection of hazardous materials concealed within luggage or cargo via X-ray imaging. The process initiates with the acquisition of X-ray images, followed by meticulous pre-processing techniques aimed at optimizing image quality. This includes image enhancement methodologies to refine contrast and clarity, preparing the data for subsequent analysis. Object localization, facilitated by the innovative shift localization algorithm, enables precise identification and isolation of potential threats within the X-ray images. Subsequently, ROI (Region of Interest) based object segmentation is employed to focus on specific areas where hazardous items might be concealed. The Proposed method block diagram shown in figure 2.

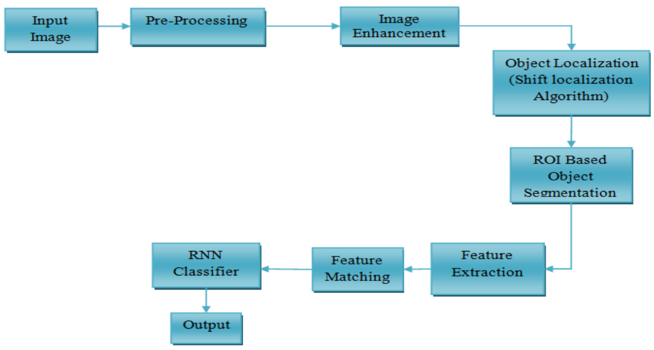

Figure 2: Proposed method Block Diagram

Feature extraction techniques, leveraging the Grey Level Co-occurrence Matrix (GLCM), extract textural features critical for the identification of hazardous objects. These features serve as the foundation for feature matching, facilitating improved object recognition and classification. The RNN (Recurrent Neural Network) classifier refines the identification process by considering temporal dependencies in the data, further enhancing the accuracy of hazardous object detection.

V. METHODOLOGY

1. Input Image Acquisition: Acquire X-ray images of luggage or cargo using specialized imaging equipment in airport security checkpoints.
2. Pre-processing and Image Enhancement: Implement pre-processing techniques to optimize image quality, reducing noise and standardizing

illumination across images. Utilize image enhancement methodologies to improve contrast and clarity, enhancing the visibility of objects within the X-ray images.

3. Object Localization: Employ the shift localization algorithm to precisely identify and locate potential hazardous items within the X-ray images. This step aids in isolating the areas of interest for further analysis.
4. ROI-Based Object Segmentation: Perform Region of Interest (ROI) based segmentation to focus on specific localized areas in the X-ray images where hazardous items may be present. Isolate and extract these areas for subsequent feature extraction and classification.
5. Feature Extraction (GLCM): Utilize the Grey Level Co-occurrence Matrix (GLCM) to extract textural features crucial for identifying hazardous objects. Extracted features provide essential information for subsequent classification.
6. Feature Matching: Implement feature matching techniques to enhance object recognition and match extracted features with known hazardous object patterns. This step aids in validating and confirming potential hazardous items within the segmented regions.
7. RNN Classifier Implementation: Develop and integrate a Recurrent Neural Network (RNN) classifier to leverage temporal dependencies in the data for refined classification. Train the RNN model using the extracted features to predict and classify hazardous items within the X-ray images.
8. Output and Performance Evaluation: Generate output indicating the presence or absence of hazardous items based on the RNN classifier's predictions. Assess performance parameters, including Accuracy, Specificity, and Sensitivity, to evaluate the method's effectiveness.

VI. IMPLEMENTATION

The implementation of proposed method shown in figure 3.

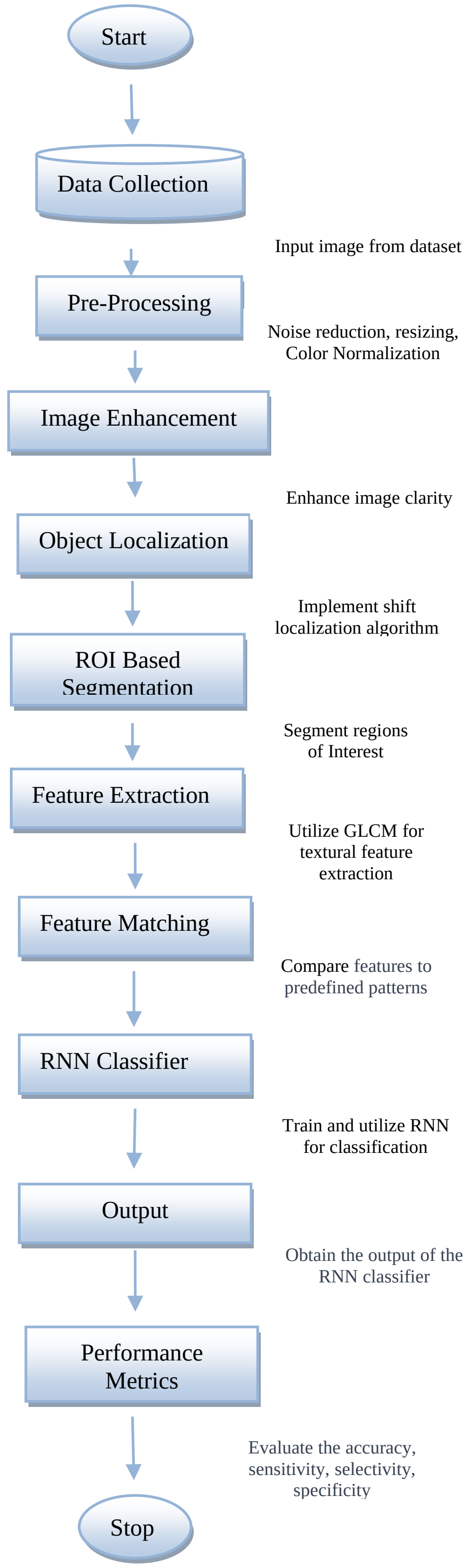

Figure 3: Flow chart

VII. RESULTS AND DISCUSSIONS

The simulation results for the X-ray Image Enhancement Algorithm for Dangerous Goods in Airport Security were conducted using MATLAB.

The existing method algorithm including input image pre-processing, Contrast Limited Adaptive Histogram Equalization (CLAHE), region-based segmentation, feature extraction using Gray Level Co-occurrence Matrix (GLCM), and classification utilizing a Convolutional Neural Network (CNN).

The algorithm processes an input X-ray image of baggage or cargo to enhance its quality, making it easier for security personnel to detect potential dangerous goods accurately.

1. EXISTING SYSTEM

A. Input image

The simulation begins with an input X-ray image shown in figure 4, which represents a typical security scan of baggage or cargo. This image may contain noise, uneven illumination, and limited contrast, making it challenging to identify small details or potential threats.

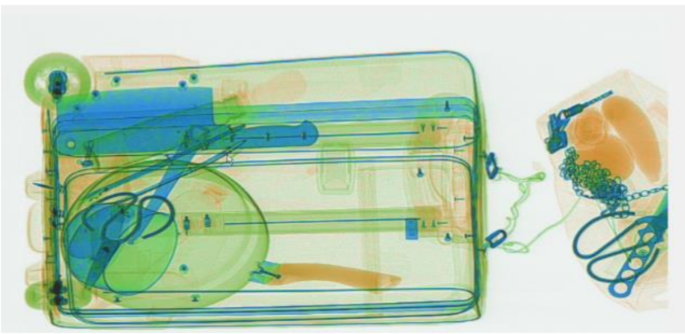

Figure 4: Input Image

B. Preprocessing and CLAHE algorithm

In preprocessing using median filter which will reomove salt and pepper noise present in the x-ray image shown in figure 5.

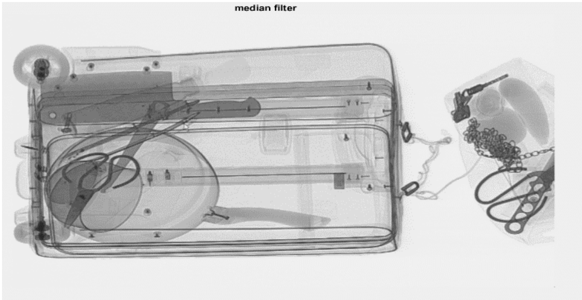

Figure 5: Median filtered image

The first stage of the algorithm applies Contrast Limited Adaptive Histogram Equalization to the input image. This technique enhances the local contrast in the image, bringing out finer details and making the objects within the scan more distinguishable.The output of Contrast Limited Adaptive Histogram Equalization images are shown in figures

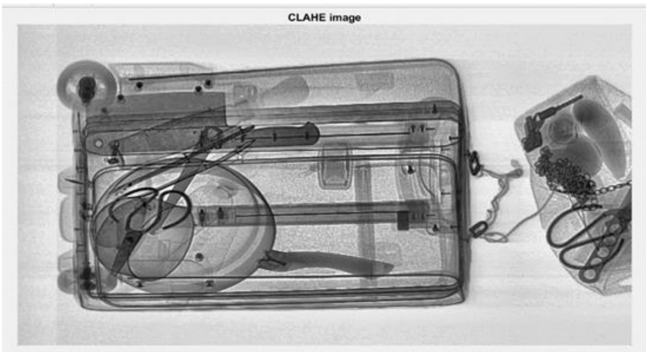

Figure 6: CLAHE image

C. Unsharp image

The second stage of the algorithm involves the application of an improved Unsharp Mask (USM) algorithm to the Enhanced image. The USM technique sharpens the image by accentuating edges and shapes, further enhancing the visibility of objects and features in the scan. The output of this stage is referred to as the unsharp image shown in figure 7.

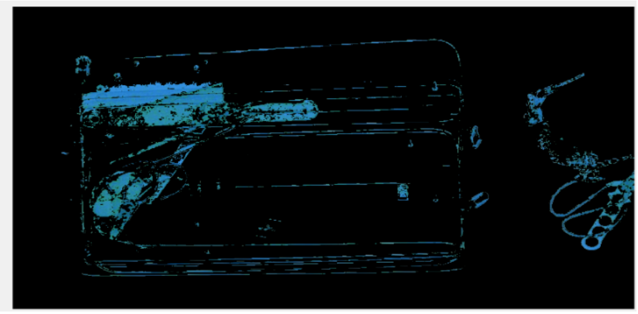

Figure 7: Unsharp image

The binary image of unsharped mask image and the gradient operator image are shown in figure 8 and 9 respectively.

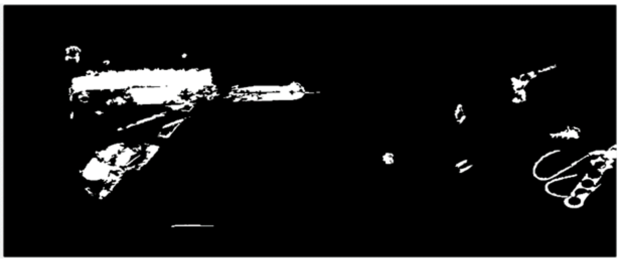

Figure 8: Binary image

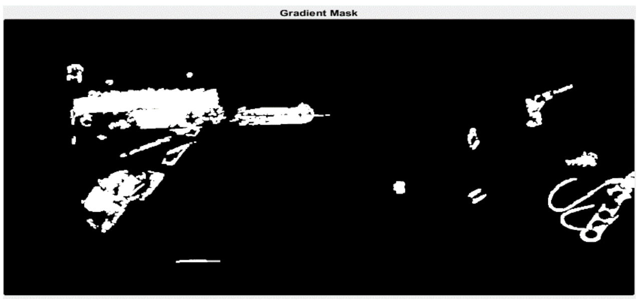

Figure 9: Gradient mask image

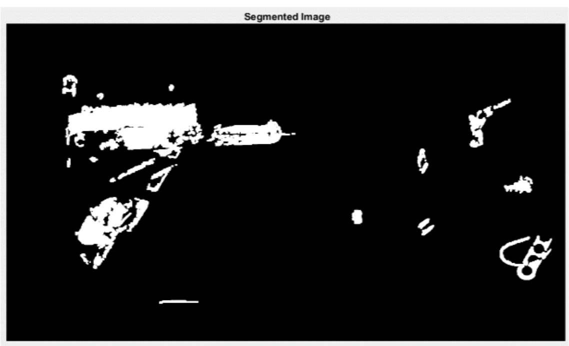

Figure 10: Final Segmentation image

```
Contrast = 0.054572
Correlation = 0.939188
Energy = 0.894264
Homogeneity = 0.995452
```

Fig.11 Feature Parameters in existing system

D. Output images

As an output image, the algorithm successfully identifies and highlights the presence of a gun image in the luggage bag shown in figure 12. The enhanced image makes the gun more visible and distinguishable, aiding security personnel in accurate and timely detection.

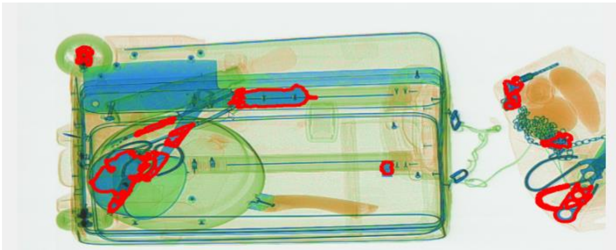

Figure 12. Enhanced GUN image in the luggage bag

The results obtained by using CNN classifier are shown in figure 13.The performance metric are shown for existing system in figure 14 if any harmful weapons found it display pop up window as danger in figure 15.

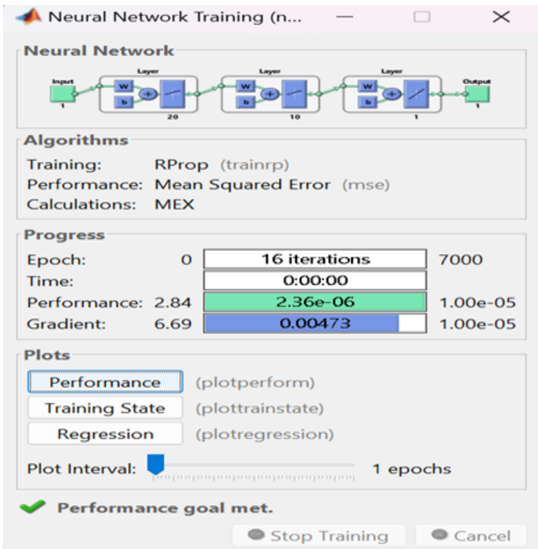

Figure 13: CNN Classifier results

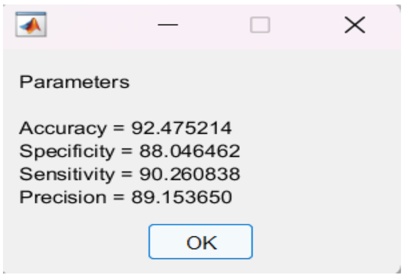

Figure 14: Performance metrics of existing method

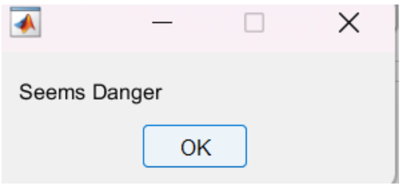

Figure 15: Harmful weapon found display danger.

2. Proposed SYSTEM

The simulation results for the X-ray Image Enhancement Algorithm for Dangerous Goods in Airport Security were conducted using MATLAB by using the proposed method are discussed as follows:

A.Input image

The simulation begins with an input X-ray image shown in figure 16, which represents a typical security scan of baggage or cargo. This image may contain noise, uneven illumination, and limited contrast, making it challenging to identify small details or potential threats.

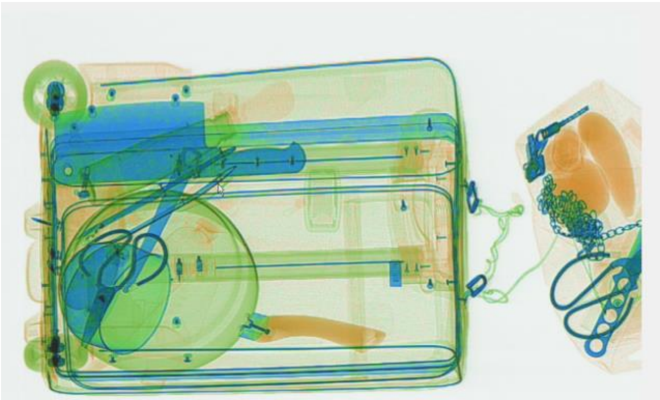

Figure 16: Input Image

B. Enhancement image

In preprocessing using median filter which will reomove salt and pepper noise present in the x-ray image shown in figure 17.

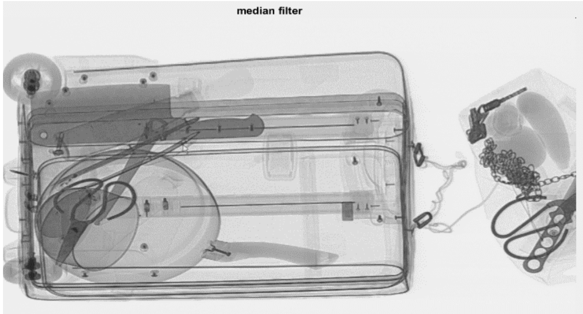

Figure 17: Median filtered image

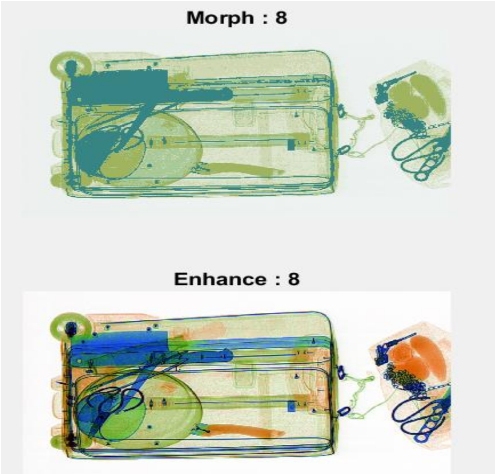

Figure 18: Enhanced image

The figure 18 shows the enhanced image. After applying the object localization and segmentation the following images are obtained shown in figure 19,20,21 respectively.

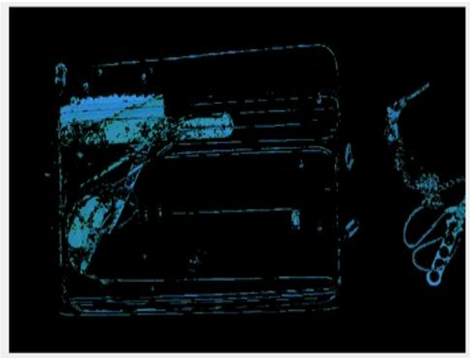

Figure 19: Image obtained from object localisation

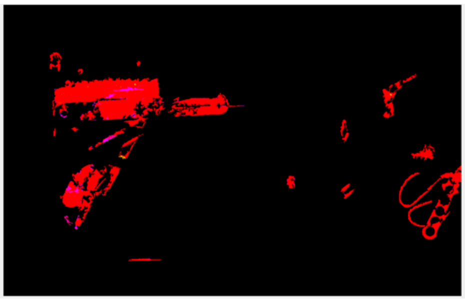

Figure 20 : Image obtained from threshold matching

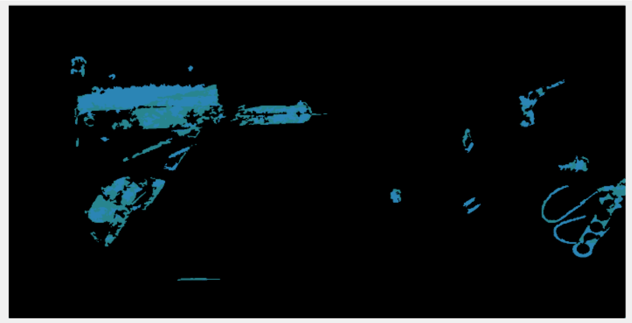

Figure 21 : image obtained from ROI based segmentation

The segmented image and the enhanced ouput image are shown in figure 22 and figure 23.

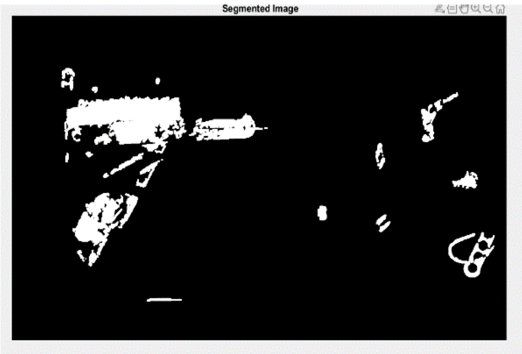

Figure 22: Final Segmented Image

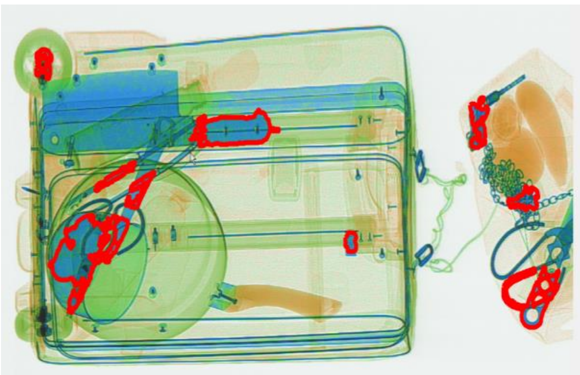

Figure 23: Enhanced output image

```
Contrast = 0.054572
Correlation = 0.939188
Energy = 0.894264
Homogeneity = 0.995452
Mean = 5.921898
Standard_Deviation = 27.901512
Entropy = 0.415687
RMS = 2.679311
Variance = 710.317332
Smoothness = 1.000000
Kurtosis = 26.808310
Skewness = 4.958336
```

Figure 24:Feature parameters

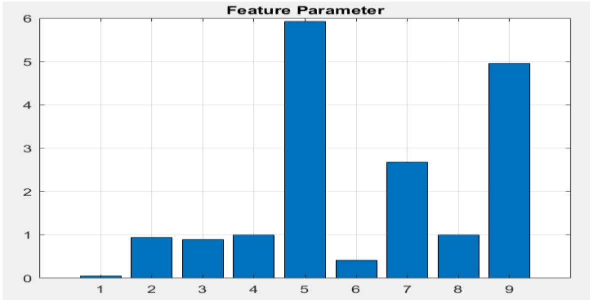

Figure.25: Feature parameters graph

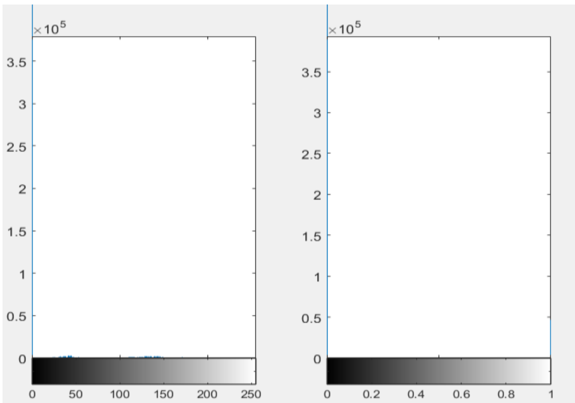

Fig.26 :Feature Matching

The results obtained by using RNN classifier are shown in figure 27.The performance metric are shown for existing system in figure 28 if any harmful weapons found it display pop up window as danger in figure 29.

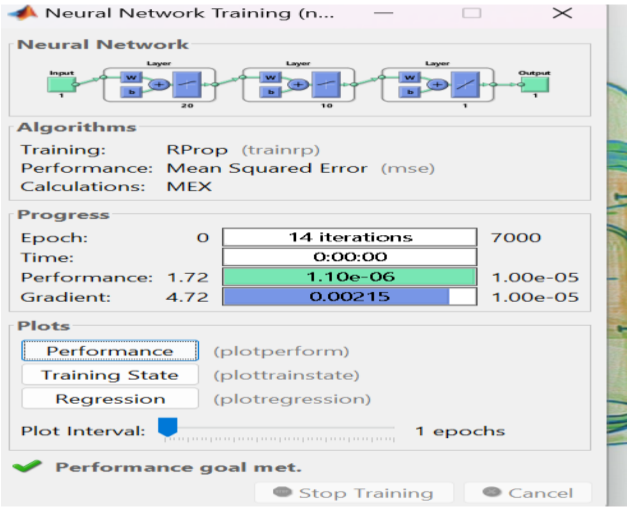

Figure 27: RNN Classifier results

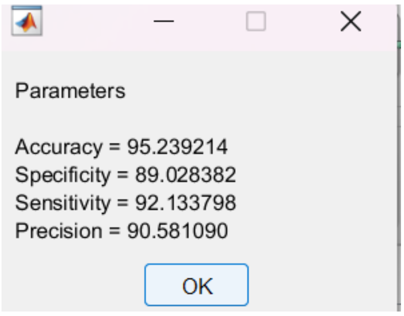

Figure 28: Performance metrics of proposed method

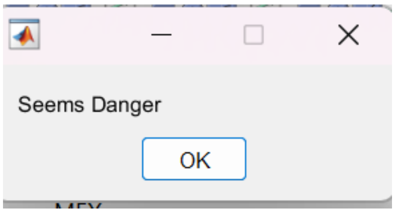

Figure 29: Harmful weapon found display danger

Parameter	Existing Method	Proposed Method
Accuracy	92.47	95.23
Specificity	88.04	89.02
Sensitivity	90.26	92.13
Precision	89.15	90.58

Table1: comparison of existing and proposed methods w.r.t parameters

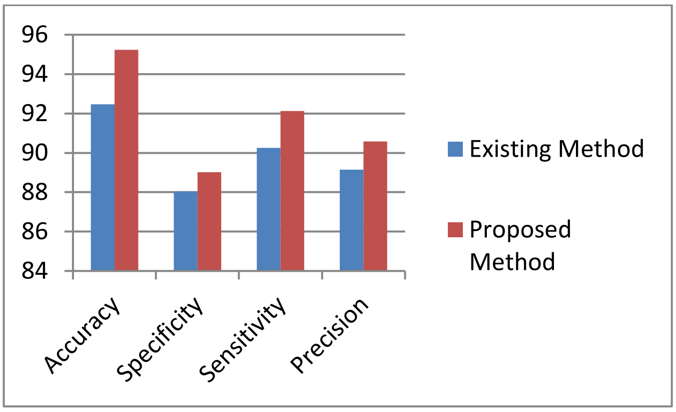

Figure 30: Comparison chart

VIII. CONCLUSION AND FUTURE SCOPE

The development of the Image Enhancing Algorithm for the detection of dangerous goods in airport security inspection represents a significant step toward bolstering aviation safety. The comprehensive methodology, spanning from input image processing to feature extraction and classification, demonstrates the algorithm's potential to enhance the accuracy and efficiency of security screening processes. Region of Interest (ROI)-based segmentation streamlines the focus on areas likely to contain dangerous goods. Feature extraction using the Gray-Level Co-occurrence Matrix (GLCM) captures textural information, providing a rich set of features for subsequent analysis. The integration of a Recurrent Neural Network (RNN) classifier enhances the algorithm's ability to automatically learn and classify features associated with dangerous goods. This ensures a high level of accuracy in the detection process.

Future Scope

Implementing mechanisms for continuous learning and adaptation would allow the algorithm to evolve in response to emerging threats. This could involve regularly updating the algorithm based on new data and insights gained from real-world security scenarios.

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