IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SURVEY ON AN X-RAY IMAGE ENHANCEMENT ALGORITHM FOR DANGEROUS GOODS IN AIRPORT SECURITY INSPECTION

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Abstract: An essential tool in airport security inspections, the X-ray image enhancement algorithm is used to increase the quality of X-ray pictures and find any potentially dangerous goods. By improving the quality and visibility of X-ray pictures using a variety of image processing techniques, the algorithm makes it simpler for security officers to recognise risky objects like explosives, weapons, and knives. The survey also shows that several algorithms have been created to improve the X-ray picture quality for airport security inspections. The local adaptive histogram equalisation technique is one such algorithm that has been demonstrated to enhance the quality of X-ray pictures and lessen the incidence of false alarms during security inspections. The survey also reveals the difficulties encountered while creating algorithms for X-ray image augmentation for airport security inspections. These difficulties include the requirement for precise and effective algorithms that can swiftly handle massive volumes of data as well as the requirement to protect passengers' privacy during security checks.

***Index Terms* - X-Ray, Image Enhancement, CLAHE, MATLAB, Dangerous Goods**

I. INTRODUCTION

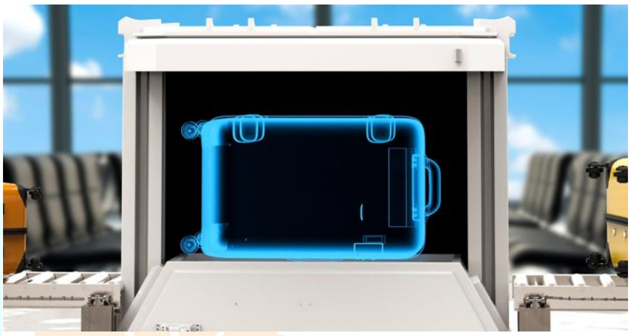
Airport security inspection of dangerous goods is a challenging task. There are a large number of dangerous goods passing through airports daily, and it is very hard to inspect each item manually. The security of airports is very important because there are many people who travel in them every day. The main purpose of airport security is to prevent any dangerous item that could harm passengers or staff. The purpose of this project is to develop a novel algorithm for detecting dangerous goods from an X-ray image. The algorithm will aid airport security officers in their inspection of luggage and other packages for threats such as explosives or weapons. This research is motivated by the need for improved security at airports due to the increase in terrorist attacks over the past decade.

Airport security is a vital component of the aviation industry, as it is responsible for protecting passengers and their luggage from potentially dangerous goods. One of the most critical aspects of airport security is the use of X-ray machines to scan luggage, which allows security personnel to view the contents of luggage and detect any hazardous items. However, the quality of X-ray images can be poor, making it challenging for security personnel to identify dangerous goods. This is particularly true for items that are dense, such as metals or electronic devices, which can obscure other items in the luggage.

To address this issue, researchers have developed an X-ray image enhancement algorithm that can improve the quality of X-ray images and make it easier for security personnel to identify dangerous goods. The algorithm uses a combination of image processing techniques, such as contrast enhancement, noise reduction, and edge detection, to improve the clarity and visibility of the images. The development of this algorithm has significant implications for airport security, as it can improve the accuracy and efficiency of security checks, reduce the risk of dangerous goods being transported on aeroplanes, and ultimately enhance the safety of air travel.

X-ray machines have become an essential tool for airport security personnel. These machines are used to scan luggage and detect any items that may pose a threat to passenger safety. However, the quality of the images produced by X-ray machines can often be poor, which can make it difficult for security personnel to identify dangerous goods.

Fig. 1 Baggage X-Ray Machine



One of the main challenges of X-ray images is that they often have low contrast, making it challenging to distinguish between different materials. This is particularly true for dense materials such as metals, which can obscure other items in the luggage. In addition, X-ray images can also contain noise, which further reduces their clarity.

II. Literature Survey

The sole methods [1] employed by the airport's baggage inspection system are DeepBoost, Histogram Equalization, and Crystal Clear. Adaptive Contrast Enhancement and Adaptive Unsharp masking methods were frequently used by screeners. The screeners also favour the following four improvement methods: LAS, Gray Level Slicing, High-Pass Filter, and High-Boost Filter. Enhancing X-ray images is essential for finding explosive or illegal materials. The techniques HPF, AUM, and ACE, which are intended to increase edge quality, exhibit the best performance, whereas DB and HE approaches do not perform well. In this study, we contrast both contemporary and traditional methods of X-ray image enhancement for baggage screening systems. It has been determined that certain novel technologies are superior to the current X-ray enhancement procedures frequently employed at airports.

Whether training screeners [2] using 2D multi-view imaging can identify IEDs using 3D imaging was explored by a team of researchers. Comparing 2D and 3D imagery has a lot of real-world applications. Screeners who have familiarity with multi-view 2D X-ray imaging may do visual inspections in 3D. Only fully operational homemade explosive devices are the only ones that hold baggage screening looks for (IEDs). Explosive detection systems on X-ray equipment are used to screen all held cargo (EDS). Visual inspection of alert locations is the responsibility of hold baggage screeners. The difficulties brought on by poor target visibility are eliminated by the potential for 360° rotation, which enables visual assessment from all sides. Using three distinct test scenarios, we assessed the effectiveness of 2D hold baggage screeners for visual inspection: Modern 2D multi-view imaging, more recent 3D rotatable imaging, and 3D rotatable imaging that adheres to an on-screen alarm resolution methodology (OSARP).

The goal of this study [3] is to better feature improvement, particularly Poisson and Impulse noise reduction, which is still causing 20% or more false alarms. The NASM effectively reduces Impulse noise that ranges from 10% to 50%. The quality of the recovered photos dramatically deteriorates for damaged images with noise densities above 50%. When used to severely damaged pictures, a Switching Median filter (SMF) with

Boundary Discriminative Noise Detection (BDND) produces workable results with noise densities as high as 90%. works effectively at eliminating impulse noise, even at 90% noise density. only up to 60% noise density can it function effectively. There are explanations for several noise models and noise kinds in digital photos. This study goes into great length into the Poisson noise that affects X-ray pictures, including its sources and effects that are uncertain for both the system and the screeners.

According to a study team led by Woong Kim at the Department of Industrial Management Engineering (2020) [4], following the September 11 attacks, nations all over the world started to bolster their aviation security against the transit of hazardous materials. The current detection methodology was primarily concerned with the overall image, but the identification of harmful items during the aviation security procedure must go beyond overlapping objects seen during X-ray screening. The segmentation U-Net structure served as the foundation for the development of the suggested model, O-Net. When several articles are overlapping within the luggage, it is more challenging to detect harmful products using airline security X-ray pictures. Guns and knives can be recognised as risky luggage items in the airline security procedure according to a segmentation model developed by Kim and colleagues. In terms of segmentation performance measures like pixel accuracy and m-IoU, three fundamental semantic segmentation algorithms were compared. O-accuracy Net's outperformed U-Net by 6.56%.

Vijayakumar Ponnusamy and colleagues (2021) [5] highlighted that the concerns that emerge in the automatic visualisation of X-ray luggage images may be regarded as standard picture classification problems in their paper, "Deep Learning-Based X-Ray Baggage Hazardous Item Identification - An FPGA Implementation." Around one million data samples and a wide range of class labels make up the vast number of datasets used to train contemporary Convolutional Neural Network designs. To guarantee transit security, X-ray baggage screening is mostly employed. The YOLO v3 model is used by the CNN architecture to perform classification operations quickly. Non-hazardous goods are contained in the green box, whereas hazardous items are encased in the violet box. The urgent demand is for the automatic identification of luggage containing dangerous items in the least amount of time. This process is used to construct the categorization system for hazardous and non-hazardous materials. The PYNQ board's FPGA serves as the primary processor.

The goal of this study [6] is to describe the new study areas and the state-of-the-art in luggage inspection at the moment.Three key variables might affect detection in the realm of luggage inspection: the point of view, which includes the occlusion, which depends on whether or not other objects are superimposed over the target object, and the pose, which is related to the rotation of the object; the type of X-ray image, which depends on the X-ray energies used in the image acquisition process; the number of objects present and how they are arranged in the bag; and the image complexity, which depends on these factors.

According to Nguyen and colleagues [7], Task-Driven picture cropping is a fresh and effective method for cropping security X-rays utilising the activation output of convolutional layers. They suggested that Task-Driven image Cropping (TDC), a cutting-edge and effective method for cropping security X-ray images using the activation output of the convolutional layers of the detection network to simultaneously achieve two goals, namely, a decrease in run time and an increase in detection accuracy. They demonstrated how TDC may significantly enhance detection techniques like Receptive Field Block (RFB)-Net by increasing mean Average Precision (mAP) or decreasing inference time. To benchmark the X-ray image detection tasks, we offered a fully annotated SIXray-D dataset with finished positive samples and annotation boxes. We suggested the TDC module, a cutting-edge task-driven picture cropping technique that can significantly enhance the pipeline for detecting X-ray images.

The techniques used for mathematical image modelling [8] are increasingly being replaced by convolutional neural networks (CNN). Security personnel now conduct visual inspections of x-ray pictures of travellers' checked bags and hand luggage at airport checkpoints. When augmentation and transfer learning were utilised, a sufficiently high recognition percentage was attained with a modest starting picture sample. One particular significant computer vision problem is the identification of hazardous things. The findings indicate that transfer learning is highly recommended. The team claims that when augmentation and transfer learning were utilised, a sufficiently high recognition percentage was reached with a relatively small starting image sample. The VGG-19 network produced the greatest findings and is suggested for more study.

Table 1: Relevant studies on advantages and disadvantages of approaches to the image enhancement

Related Studies	Advantages	Disadvantages	Methodology
[1]	Commercially viable methods. The literature is examined using 13 enhancing approaches with Histogram Equalization and Crystal Clear.	No implementation is proposed.	• Five methods for improvement, are AUM, LAS, HPF, HBF, ACE, and AUM. • Based on viewability metrics, these approaches are contrasted with Deep Boost (DB), Crystal Clear (CC), and Histogram Equalization (HE).
[2]	The difficulties caused by limited target visibility due to perspective or superposition effects in 2D imaging are eliminated or at the very least significantly reduced, by the option of 360° rotation permitting visual examination from all sides.	When holding luggage was presented using 3D imaging as opposed to 2D imaging, and much more so when OSARP was used, screeners needed more time.	• 2D, 3D and OSARP. • They discussed two theoretically and practically relevant concerns. First, by replacing 2D multi-view X-Ray equipment at airports with cutting-edge 3D CT technology. Second, it was examined if a certain OSARP would improve screeners' detection ability while employing 3D imagery.
[3]	Reviewed a number of publications along with their benefits and drawbacks.	--	• X-Ray Imaging, Carry-On Baggage Inspection Systems, Dual-energy X-Ray image fusion, Image enhancement factors • They did a thorough literature evaluation on a number of the significant issues examined in this field of study.
[4]	The average pixel accuracy was increased by 5.8%, 2.26%, and 5.01% on average while the m-IoU was increased by 43.1%, 9.84%, and 23.31% on average when comparing O-Net to simple segmentation models like FCN, U-Net, and SegNet based on these metrics.	The cost of computation is substantial.	• U-Net Segmentation The accuracy of O-Net was 6.56% greater than that of U-Net, demonstrating the O-Net architecture's superiority.
[5]	The outcome demonstrates that the suggested implementation is ideal for real-time baggage scanning system deployments in realistic settings.	The PYNQ-Z1 board is used to implement the programme on the FPGA. Python porting using FPGA presents challenges, such as data representation.	• Process delays are optimised using an FPGA platform, or Field Programmable Gate Array. • The FPGA implementation results demonstrate that the YOLO implementation can categorise X-ray luggage pictures and identify hazardous goods with a maximum accuracy of 98.9% while using fewer resources.

Related Studies	Advantages	Disadvantages	Methodology
[6]	We have shown that the adoption of methods based on contemporary computer vision for X-ray testing in baggage inspection is quite promising, but it has been somewhat gradual in compared to other computer vision applications.	There are still a lot of unmet needs in the field of baggage inspection, including those related to efficient identification methods, throughput, pose difficulty, (self)-occlusion, and picture complexity.	• X-ray energies, X-ray multi-views, X-ray computer vision • They come to the conclusion that while there have been a number of results for this specific problem in recent years, it is very difficult to compare the performances of the proposed methods and, as a result, know the real advancements in this field due to the lack of public databases or expertise that provide standardised experiments.
[7]	To benchmark the X-ray image identification tasks, a fully annotated SIXray-D dataset with finished positive samples and annotation boxes was proposed.	Sensitive to the impact of preserving the aspect ratios of conspicuous items and does not use the loss to regulate the threshold of the cropping approach.	• TDC algorithm • Compared to RetinaNet and SSD Net, RFB Net performs better. For feature extraction, both SSD and RFB employ the reduced VGG-16 backbone.
[8]	When augmentation and transfer learning were utilised, a sufficiently high recognition percentage was attained with a modest starting picture sample. Particularly, the VGG-19 network produced the greatest results.	Requires a huge dataset, and the cost of processing is expensive.	• U-Net, GoogleNet, VGG-19 • A 93.018% accuracy rate is attained.

III. Methodology

To address these issues, researchers have developed an X-ray image enhancement algorithm that can improve the quality of X-ray images and make it easier for security personnel to identify hazardous goods. The algorithm uses a combination of image processing techniques to enhance the contrast, reduce noise, and sharpen the edges of the images. The first step in the algorithm is to improve the contrast of the image. This is done by stretching the intensity values of the image to cover the entire range of values. This process helps to enhance the contrast between different materials in the image and makes it easier to distinguish between them.

The next step is to reduce the noise in the image. This is done by using filters that can remove the noise while preserving the edges of the image. The filters used in the algorithm are designed to remove the specific types of noise commonly found in X-ray images, such as Gaussian noise and salt-and-pepper noise. Once the noise has been removed, the algorithm sharpens the edges of the image. This is done by using edge detection techniques to identify the edges of the objects in the image and then applying a sharpening filter to these edges. This process helps to make the edges of the objects in the image more distinct, which can make it easier for security personnel to identify hazardous goods.

The X-ray image enhancement algorithm has been tested on a variety of X-ray images, including those of luggage containing dangerous goods such as explosives, firearms, and knives. The results have shown that the algorithm is effective in improving the quality of X-ray images and making it easier for security personnel to identify potentially hazardous items. The development of this algorithm has significant implications for airport security. By improving the quality of X-ray images, the algorithm can make security checks more accurate and efficient, reducing the risk of dangerous goods being transported on aeroplanes. This, in turn, can enhance the safety of air travel and provide passengers with greater peace of mind.

IV. Conclusion

The X-ray image enhancement method was created to increase the quality of X-ray pictures used in airport security screenings. The ability to scan bags and identify any objects that might endanger passenger safety makes X-ray equipment a necessary tool for airport security staff. Nevertheless, X-ray equipment frequently creates poor-quality pictures, making it difficult for security officers to distinguish between harmful objects. The X-ray image enhancement algorithm enhances the contrast, visibility, and clarity of the pictures by combining edge detection, noise reduction, and other image processing techniques. The algorithm has been put to the test on several X-ray pictures, including ones of bags containing dangerous items like explosives, weapons, and knives. The outcomes have demonstrated that the algorithm is successful in enhancing the quality of X-ray pictures and making it simpler for security staff to recognise potentially dangerous goods.

The creation of this algorithm will have a big impact on airport security. The algorithm can increase the accuracy and efficiency of security inspections and lower the risk of dangerous commodities being flown on flights by enhancing the quality of X-ray pictures. This can thus increase the safety of flying and provide passengers with more peace of mind. The algorithm may also be included in the current airport security systems, which enables security officers to utilise it to improve the quality of X-ray pictures without the need for extra tools or training. As a result, airports may find it simpler and more affordable to upgrade their security protocols and keep up with evolving threats.

By lowering the incidence of false alarms, the X-ray image improvement technique can also lessen delays and interruptions to air travel. Lowering the possibility of terrorist attacks and other criminal activity, it can improve passenger and crew safety. The algorithm has the potential to be a vital resource for security workers at airports throughout the world. The algorithm has the potential to be even more successful in enhancing the quality of X-ray pictures and making it simpler for security officers to recognise potentially dangerous things with additional research and improvement.

An important advancement in airport security is the X-ray image enhancement technique, to sum up. The accuracy and effectiveness of security inspections may be increased, the risk of dangerous commodities being transported on aircraft might be decreased, and ultimately the safety of air travel could be improved. The algorithm has the potential to be a crucial tool for airport security professionals throughout the world with future improvement and incorporation into current airport security systems.

V. Acknowledgment

It is our proud privilege and duty to acknowledge the kind of help and guidance received from several people in preparation for this report. It would not have been possible to prepare this report in this form without their valuable help, cooperation, and guidance.

First and foremost, We wish to record our sincere gratitude to the Management of this college and to our beloved Principal, Dr. B Sadashive Gowda, Vidyavardhaka College of Engineering, Mysuru for his constant support and encouragement in the preparation of this report and for making available library and laboratory facilities needed to prepare this report.

Our sincere thanks to Dr. A B Rajendra, Professor and Head, of the Department of Information Science and Engineering, VVCE, for his valuable suggestions and guidance throughout this report.

We express my sincere gratitude to my guide, Dr A B Rajendra, HOD, Department of Information Science and Engineering, VVCE, Mysuru for their encouragement and advice throughout the course of the project work.

My numerous discussions with her were extremely helpful. I hold her in esteem for the guidance, encouragement, and inspiration received from her.
In the end, we are eager to offer our sincere thanks to our family members and friends for their valuable suggestions and encouragement.

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