Digital Image Processing

An X-Ray Image Enhancement Algorithm for Dangerous Goods in Airport Security Inspection

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I hereby affirm that the project titled ″**An X-Ray Image Enhancement Algorithm for Dangerous Goods in Airport Security Inspection**″ has been conducted by the following individuals under my guidance:

Dr. Suvendu Rana

I certify that the work submitted is legitimate, unique, and suitable for submission to SRM University – AP in order to complete the requirements for the School of Engineering and Sciences' Bachelor of Technology degree.

Supervisor

(Signature)
Dr.Suvendu Rana
Designation, Affiliation

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Lastly, we appreciate everyone who supported us directly or indirectly in successfully completing this project.

Objective:

Study the problem of "airport security X-ray image enhancement", and propose an image enhancement algorithm of USM+CLAHE.

Abstract:

An X-ray image enhancement algorithm combining USM+CLAHE is proposed to address the problem of colour distortion in CLAHE enhanced airport security X-ray images.
First, compute grayscale images on the R, G, and B channels of the X-ray image, then perform CLAHE enhancement on the enhanced R, G, and B grayscale images. Following that, perform the USM sharpening operation on the CLAHE-enhanced X-ray image, and finally merge the original image and the USM sharpened image
based on the weight. The experimental results show that the USM+CLAHE algorithm can effectively enhance the security X-ray image while suppressing the enhanced image's colour distortion.

Keywords: Airport security, X-ray image, USM, CLAHE, Image enhancement

Introduction:

X-ray technology is frequently used in airport passenger security inspections and other situations because it has the benefits of causing little damage to objects, eliminating the need to open the box, safety, reliability, and ease of use. The degree of X-ray absorption and scattering attenuation of objects made of various materials varies, and the resulting X-ray images produced by the objects also vary in colour. Security personnel can recognise prohibited items carried in luggage and packages, such as controlled knives and guns, by combining morphological characteristics like edges and shapes. They are more likely to overlap, block, and mix because there are so many different types of checked luggage and packages. Additionally, objects are easily influenced by different interference factors when X-ray images are being created, and the gathered security X-ray images may exist. Background noise, low contrast, and blurry objects are all present. It is necessary to enhance the security

X-ray image to highlight the colour, edge, shape, and other details of the various items in the image in order to facilitate the security personnel's identification of the items in the image. This will help to ensure the safe operation of the airport by allowing the security personnel to identify the inspected items more accurately and quickly.

Contrast Limited Adaptive Histogram Equalization (CLAHE) :

The most popular image enhancement technique is histogram equalisation (HE), which has the advantages of a simple and direct theory, easy implementation, and good real-time performance. Contrast Limited Adaptive Histogram Equalization (CLAHE) is a local histogram equalisation enhancement algorithm that is based on the local adaptive histogram enhancement algorithm (Adaptive Histogram Equalization, AHE). By using a fixed threshold, the limiting method effectively suppresses the excessive amplification of local contrast and noise, making it particularly suitable for low-contrast images.The CLAHE algorithm combines the advantages of two technologies, adaptive histogram equalization and limited contrast.

Algorithm Based on USM+CLAHE:

1. Image sub-region division: The original image is divided into multiple sub-regions of equal size, each subregion does not overlap each other and is continuous with each other, and the number of pixels contained in each subregion is C. The larger the sub-area, the better the enhancement effect, which can usually be adjusted according to actual needs.
2. Calculate the histogram: use Hij(k) to represent the histogram of a certain subregion, k represents the gray level, and its value is [0, L−1], and L is the number of gray levels.
3. Calculation limit value: Calculate the cutoff limit value

   showed in "(2)" $\beta=C/L(1+\alpha/100(s_{max}-1))$

   β is the calculated limit value α is the cutoff coefficient s_{max} is the maximum slope

USM Sharpening

The traditional unsharp mask (USM) operation can eliminate some minute interference details, but the sharpened image that results is sensitive to vibrations and false edges. As a result, the USM algorithm and threshold are used in this project.

Industrial Use

Airport Security

> *"Enhanced X-ray images significantly improve the identification of prohibited items such as weapons or explosives in airport luggage screening. By reducing noise and improving contrast, our algorithm ensures faster and more accurate detection, reducing reliance on manual inspection and enhancing operational efficiency in high-throughput environments."*

Customs and Border Control

> *"Customs agencies rely on X-ray imaging to detect contraband, hidden compartments, or smuggled goods. Enhanced imaging clarifies visual ambiguities, making it easier to detect illegal substances or hidden materials in cargo and luggage scans."*

Medical Imaging

> *"The healthcare sector benefits from improved diagnostic accuracy through better X-ray clarity. Enhanced images highlight critical features like fractures or tumors, reducing the likelihood of diagnostic errors and minimizing the need for repeated scans."*

Non-Destructive Testing (NDT)

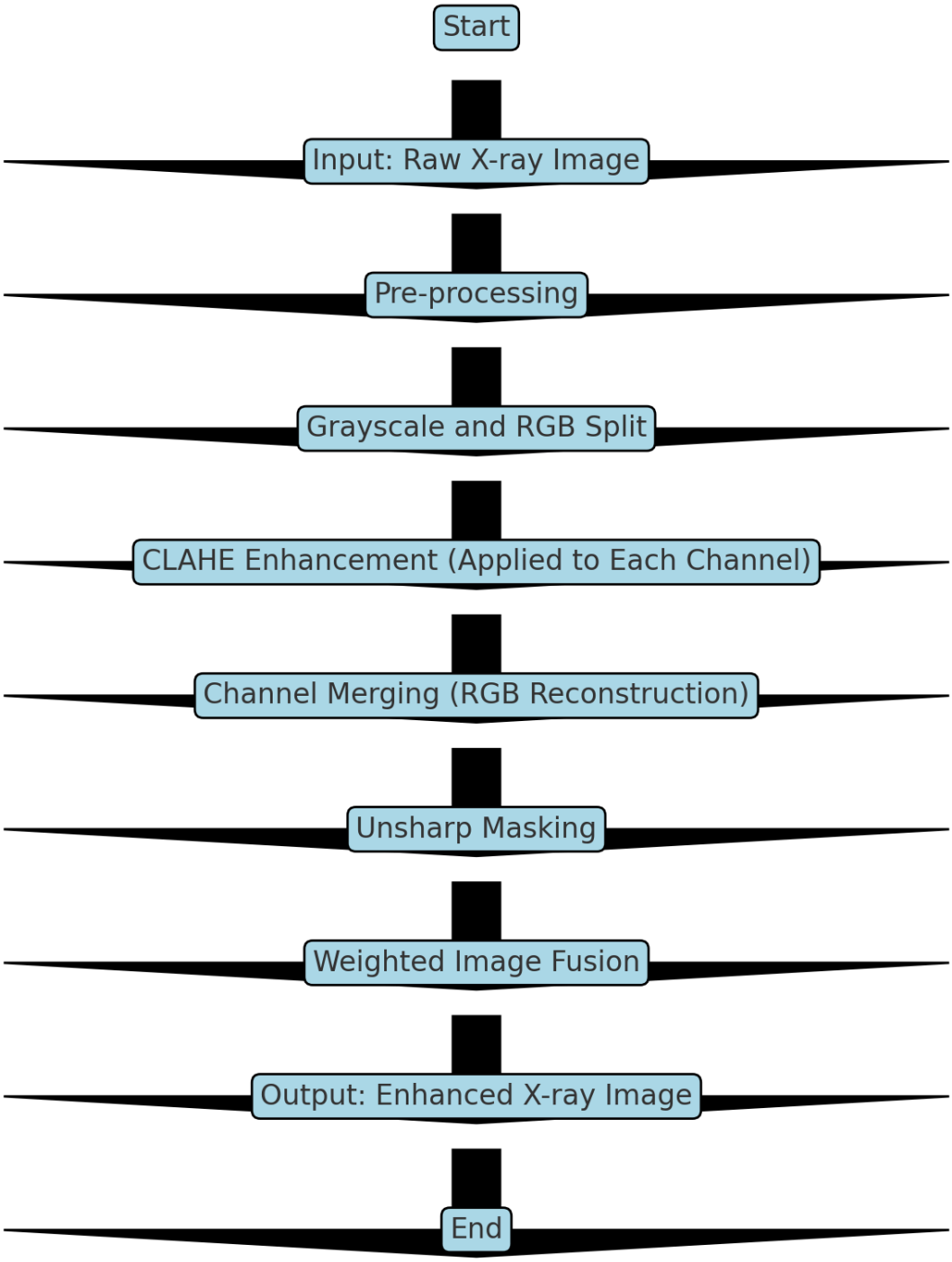
> *"In manufacturing, enhanced X-ray imaging detects internal flaws such as cracks or voids in materials without damaging them. This ensures the reliability of components in industries like aerospace and automotive, where safety and precision are paramount."*

Food and Beverage Industry

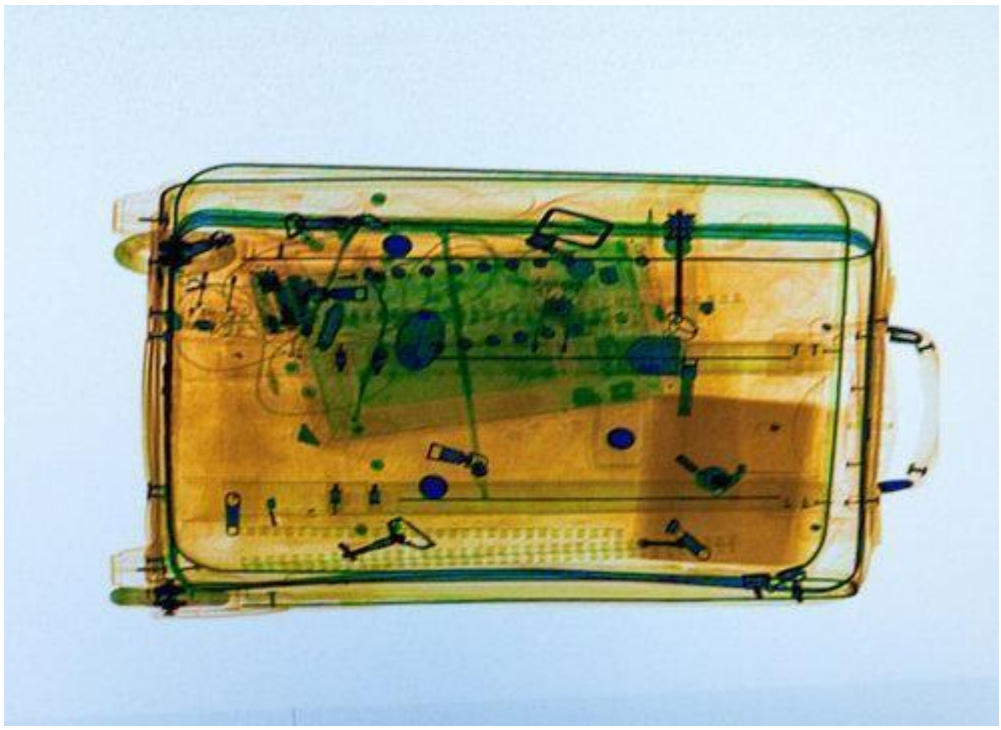
> *"Food manufacturers use X-ray imaging to detect contaminants such as glass, metal, or plastic in products. Our algorithm improves visibility and ensures stringent quality control, preventing defective products from reaching consumers."*

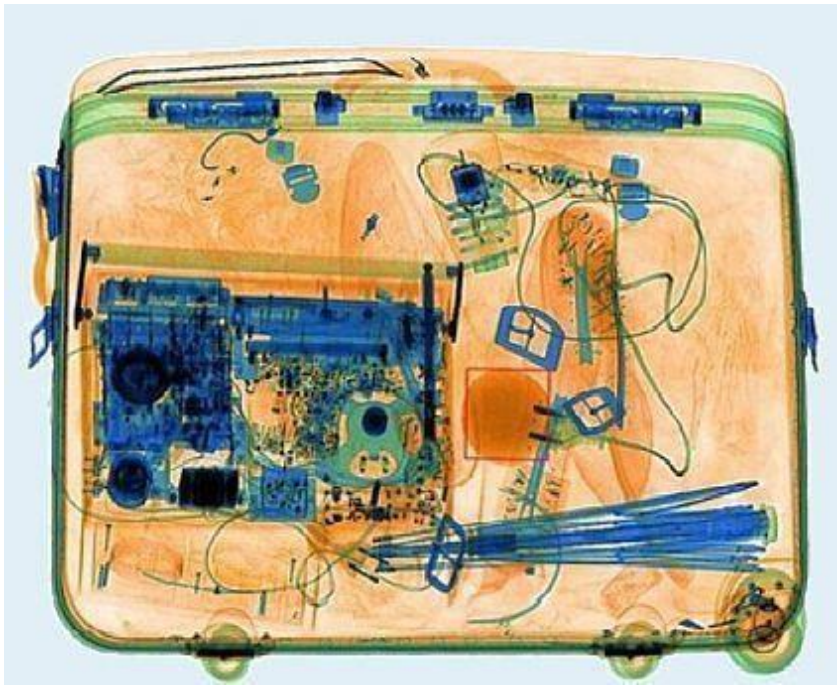
The proposed enhancement algorithm demonstrates wide-ranging industrial applications, addressing critical challenges in X-ray imaging. By improving contrast, reducing noise, and sharpening features, it enhances the reliability and efficiency of X-ray systems in diverse sectors."

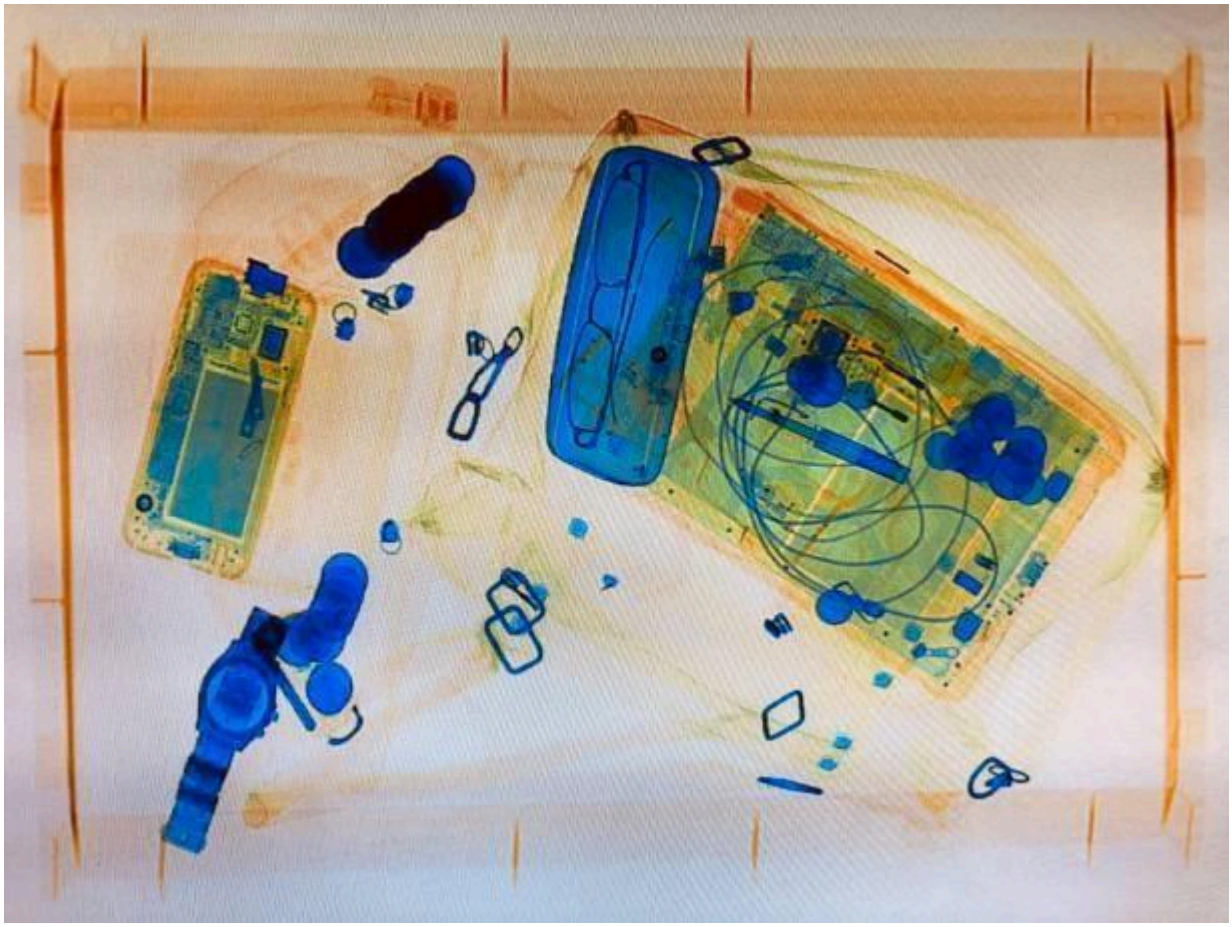
Algorithm :


Start
Input: Raw X-ray Image
Pre-processing
Grayscale and RGB Split
CLAHE Enhancement (Applied to Each Channel)
Channel Merging (RGB Reconstruction)
Unsharp Masking
Weighted Image Fusion
Output: Enhanced X-ray Image
End

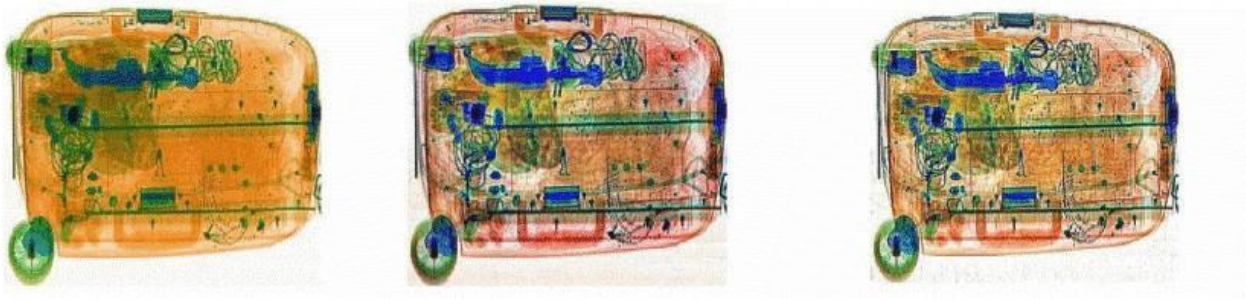
FINAL OUTPUT IMAGES :







COMPARISON OF IMAGES:



(1) **(2)** **(3)**

1. **ORIGINAL IMAGE**
2. **ENHANCEMENT IMAGE RESULT OF CLACHE**
3. **ENHANCEMENT IMAGE RESULT OF PROPOSED**

Conclusions:

The experimental platform to study the problem of “airport security X-ray image enhancement”, and proposes an image enhancement algorithm of USM+CLAHE. This algorithm can significantly enhance the X-ray image of common items in airport security checks, and can effectively suppress the color distortion of the image after enhancement. It is an effective image enhancement algorithm. The next step will be to optimize the algorithm to further improve the image color fidelity and eliminate background noise**.**

Reference:

https://ieeexplore.ieee.org/document/9407728