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Original Article

Detection of Airport Disguise and Threat Objects using Shortwave-Infrared Imaging and Machine Learning Techniques

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Abstract - *Aiming to solve a problem that involves humans disguised with fake facial hair and skin at airport security inspection. By X-ray imaging for scanning of luggage to prevent security threats such as threat object detection. With the help of a Short wave-Infrared (SWIR) imaging camera, it can be detected whether a person is in disguise or not. As SWIR has 1-2 µm of spectral range, it can differentiate the real facial hair and skin colour between fake facial hair and skin colour in the image. The luggage is the most vulnerable place where threat objects could be hidden inside any amount of luggage. X-ray imaging technology is most suitable for scanning because every material has a different degree of absorption of X-ray, and different items scatter the X-ray differently by which different colours could be obtained. Machine learning will be implemented to these images by which the detection of unwanted objects is identified in a possibly effective way. An automatic alarm will be sent to any defence system available to oversee the detected object and make way for further investigation. In contrast, the SWIR system is used to detect and disguise the person being investigated by the authorities on the spot. The threat object detection could be done by implementing specialized libraries in machine learning like Keras with Tensor Flow, OpenCV and Convolution Neural Network. With the combination of the above technologies, disguise detection and threat objects could be covered, which makes the airport security more secure and less vulnerable to any kinds of attacks.*

Keywords - *Face Disguise Detection, Threat Object Detection, Shortwave-Infrared, Machine Learning, Airport Security.*

I. INTRODUCTION

Airport security is considered to be the most secure system, as a large number of innocent lives depends on that security system. There is no room for any kind of error to ensure all forms of security. If this security is off-balance, then the entire country could be in danger. To ensure security, Transportation Security Administration (TSA) was created by the United States Congress on November 19, 2001. The Aviation and Transportation Security Act ensures that TSA is responsible for all kinds of security in transportation [1-3]. Irrespective of all the security measures taken, crimes are frequently happening as time passes by. Every time the security system faces a challenge, the system is updated accordantly. The security systems have evolved to be more effective with the help of technology for scanning specific materials in order to detect unwanted items. As the crimes are being well planned, the need for technology with good engineering is the best way to prevent all those crimes. All the security protocols take a lot of time to go through all the passengers as the number of passengers is gradually increasing. With the help of modern machines, we can speed up the process of security procedures. Current technologies are Advanced Imaging Technology (AIT), Advanced Technology X-ray (AT-2), Explosives Trace Detection (ETD), Explosives Detection System (EDS). Further, the security can be enhanced by confirming a person's face with his id proof, where the id proof is stored in a database with respect to id number and photo, a camera can be used to cross verify the Pearson's id number with his face. Face recognition can be done by extracting facial features using a pattern recognition system called face localization. This can be achieved by MATLAB and Open CV. A prototype or a system can be created to detect faces [4-7].

There are various algorithms for effective detection, but the accuracy and efficiency of the algorithm should be considered in order to implement a better system; by the use of Multi-task Cascaded Convolutional Networks (MTCNN), an enhanced face and eye detection can be performed [8-10]. When it comes to scanning luggage, we use advanced technology in X-ray, which scans for any unwanted items. It is very important to scan each and every piece of luggage as fast and effective as possible. For detection of unwanted items is done manually, which is not effective and fast.

Instead, we can implement a machine learning model which detects faster and in a very effective way. To create and implement a machine learning model, we use a conventional neural network which is called a deep learning algorithm for computer vision tasks and image classification [11-13]. By this, the model can see through the luggage and can detect unwanted materials. Human verification can be compromised by many variables depending on certain conditions, whereas the Machine Learning Model (ML Model) cannot be compromised by the same variables. Of course, the security of the system should be maintained, and if there is any breach in the system, humans can take control of it. This ensures that if there are any unwanted items, then an alert can be sent to verify. By all the security measures mentioned, the security system can be more effective and can reduce the crime rate drastically, which is very much helpful for the entire country.

II. PRIOR ART

When it comes to security, the aviation industry should be given the most important because the nation's security depends on it. At present, the security measures which are being taken by the airport security systems are discussed. AIT is used to detect any metallic threat objects like guns or non-metallic explosive material items if they are hidden under a passenger's clothes. There are two methods for this task, the backscatter X-ray and the millimetre wave scanner. The backscatter X-ray scanner uses a very small amount of weak X-ray that only penetrates cloths but not skin. This creates an image of if anything is hidden under clothes. The millimetre wave scanner uses microwaves which is non-ionizing, and it is much safer than the backscatter X-ray; the image is created if there is anything hidden by the passenger [1-3]. AT-2 is used for checking luggage by scanning than for threatening objects or any other harmful items. It uses X-ray the detect objects inside the luggage, one side of the machine emits both high and low energy X-rays simultaneously, which passes through all the objects in the luggage, and they hit the detectors on the other side, now as the X-rays have passed through the luggage, objects inside the luggage have absorbed some X-rays [4-7].

Lower density objects made up of organic materials allows lower-energy X-rays to pass through them. Things with a higher density like metal could be absorbed maximum of low energy X-rays and allow only a minimum of the higher energy X-rays to pass through them. Now the X-rays which have reached the detector creates an image that shows all the objects that are present, with different colours based on their density. The security analyses specific patterns such as an outline of a gun or a bunch of organic materials hidden inside an object or, there are algorithms that detect such kinds of patterns and alarms the security. If there are any explosive compounds inside the luggage, then the ETD detectors will trace the suspicious compound, and it will be analyzed by the Ion Mobility Spectrometry (IMS) process. This is a secondary screening process. A sample of the swab is collected and is placed inside the machine. The machine gives the molecule on the swab an electric change, turning them into ions. These ions are carried by gas through a tube, different ions will take a different amount of time to pass from start point to endpoint in the tube, and this depends on the mass and charge of ions. Now the machine calculates the amount of time taken for the ions to travel through the tube. Different ions take a different amount of time to pass. By this, the difference in compounds can be determined [8-10].

EDS is also used to screen checked luggage by the TSA, and it also uses Computed Tomography (CT) technology. This process is done before the luggage is loaded to the plane, and to produce images X-ray is used. By all these technologies, the current airport security system is being operated. Machine learning models are being used to recognize images with similar patterns present in them. With the help of a conventional neural network, a model can be created, and all the patterns related to threat objects can be detected. In order to create a model for threat detection, we need algorithms to perform the work effectively. X-ray enhance algorithms are used to get a clear image of the objects that are being scanned [11-13].

For enhancing the image algorithm process, we can use Contrast Limited Adaptive Histogram Equalization (CLAHE) enhancement. In this, the calculation of grayscale images on the R, G, and B channels of the x-ray and the process of CLAHE enhancement can be done respectively, and for sharpening the image Un-Sharp Masking (USM) can be used. When it comes to face detection, it is being detected with the help of three basic steps such as face detection, face recognition, and face extraction [14-16]. There are few airports with face and fingerprint scanners to verify the passengers, but disguise detection is not possible by just recognizing the patterns between different faces. Fake facial covers must detect precisely on a person. Detecting a face can be done with the help of a camera at the airport, but with this regular camera, only the face can be detected. Our goal is to detect a disguised face. The shortwave-infrared camera can detect different wavelengths for real skin and fake facial skin. By this difference in the wavelength, there will be a difference in the colour of the image. With the help of this image, that person can be verified to make sure that he is no threat to anyone.

III. PROPOSED METHODOLOGY

The idea of this article is to detect disguised people at the airports, and security systems can not only rely on biometric scanners as it takes a lot of space, and it's difficult to scan every passenger for their biometrics. Hence to solve the issue, facial recognition could be used in all the checkpoints. Facial detection includes eye and faces patterns as a basic component to perform the detection process, and this can be done with the help of detection based on MTCNN. Based on the experimental results, the MTCNN method is much better than most other existing methods. Only face recognition will not improve the security system. Face detection along with a system to identify the disguised face will definitely improve the security system. Facial recognition with disguise detection can be used in border security and surveillance too. As all objects have a different refractive index, their wavelength is also different. This difference cannot be seen by visible light, but with shortwave-infrared light, the difference can be easily detected. For example, during disguise detection, if in case a person is disguised with fake facial hair, then the fake hair will be darkened in the image. On the other hand, real facial hair will appear to be lighter as its wavelength is about 0.7 microns to 2.0 microns. This can be observed in the SWIR part of the spectrum [17-20].

The SWIR camera produced images will be in black and white, which can create a slight difficulty in identifying the image all of a sudden, meaning the SWIR image does not match human intuition, but when the image is observed with a bit of time, there will be no problem, as in airport all the process should be quick and effective, the identification of the images should also be fast. To solve this problem, tone mapping for shortwave infrared images can be done. In this, the SWIR image can be converted to a more similar image as they appear in the visible band. With the help of two different functions, the image can be optimized. The first mapping function is used to apply for skin pixels, and the other function is used to apply for hair pixels. With the help of these functions, the image can be optimized [21].

IV. PROGRAMMES AND TECHNIQUES

A collection of images with fake facial hair and skin can be created to train the model. A model with a machine learning model could be developed to identify the differences in the SWIR image and can be alarmed when needed. The model will be able to identify these changes efficiently in the SWIR images only if we train the model with a large number of data set, the identification efficiency will increase accordingly, and the processing time will increase too. To implement this project, a text editor to code python can be used. Python programming language can be used to do this project because of its wide range of libraries and coding advantages offered by python will be really useful in order to create this project effectively by all possible terms. Data collection can be done with the help of OpenCV and its library that deals with real-time computer vision.

A conventional neural network algorithm can be used to carry out this project which is most needed and is the heart of the project. For improving the performance of the model, a large data set is required, along with the development of the existing data set. When the luggage is scanned, there will be colour distortion which makes the image not clear for examination, and this can lead to misjudging the image. Minor misjudging of an image caused by the colour distortion can lead to compromising the security, and threat objects could pass through the scanners by this problem. The solution to solve this problem is to implement an algorithm that handles the colour distortion problem. The enhancement algorithm (USM)+CLAHE can be used. This algorithm can reduce colour distortion significantly by enhancing X-ray scan images. CLAHE can enhance the image by automatic image contrast adjusting by grayscale transformation and can also adjust the image contrast by calculating the local histogram of the image and then the brightness of the image will be redistributed evenly, which improves the image quality and this will make precise detections. USM is used to sharpen the image, and the main objective is to observe and recognize the shape and size of any object in the X-ray images.

So, the sharpening algorithm is used to make the image more clearly visible and can be detected more effectively. It is a process of making the edges clear in an image. The principle for the USM technique is to first extract high-frequency components from the image and next superimpose it with the original image with the help of specific rules. Then finally, after all these processes, the final result can be obtained. Afterimage is sharpened by USM and enhanced by CLAHE, the edge, shape, and other details in the image will be enhanced; by this, all the items in the image can be identified. The security system can be more secure by the implementations of the discussed methods, algorithms and upgrades. By this, the rate of criminal cases can be reduced, and all the people can travel without any compromise in the security system.

V. RESULTS AND DISCUSSIONS

The expected results will be a SWIR image that shows any disguised person, and this outcome is not from an experiment, but the outcome will be as such. Figure1 shows the original image in the visible spectrum range, and it is from a normal camera.

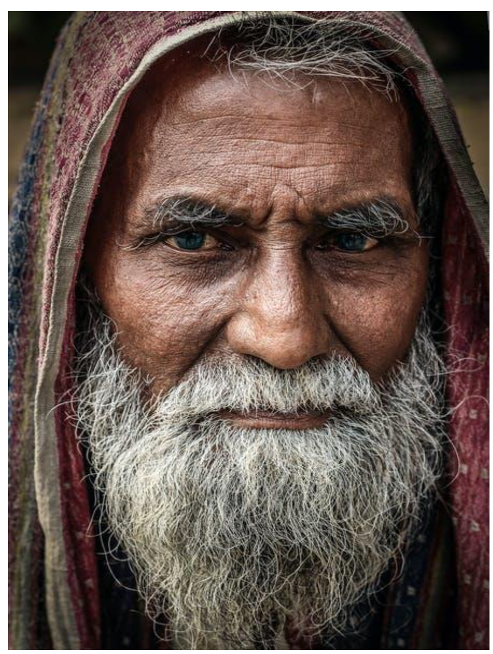

Fig 1. Original Image

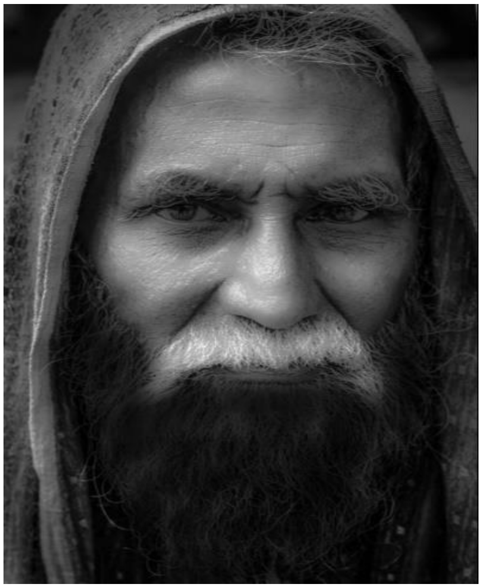

Fig 2. Short Wave Infrared Image (1-2µm)

Figure 2 is an image taken by a SWIR camera, and it is a short wave infrared image within the spectrum range of 1-2µm, and hence it is in black and white image. But the beard part is darker than the moustache as the beard is fake facial hair, whereas the moustache is real facial hair. Fake facial hair's wavelength is different from the real facial hair; hence the difference will be observed.

Fig 3. Image by Machine Learning Model

VI. CONCLUSION

The disguise detection method to be implemented at the airport to improve the security system has been discussed. Disguise detection could be carried out with the help of a SWIR camera which will show the difference between real facial hair or skin and fake facial hair or skin. This is done as the wavelength is different between real and fake hair and skin. A machine learning model is to be trained to detect these patterns and thus can be notified respectively. Luggage is also to be scanned by X-ray to identify and detect threat objects with the help of algorithms which enhances and sharpens the objects in the scanned image.

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