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An Effcient, Automatic Abandoned Luggage Detection using DenseNet for Intelligent Video Surveillance Systems

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Abstract

Over the past few years, terrorism has been rising in many parts of the world. Most of the terrorist attacks employ different kinds of bombs and explosives. Compared to the frequently used bombs like suicide bomb, car bombs, barrel bombs etc., luggage or baggage bombs can be prevented easily using a surveillance system. The preclusion of such explodes is made possible by detecting and tracking different luggage and its owner in public areas like airports, railway stations, malls etc. by using the surveillance camera installed in that area. The method proposed in the paper automatically detects and tracks abandoned luggage items in the crowded areas using DenseNet. Haar cascade classifier is used to distinguish human beings from the luggage. Finally the distance between the luggage and its owner is determined to identify and track the abandoned luggage when the owner walks away from it. Comparative study of various methods for abandoned luggage detection reveals that the present work significantly reduces the false alarm rate and improves the overall performance.

Keywords: *DenseNet, Haar Cascade Classifier, CNN, CCNN, Abandoned Luggage Detection*

1. Introduction

Most of the terrorist attacks take place in highly crowded public areas such as malls, airports, railway stations and places of tourist attractions. Abandoned luggage is a potential threat in public areas. Attacks can be prevented to a huge extend in such areas by employing automatic surveillance systems. The video from the cameras installed in a particular area is usually analyzed by the concerned staff. The manual method is time consuming as well as not efficient due to the carelessness and fatigue of human. Hence, to detect suspicious items which are abandoned by its owner, an automated surveillance method is proposed. In the proposed method all the luggage items in the scene are initially identified by using DenseNet architecture. In the second stage, owners of these identified items are detected and tracked. Once the owner leaves the baggage unattended, an alarm is raised and the owners face is recognized.

Initially abandoned luggage is detected using convolutional neural network (CNN) followed by a cascaded CNN (CCNN) is used. The efficiency between traditional CNN, cascade of CNN and DenseNet architectures are studied . In the CNN architecture information has to pass a long way to get the correct result and may get lost before it reaches the output. Hence DenseNet architecture is used in deeper networks as every layer is connected to each other. By connecting layers, DeneNets require lesser parameters when compared to traditional convolutional neural networks. DenseNet layers are more tapered than equivalent CNN or ResNets as they only add a small set of feature-maps.

The rest of the paper is organized as follows. Section 2 reviews the literature in the abandoned object detection. Proposed method is presented in section 3. Results and discussion is given in section 4 and a conclusion in section 5.

2. Related Research

Abandoned luggage detection has become an active research area over the years due to the rapidly growing need for security. Researchers found many methods for detecting and tracking abandoned luggage over a decade but those techniques cannot reach in the expectation level.

The review of related literature explains the diversity of applocationsof luggage detection in crowded areas and there are many promising results for improvements in the false alarm rate which has

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been reported in the literature. Fore-ground mask sampling and selective tracking methods are used to carry out luggage detection in [1]. The first method is used to localize abandoned luggage items and the second method provides information on the location of the item. These methods are mainly used to identify and locate luggage and track its owner by searching the locality. A two phase deep learning method in [2] reduces the false alarm rate. In the first phase, the unattended object is detected and it is identified as a luggage and the second phase checks whether the luggage is abandoned or not by using deep learning similarity matching.

Convolutional network is one of the efficient methods used for baggage detection. It can be more deep and accurate if it has lesser connections between each layer. Dense Convolutional Network presented in [4] established links of each layer to every other layer in the network. Each layer uses the feature-maps of former layers as inputs. The network is more precise if the layers are connected in a feed forward fashion [5].

The authors explain the Haar cascade method in [6] to identify human faces with different lightings for improving the clarity of the image. Even though the human face has varied color and shape, it will produce issues comparing to other object images. Face detection algorithms are used to identify the existence of faces in a picture. Haar feature is used to locate and spotted the faces. Authors in [6] presented a wavelet-based Haar which is a single rectangle wave with one high interval and one low interval. In the two dimension (2D) images, there is one light side and one dark side. The method initially converts the real image to gray scale. Because facial object in grayscale image will have the same pattern as in colour images such as cheeks or nose color is lighter than eyes color.

Authentication using face recognition in surveillance cameras or CCTV is by far one of the common security activity [7]. One of the main security concern is to detect the appearance of humans in a particular space or room. Each and every person entering the building will go through multiple authentication processes. In the future these information's can be used for different security purposes. There are many different ways to identify the presence of humans in a building. One of the most commonly used authentication technique is biometric-based method even though it takes a long processing time. Haar cascade classifier can be used for face identification. The method required the persons position their faces towards the scanner as in the fingerprint scanner.

In practical situations the methods described above can be used in stages to identify the abandoned luggage item from the scene and to identify the owner effectively. DenseNet can be used to detect abandoned luggage more effectively than the traditional CNN and the human abandoning the luggage can be spotted using Haar cascade classifier. This paper proposes a method to identify an abandoned luggage in a crowded scene with the reduction of false alarm rate using a dense network.

3. Proposed Architecture

The proposed method finds abandoned luggage in a crowded scene using DenseNet as a two-stage process. In the first stage, all luggage items in the scene are detected and its corresponding owners are detected in the second stage. There are many improvement reported in literature to detect and identify the abandoned luggage. In this paper luggage detection using convolutional neural network (CNN), cascaded CNN (CCNN) and DenseNet are presented. The following subsections describe the details of each method.

A. Static Luggage Detection using CNN

Video from the surveillance cameras installed in a particular area is retrieved and pre-processed. Once the foreign objects in the scene are detected it is recognized using a deep learning method called convolutional neural network (CNN) [14].

Initially the video is split into image frames. Background subtraction and foreign object detection are used to find the static image from the image frames. Background subtraction is the basic pre-processing method which is carried out by subtracting the image from the background surroundings.

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Then the foreign objects are detected by identifying contours in the frame. To crop the static image for detecting the static item, use bounding box. The convolutional neural network is trained with positive samples containing luggage items, e.g. suitcases, briefcases, hand bags, backpacks. If the object is recognized as a luggage, then the neighbourhood is analysed. If there is no object near the luggage item an alarm is raised. This process illustrated in the Figure 1. It can be observed that this method cannot be used to reduce false alarm rate as it does not recognize the owner of the luggage. Hence any other object which is next to the luggage item is labelled as the owner and it is tagged as attended.

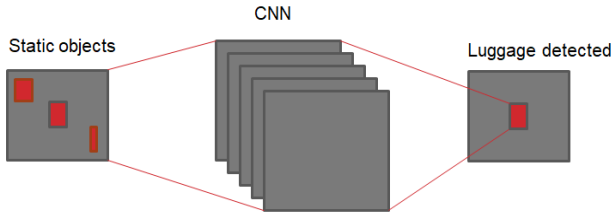

Figure 1: Luggage Detection using CNN

B. Abandoned Luggage Detection using CCNN

The efficiency of CNN method is improved by adding more number of CNN in the network. In this work, two neural networks are used to generate cascaded CNN. Neural network is trained to recomgnize images of static luggage items [8]. CCNN is mainly used for detecting only unattended luggage, however it is avoided to detect the luggage that is attended. First CNN detects all the static luggage items even if it has an owner standing next to it. Hence, the exceptional situations are handled by the second CNN in the cascade. It identifies abandoned luggage item in the scene which doesn't have an owner. The positive and negative situations are identified and trained with network. A cascade of classifiers are used in this method and the second CNN is active only if the first CNN identify the luggage items. Figure 2 depicts the structure of CCNN.

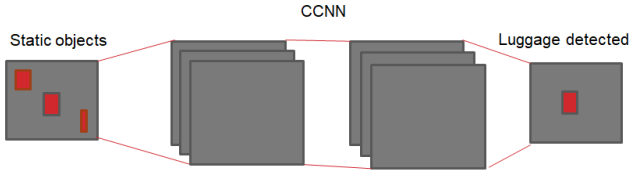

Figure 2: Abandoned Luggage Detection using CCNN

Both the methods discussed above use CNN to recognize luggage. It is seen that if CNN has lesser connections between layers close to the input and output, it can be more accurate and efficient to train. Hence DenseNet architecture can be used as a better alternative for CNN. Traditional CNN has l connections for l layers. A DenseNet is collection of CNN which connects every layer to every other layer in the network in a feed forward fashion. Hence for l layers it will have $l(l+1)/2$. It also needs lesser parameters when compared to the traditional CNN.

C. Abandoned Luggage Detection using Dense Network

Here DenseNet is used for detecting the unattended luggage item. DenseNet concatenates outputs from the previous layers into the future layer. In the normal convolutional neural networks having l layers constitutes connections, each layer is connected to its subsequent layer. DenseNet has $l(l+1)/2$ direct connections. The feature map generated by each layer becomes the input of the subsequent layers. Dense CNN is a type of Deep CNN in which each layer is connected with another layer deeper than itself. In normal CNN each layer is only connected to its siblings. Consider 4 layers, output from $l1$ is connected to only $l2$, output from $l2$ is connected only to $l3$, output from $l3$ is connected only to $l4$.

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In a dense CNN, consider 4 layers, output from *l1* is connected to *l2, l3, l4*, output from *l2* is connected to *l3, l4*, output from *l3* is connected to *l4*.

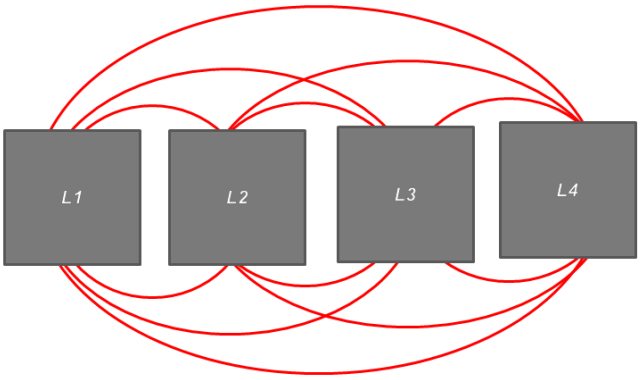

Figure 3: Dense CNN

DenseNet architecture for abandoned luggage detection is illustrated in Figure 3. Initially the video is pre-processed and the luggage is detected using DenseNet architecture. Once the luggage is detected, its corresponding owner is recognized using Haar cascade classifier. The luggage and its owner are tracked simultaneously until the owner and the luggage disappears. The distance between the owner and the luggage is tracked. As the distance increases more than a predefined threshold value, the luggage item will be labelled as abandoned. Once the owner disappears from the scene the luggage is tagged as abandoned, the face of the owner is retrieved and an alarm is raised (Figure 4).

The input information and the information preserved is clearly differentiate in DenseNet. Very narrow layers are in DenseNet which is capable of adding small amount of feature-maps to the network. It also keeps the remaining feature-maps consistent. The classifier makes a decision based on all feature-maps generated bythe network.

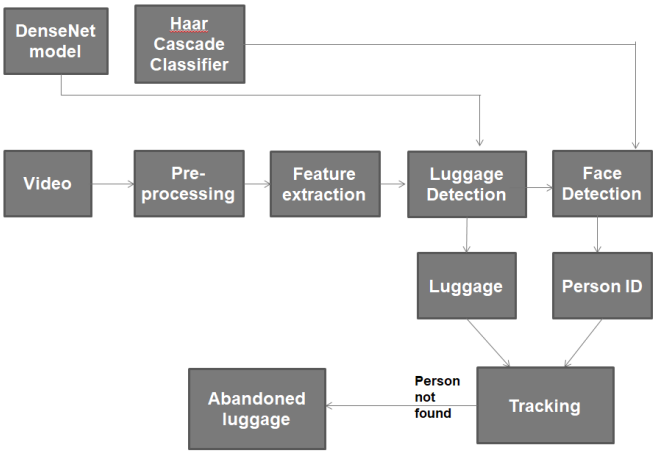

Figure 4: Proposed Model of Abandoned Luggage Detection using DenseNet

4. Result and Discussions

The above proposed algorithms are implemented and tested in the college premises to detect abandoned luggage. Initially the luggage is classified using CNN from other objects and the classification score report generated is presented in Table 1. The performance of the network is evaluated in terms of the classification report based on the parameters precision, recall and F1 score.

(i) Precision- correctly predicted positive observation / total positive observations (TP/TP+FP)
(ii) Recall-correctly predicted positive observation/all the observation in the class(TP/TP+FN)

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(iii) F1-score-harmonic mean of precision and recall
where TP is true positive, FP is false positive and FN is false negative.

Table 1.Classification Report of CNN

	Precision	Recall	F1 – Score
Class0 (BAGS)	0. 90	0.98	0.93
Class 1 (NO BAGS)	0. 93	0.73	0.82

Examine the luggage which is static for a period of time. If there is no object in the neighbourhood of the item then the luggage is labelled as abandoned and an alarm is raised. The result of the static luggage identification is given in Figure 5.

Figure 5: The object is detected if it is static for a particular period of time

The second method for object detection using CCNN. The first CNN was used to identify all the luggage items on the screen and the second CNN identified the unattended luggage. The classification score report of both the CNN are described in the Table 2.

Table 1.Classification Report of CCNN

	Precision	Recall	F1- Score
Class0 (BAGS)	0.95	0.84	0.89
Class 1 (NO BAGS)	0.96	0.92	0.94

Finally, the abandoned luggage is detected using DenseNet architecture. The Classification score report generated is depicted in Table 3.

Table 2.Classification Report of DenseNet

	Precision	Recall	F1- Score
Class0 (BAGS)	0.98	0.96	0.97
Class 1 (NO BAGS)	0.96	0.94	0.95

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Initially all the luggage items and its corresponding owners in the scene are detected. The luggage is identified and tracked based on the distance between them. If the distance increases with respect to a specific threshold value the luggage is tagged as abandoned as the owner has moved away from the luggage.

5. Conclusion

The main objective of this proposal is to reduce the false alarm rate in the abandoned luggage detection and improve the accuracy of threat identification. The method proposed in this paper uses DenseNet for abandoned luggage detection, which has the capability of alleviating the vanishing-gradient problem, strengthening feature propagation, encouraging feature reuse and implicit deep supervision. In comparison with other abandoned luggage detection methods using CNN and CCNN, the proposed method tries to reduce the false alarm rate and improves the response time appreciably.

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