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Deep Convolutional Neural Network Exploiting Transfer Learning for Country Recognition by Classifying Passport Cover

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***Abstract*—Nowadays, Citizen of one country is traveling to another country to settle their various needs through widespread modern transportation system. However, Passport is a worldly recognized indispensable identity document which is required for travelling internationally. Moreover, Citizen of many countries is strictly prohibited from travelling to other certain countries. So, Passport inspection is a key responsibility for immigration officers in order to confirm the identity of traveler. In addition to that it is a laborious and time-consuming task for immigration officers to check all passports meticulously. Hence, automatic country recognition from passport cover image can save a lot of time and physical labour by identifying those unauthorized travelers. Thus in this paper, we have investigated an automatic system using Deep Convolutional Neural Network (DCNN) based on transfer learning with Support Vector Machine (SVM) classifier to analyze passport cover for country identification. Here, the Inception-ResNet-v2 DCNN architecture has been retrained with 80% of image dataset which includes ten classes of passport cover of ten countries using transfer learning method for feature extraction and the extracted feature were then used to train SVM. The proposed model achieved an accuracy level around of 98.75% on the test image dataset.**

Keywords—passport, deep convolutional neural network, transfer learning, support vector machine, feature extraction.

I. INTRODUCTION

In the modern era, global interactions have increased due to the advancement in transportation and communication system. As a consequence, people are now travelling all around the universe to meet up their different purposes such as job, trade, education, treatment, refreshment and so on [1]. Hence, the number of inward and outward travelers has increased significantly [2]. But, traveler must have a passport which is an official document certifying the identity and nationality of its holder issued by a country's government for overseas travel in order to verify their identity and eligibility to enter in the country being visited. Besides that there are many countries whose people are forbidden from entering another country [3]. So, passport inspection is of great importance in order to restrict those illegal travelers. The task of passport inspection is performed by immigration control. The purpose of immigration control is to manage incoming and outgoing travelers through examining their passport. Immigration officer checks the passport by the naked eye that consumes long time in immigration control which is inconvenient for traveler as well as sometimes it is difficult to find illegal travelers accurately due to inaccurate decision and management [1][2]. Computer vision and machine learning technologies can be implemented to solve this entire problem. Therefore, we have developed a process for country identification from passport cover utilizing DCNN and SVM to make the process easy and accurate.

In recent years, the major breakthrough in machine learning is deep learning. Due to its capacity to learn data representation, it has attained enormous popularity in computer vision. Particularly, Deep CNN proved to be a very effective tool for image classification in various domains including pattern recognition, text classification, human pose estimation and document analysis [4]. Loss function of deep CNN was minimized using gradient based algorithm [5]. It showed pretty good accuracy in classifying handwritten image classification, rice disease image classification, sign language images classification by extracting invariant feature. However, transfer learning is a promising approach to exploiting deep CNN for training more deep neural networks like Inception-V3, VGG-16, VGG-19, Inception-ResNet-v2 etc with comparatively little data. It has become quite popular in the combination with neural networks, since they need massive amounts of data and computational power for training. Transfer learning based DCNN model has also been being practiced in many application domain such as classification of microscopic bacteria images[6], image classification and human action recognition[7]. Beside that SVM is a supervised machine learning algorithm which can be mostly used for classification task by finding the proper hyper-plane and kernel parameters. Previously it attained remarkable success in classifying Handwriting Word Recognition [8]. Recently, Big data processing and classification such as pattern recognition [9] and image classification have been done by implementing combination of CNN and SVM which showed very good accuracy. Therefore, we were inspired to develop a process for country recognition from passport cover image classification by combining DCNN model and SVM.

Several fascinating methods have been researched already in order to classify passport images. A ART2 (adaptive resonance theory) based RBF neural network for passport recognition was proposed by K. Kim et al. [1]. The authors applied sobel masking for edge extraction and then horizontal smearing and contour tracking algorithms is employed on the egde image for extracting code block. Vertical seamiring was then applied to code block for separating individual codes from passport image. K. Kim et al. proposed [10] a method for passport recognition utilizing RBF network based enhanced

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fuzzy ART and face verification using PCA algorithm for distinguish forgery passports. K. Kim [11] presented passport recognition and face verification system based on ART algorithm. The authors has created adaptive clusters considering the variations of input patterns for extracting code areas. All the method mentioned above has been described in order to resolve passport recognition based on Machine learning. Recently a work has been done by A. A. Jeny et al. [12] for country identification through its passport cover image to restrict illegal travelers using Residual Network architecture with 50 layers and shows significant accuracy.

In this paper an automatic system is proposed for country recognition from passport cover image by combining Inception-ResNet-v2 DCNN architecture with SVM. At first, transfer-learning method has been employed to retrain the pertained DCNN model on 1792 passport cover images of ten countries. Then this model can able to find out automatically one-dimensional unique features from input image and extract them. This extracted features are used to train a SVM classifier. The proposed model is then evaluated on a test-dataset of 448 images and obtained evaluation accuracy around 98.75%. The objective of this proposed automatic system is to identify unauthorized traveler within a short time in the immigration control for overseas travel.

II. Dataset Preparation

The task of preparing the dataset is divided into two steps: A. Accumulation of passport images and B. Image pre-processing.

A. Accumulation of passport images

We have collected 1040 passport cover images of ten countries from several online resources with minimum 100 samples per class. Those countries are- Bangladesh, South Africa, Japan, Malaysia, Sri Lanka, Singapore, Pakistan, Spain, Russia, and South Korea. Some samples of our dataset are represented in Table I.

TABLE I. Passport Cover Images of Selected Country's for Classification

Country Name	Spain	Pakistan	Sri Lanka	Japan
Passport Cover Image				
Country Name	**Singapore**	**Malaysia**	**South Africa**	
Passport Cover Image				
Country Name	**Bangladesh**	**South Korea**	**Russia**	
Passport Cover Image				

B. Image preprocessing of accumulated image

Convolutional neural network (CNN) feature extraction efficiency generally relies on the amount, resolution and variety of image samples. Hence in image pre-processing steps, we raise the number of passport cover images by manual cropping without reducing its quality from images that containing numerous samples and also enhance the quality of images through suppressing unwanted distortions of image using median filter. All those images were resized at desired size of the model that is 299x299pixel. Fig.1 shows the implementation of manual-cropping process on passport cover image samples.

Original Sample (A) (B) (C)

Fig. 1. Manual-cropping scheme

Finally, the amount and diversities of images are increased through augmentation technique which includes rotation, translation up to 10pixels vertically or horizontally, randomize flipping and the unnecessary distortions are suppressed as well. After augmentation process, we havetotal 2240 passport cover images with minimum 220 samples per classes.

III. Methodology

Elegance in obtaining unique features is the greatest benefit of deep CNN architecture. But it's not always perfect as an image classifier because of the positioning of the trainable parameters in the hidden layer. On the contrast, high classification accuracy with SVM is obtained by tuning very few parameters for a effectively extracted one-dimensional feature vector, although owing to it's fixed kernel parameters it does not learn very complex feature. Thus, we combined Inception-ResNet-v2 deep CNN architecture with SVM classifier for obtaining notable classification result in recognizing passport cover. The complete process is divided into two sub-sections: deep CNN to extract feature and SVM to classify.

A. Deep CNN to Extract Feature

In feature extraction, All the unique information and representations present in the input image was find out by deep CNN using different kernels and the collected features were presented in a lower dimensional space which is useful for image matching and retrieval of information. Accurate feature extraction approach enhances the classification speed and accuracy. Development of Inception-ResNet-v2 [13] network is considered to be a state-of-the-art architecture for extracting invariant feature from an image. In order to identify a image, it utilizes almost 0.053 billion parameters. But to train efficiently such a enormous architecture requires massive memory, time and computing resources like GPUs and TPUs. Therefore, the transfer learning [14] method comes into play, which allows partial use of pre-trained Inception-ResNet-v2 architecture weights on the proposed network. Thus, transfer learning technique helps to a great extent to reduce the computing time and complexity. The pretrained Inception-ResNet-v2 network was trained with over 1 million images to

achieves state-of-the-art accuracy in the recognition of 1000 classes general objects[15]. The Inception-ResNet-v2 model has 784 layers where we kept frozen initial 41 layers (up to 'mixed_5b' layer) to aviod change in weights. Then, the remaining portion of the model were trained with passport cover images for extracting high level relevant feature. Fig. 2 shows the modified architecture.

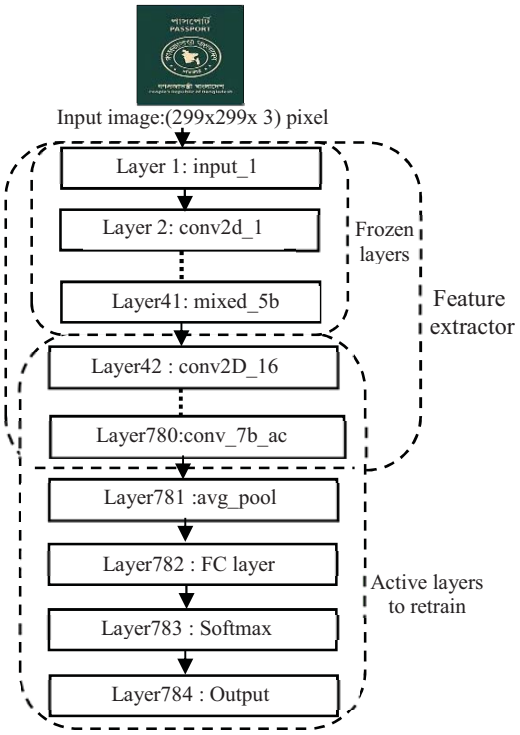

Fig. 2. Modified Inception-ResNet-v2 architecture for feature extraction

After retraining the Inception-ResNet-v2 architecture, the avg-pool, dense layer, activation layer (σ) and prediction layer were removed. Then the extracted feature is used to train SVM for preforming classification task.

B. SVM to Classify

'Global average-pooling' function was used to flatten all features extracted by DCNN model. Then, we trained multi-class Support Vector Classifier (SVC) with Radial basis function (RBF) kernel for recognition by feeding the extracted feature while keeping one-fifth extracted features separated for future usage. Grid-search algorithm was used to tune hyper-parameters of SVC such as 'gamma', cost parameter 'C'. Finally, the performance of the classifier was evaluated on the previously separated features to find the classification output. Training steps of the SVM classifier is shown in Fig. 3.

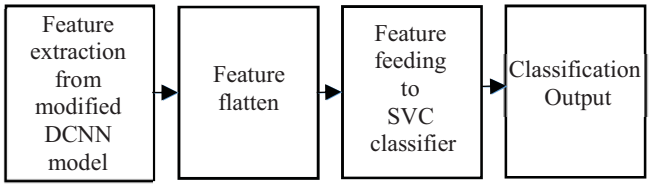

Fig. 3. Training Step of SVM classifier

IV. RESULT AND DISCUSSION

Training and Testing are the two phases through which the experiment is carried out. A computer with CPU Intel core i7 @ (2.7-3.6GHz), NVIDIA GeForce GTX 1070 and 8GB of RAM with 'Windows 10' operating system was used to render the complete process of training and testing.

We have collected 2240 passport cover images of ten different countries. For training phase, we used 80% images of the total dataset to train the proposed DCNN model that are 1792 images. In order to validate that model, 350 images are separated which isnearly 20% of the training dataset. Here, we set learning-rate to very low at 0.0001 in feature-extractor section as the ultimate target is to obtain high precision in finding unique features of passport cover image by using the pre-trained DCNN model. Then, we evaluated the proposed system performance on test set with various combinations of epochs and batch-size so that we get minimum training time with optimal training accuracy.Table II shows the optimized value of all parameters and hyper-parameters of the proposed architecture.

TABLE II. PARAMETER TABLE OF PROPOSED CNN-SVM MODEL

Inception-ResNet-v2		**SVC**	
Names	***Value***	***Names***	***Value***
Learning-rate	2xe-4	Kernel	RBF
Size of batch	20	Cost-function(C)	100
Epochs	15	Gamma	1xe-3
Non-trainable layers	41	-	-

The graphical presentation of the evaluation process was recorded while the Inception-ResNet-v2 architecture was evaluated according to the optimized parameter. Fig. 4 and Fig. 5 shows accuracy and loss curve of the proposed architecture.

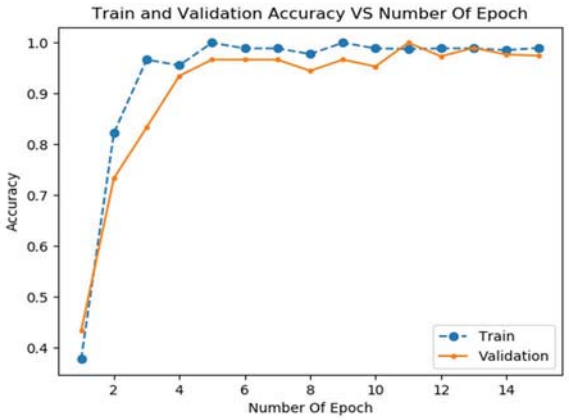

Fig. 4. Graphical representation of training and validation curve(accuracy)

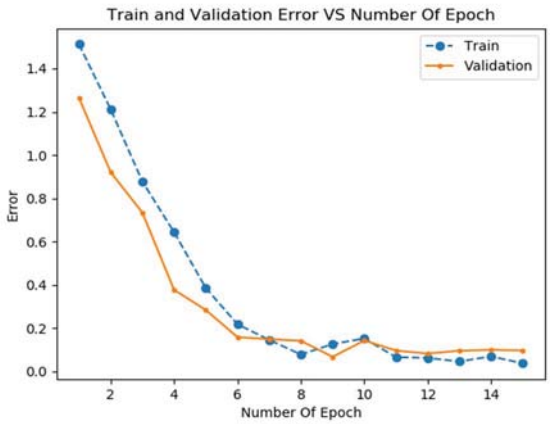

Fig. 5. Graphical representation of training and validation curve(loss)

During last 4 epochs, we found training and validation precision above 98% from Fig. 4 and training and validation error below 0.1 from Fig. 5. Finally, the proposed system performance was evaluated on the test set of 448 samples and the system obtained prediction accuracy of 98.75% which is higher compared to [12] with average accuracy 98.56%. Ref. [12] used a dataset of 4200 images, while we obtain higher accuracy with a dataset of 2240 image because CNN-Softmax combination needs massive amount of data to properly adjust model weights through back-propagation while CNN-SVM works well on small dataset for perfectly classifying an image due to its kernel trick. Moreover, this system requires processing time 0.01 seconds to infer an image which indicates that the system is compatible for real time passport assessing.

V. CONCLUSION

In this work, we have proposed an automatic country identification system by assessing passport cover image using Inception-ResNet-v2 architecture based on transfer learning with SVM classifier. The automatic system helps to identify unauthorized traveler in the immigration control within a short time for overseas travel. Here, the Inception-ResNet-v2 DCNN architecture was used to learn good invariant hidden latent representations from training image dataset which includes ten classes of passport cover of ten different countries using transfer learning method and the SVM with RBF kernel has perfomed the recognition task. The proposed model achieved an accuracy level around of 98.75% on the test image dataset. In future, this model can be enhanced by exploiting feature fusion and also try to include more classes of passport cover of more countries.

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