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Design of Deep Learning Algorithm for IoT Application by Image based Recognition

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ABSTRACT

The Internet of Things (IoT) is an ecosystem comprised of multiple devices and connections, a large number of users, and a massive amount of data. Deep learning is especially suited for these scenarios due to its appropriateness for "big data" difficulties and future concerns. Nonetheless, guaranteeing security and privacy has emerged as a critical challenge for IoT administration. In many recent cases, deep learning algorithms have proven to be increasingly efficient in performing security assessments for IoT devices without resorting to handcrafted rules. This research work integrates principal component analysis (PCA) for feature extraction with superior performance. Besides, the primary objective of this research work is to gather a comprehensive survey data on the types of IoT deployments, along with security and privacy challenges with good recognition rate. The deep learning method is performed through PCA feature extraction for improving the accuracy of the process. Our other primary goal in this study paper is to achieve a high recognition rate for IoT based image recognition. The CNN approach was trained and evaluated on the IoT image dataset for performance evaluation using multiple methodologies. The initial step would be to investigate the application of deep learning for IoT image acquisition. Additionally, when it comes to IoT image registering, the usefulness of the deep learning method has been evaluated for increasing the appropriateness of image recognition with good testing accuracy. The research discoveries on the application of deep

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learning in the Internet of Things (IoT) system are summarized in an image-based identification method that introduces a variety of appropriate criteria.

Keywords: IoT, deep learning algorithm

1. INTRODUCTION

Robotics and artificial intelligence have emerged as promising technological sciences with the potential to significantly improve the quality and safety of human existence. For many years, science fiction, movies, and popular literature have all depicted a future inhabited with sentient humanoid robots [1–4]. Robots were anticipated to achieve a new level of human companionship, wherein today's robots are intelligent partners for people, not slaves or self-aware toys. This failure is due to the inability of robots to figure out what has to be done and how to accomplish it in a dynamic environment with the constantly changing inputs. Only three of the five human senses transmit information (vision, hearing, and touch); the other two (taste and smell) do not. The robot can do the human action through image based recognition [5-8]. Figure 1 shows the categorization of the bird type through image based recognition process by using robot. Observation of nature and everyday life shows the correctness of this statement.

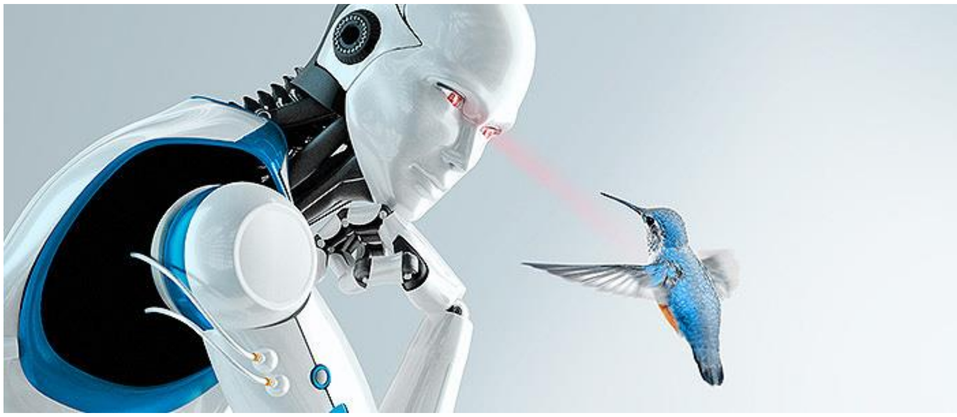

Figure 1 Image based Recognition by Robot

With vision, an individual may still accomplish his or her objectives but this becomes much more difficult without it. The senses of mammals and terrestrial animals are less reliant on

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sound for navigation than the senses of aquatic mammals and reptiles. Depending on the imaging modality and the surroundings, a visual sensor may include infrared, visible light, laser, millimeter wave, radar, and LiDAR. It is via the constant acquisition of sensory input about the model visual world that navigational tasks such as finding one's position in 2D and 3D scenes, reconstruction of 2D and 3D scenes, detection of objects and obstacles, tracking, identification, control, and inference are aided [9]. In order to navigate autonomously, you'll need a number of different capabilities, such as mapping the surroundings, interpreting scenes, planning paths, detecting and avoiding obstacles, locating and moving to positions, and directing your attention.

Massive image collection contained in a dataset has been gathered due to the growth of internet technology and the increasing use of IoT imaging equipment, and processing this data has become an extremely topical issue today [10, 11]. These images, in addition to being utilized to store various forms of data, give information on the many aspects of human production and existence, resulting in a sizable market for image recognition and application. Many issues can be dealt with based on the available data in the 5G mobile network, which means the solution to those problems becomes more reliant on visual-based data and modern deep learning methods; that being said, finding a reliable way to process the picture data of IoT devices will be difficult [12-14]. Figure 2 shows some sample birds images obtained from IoT image datasets.

Figure 2 Sample Birds of IoT Image Datasets

IoT systems integration may provide a wide attack surface for adversaries. It's not hard to hack and control devices that have simple authentication requirements, much as the Mirai botnet.

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The attack surface grows as the number of linked devices rises. To determine how deep learning might improve security and privacy in the IoT age, we research this article. To begin, we analyzed many security and privacy issues associated with IoT devices [15]. To establish a taxonomy for looking at these IoT security and privacy applications through the perspective of the contemporary deep learning algorithms used and IoT security concerns, we investigated IoT security for privacy via security applications [16].

2. ORGANIZATION OF THE RESEARCH

This research article is organized as follows; section 3 provides existing research work on IoT based image recognition in deep learning domain. Section 4 discusses various deep learning processes for image based recognition technique for IoT domain. Section 5 delivers a description of results obtained in IoT domain. Section 6 concludes the proposed research article with future research directions.

3. PRELIMINARIES

Minerva et al. developed IoT architecture and listed the characteristics an IoT system, which must have to be classified as an IoT system [17]. L. Bondi et al have showed how CNN may be used to retrieve model-related information, and subsequently, SVM is used to make predictions. In each of these instances, the feature extractor utilizes deep learning [18]. Additional comparable instances have also been used for audio device identification, which was also discussed by S.Qi et al in a different publication [19].

The researchers Yu et al. suggest utilizing DAE that is partly stacked to identify devices based on reconstructing a high-SNR signal [20]. Bassey et al. developed a system to identify unverified devices using deep learning based on RF fingerprinting methods. To extract the most relevant characteristics from the RF traces, they first utilize a convolutional neural network (CNN) to automatically identify important features. Then, they employ dimensionality reduction and decorrelation to prune the most relevant features. Using clustering methods, they finally

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categorize the devices in the IoT [21]. Using ensembles of auto encoders looks for abnormalities such as Mirai in IoT. Both of the aforementioned strategies presume that the traffic flow from the usual flow can be calculated to a sufficient degree, whereas an anomaly introduces a significant calculation error. The following two approaches address heterogeneity and resource limitations in the IoT context and are non-traditional [22].

R. Shire et al. view the payload of the communication packet as a hexadecimal representation and convert it into a 2D picture in their work. Once the pictures have been classified, they use a lightweight CNN called MobileNet to obtain characteristics from the images of traffic and virus categorization [23]. M. Bohadana et al. construct a typical behaviour profile for each device by using deep auto-encoders. These machines extract traffic feature statistics and train auto-encoders using the traffic feature statistics for ensuring safe traffic [24].

RESEARCH GAP

According to preliminary study, the research gap from existing faults and the discrepancies between these shortcomings and the demands of the IoT ecosystem are challenges that still exist in current research. It is necessary to gather data from various devices to train a device recognition model. Once this data has been properly prepared, it is next processed to create features that may be utilized as an input to a deep learning model. Deep learning often starts with these items:

1. Matrix-based
2. Sequence-based
3. Statistical data-based

In all current IoT applications, there is no security integrated into the devices. Using the proposed strategy, we'll be able to accomplish the objectives of these formulations using the deep learning method. On top of that, we'll be investigating the future research paths for deep learning-powered IoT security.

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4. PROPOSED WORK

4.1 Construction of CNN for Image based Recognition

Proposed convolutional neural networks, or CNNs, enable outstanding image identification process to their architecture. This architecture is used to classify the text data from the image input [25]. Within the CNN framework, the following sections are featured with many layers and sections for image-based recognition in the IoT context. Our algorithm is performing conditioning process for IoT image from the sensor output. The proposed work block diagram is showing in the figure 3.

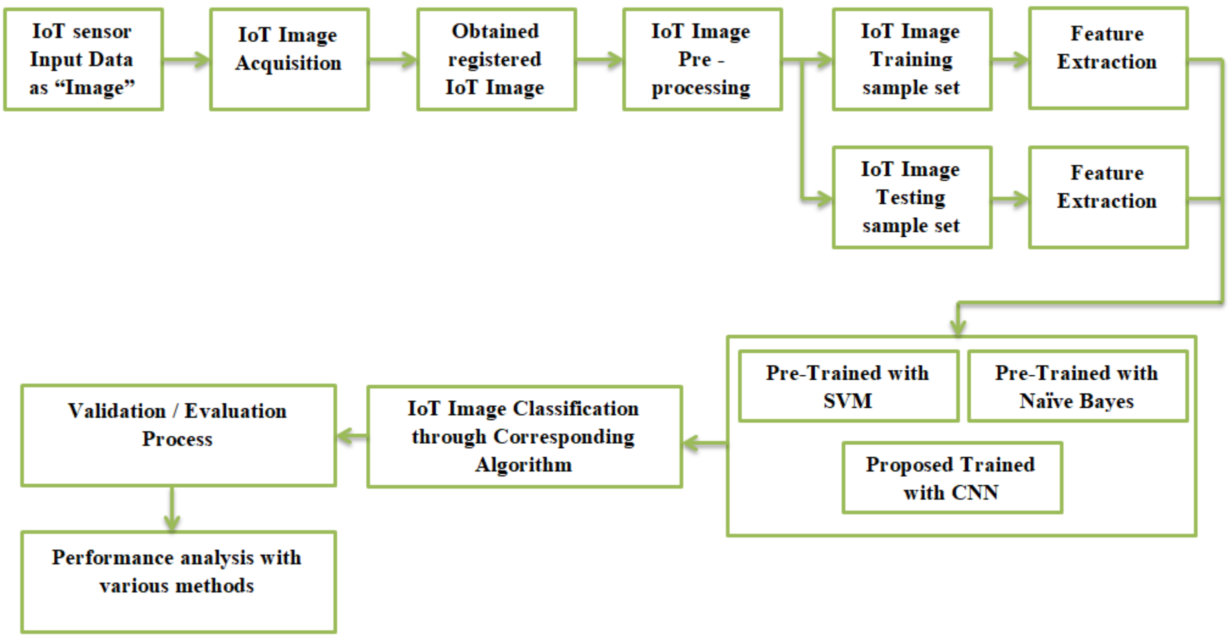

Figure 3 Block Diagram of Proposed Framework

4.1.1 Convolution Layer

The filter size can be structured with 100 and weight parameters are assumed with 10k size to analyse the image processing. The architecture is fully connected through many neurons in the structure. This convolution layer is reducing the parameters to share weights between the local connections [26 - 28]. This convolution process is defined as;

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$$\boldsymbol{x^{l+1} = w^{l+1}x^{l} + b^{l+1}}$$

Where, x is the output layer of l. Also W and b is weight vector and bias items. This description is providing output data through many convolution kernels with filled pixels at the boundary of the image.

4.1.2 Pooling layer

Generally, the pooling layers are used to reduce the size of the feature map that to control the number of training parameters for the main process significantly. This layer is located at the middle of the framework of neural network which is used for reduction of size through down sampling concepts [29 – 31]. The max pooling concept is used in pooling layer to reduce the size of the feature map.

The input data sizes of pooling layer are dynamic and moving through step size for output feature map from the pooling layer. In this structure the parameters are fixed through variable mode for the feature map output.

4.1.3 Post processing

This post processing in this proposed framework includes two functions named as

1. Loss function
2. Weight initialization function

(a) Loss function

The sample set contains N samples for predicted value in the output section with kth sample and function representation model. The loss function is computed with true value of the kth sample as follows;

$$L = \sum_{k=1}^{N} l(y_k, Y_k)$$

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(b) Weight initialization function

The weight initialization is used through activation function at the origin value. This single layer convolution is computed for weight initialization function as follows;

$$\boldsymbol{y = w_1 x_1 + \cdots + w_{n_k} x_{n_k} + b}$$

Where, n_k is the dimension of layer for the input.

4.2 Principal Component Analysis (PCA)

There are many methods to extract the image features from the images through many concepts. The proposed architecture believes principal component analysis (PCA) method for performing feature extraction through statistical learning method. It is also called as KL transformation method in deep learning domain. Besides, this process is an unsupervised image dimensionality reduction method for any image based recognition. This concept is used for performing linear transformation in order to gather the image features for recognition process [32]. This transformable image features can be collected for establishing more effective information to its extent.

5. RESULTS & DISCUSSION

The proposed framework has been experimented with sample IoT Image dataset. The full name of this dataset is "Caltech-UCSD Birds-200-2011", which is a Caltech-UCSD birds dataset expanded by the addition of data gathered from a supplemental study on the CUB-200, a bird species categorization model. There are 200 different types of birds, and the total number of images in the training set is 11,000, of which 6,000 are for training and 5,500 are for testing. For improved identification, each picture includes a target frame label, component labels, and characteristics. The four-layer structure of all categories has now been revealed. Table 1 shows the overall accuracy and performance measures for image based recognition. Out of the total of 264 nodes, 200 are leaf nodes (class label nodes), and 64 are parent nodes (categories higher in the taxonomy).

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Table 1 Overall accuracy performance measures for recognition

S.No	Methods	Test Accuracy	Train Accuracy	Average Accuracy	Recognition Rate	Recognition error (%)
1	Pre-trained SVM	90%	95%	92.5%	94%	0.091
2	Single Classifier NB	85%	92%	88.5%	90%	0.920
3	Proposed CNN framework	98%	99%	98.5%	97%	0.002

In general, the accuracy of the resulting recognition is proportional to the resolution of the feature map in the preceding layer. Several transformations seem to have an impact on the final recognition rate. This modification will be utilized in future tests since the random number k has the greatest recognition impact. The overall accuracy-based performance measures are shown in figure 4.

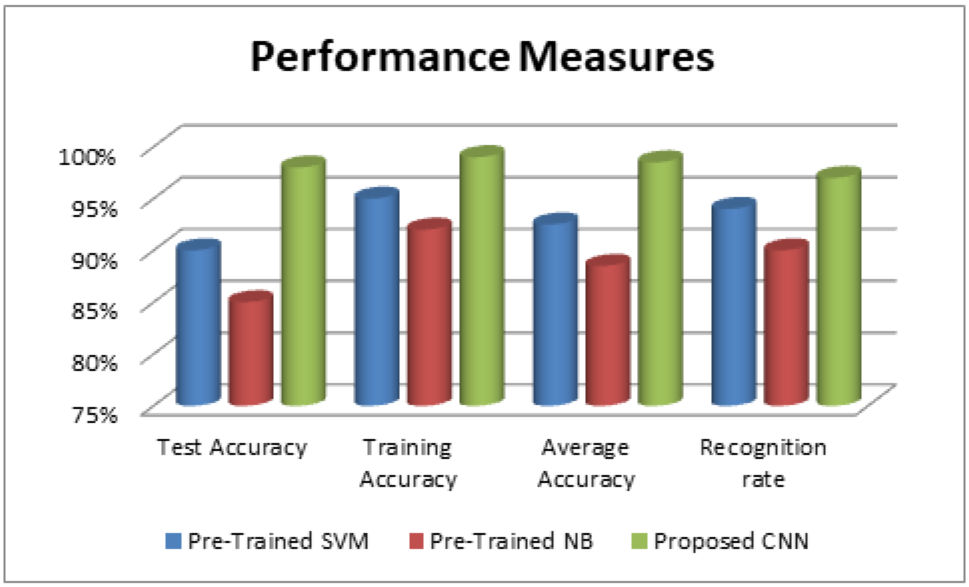

Figure 4 Accuracy Performance Measure

The experiment chooses two-by-two, four-by-four, six-by-six, and eight-by-eight convolution kernels. Neural networks use convolution kernels of four different sizes and track the changes in the recognition rate. It shows the effect of the various convolution kernels on the network recognition rate.

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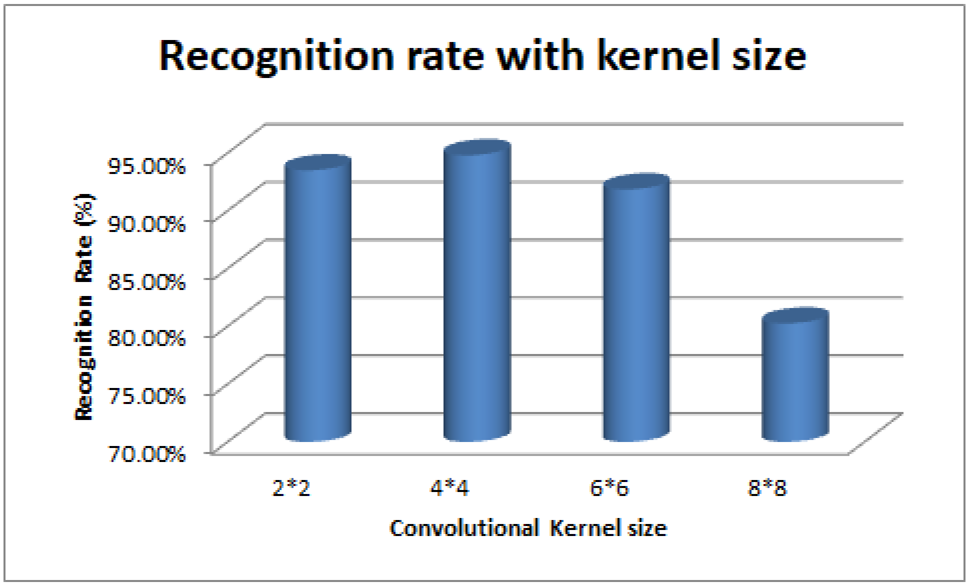

Figure 5 Comparison of Recognition Rate with Convolutional Kernel Size

If the number of connections between layers is lower, the feature map will be more distinct when the convolution kernel is higher. The smaller the kernel size, the more characteristics the network can be extracted but the greater the computational expense, which is shown in figure 5. The optimum convolutional kernel size is found at 4*4 compared to other kernel sizes for some specific datasets, but not to all datasets in our research work. It is concluded that the computation varies with different datasets for image based recognition.

6. CONCLUSION

This research work has constructed a novel framework with deep learning and PCA to build an IoT image-based identification system that applies to all IoT sectors. Using image modification, PCA technique has successfully extracted the different image features, resulting in generally excellent experimental findings. Image identification on the IoT was aided by the high degree of dispersion, or scatter, which have occurred after projection. This proposed research work has conducted many tests and discovered that PCA (or PCA with a dimension of 25) delivers the greatest image-based recognition results. The obtained results show that the proposed CNN algorithm has a greater recognition rate when compared to traditional methods. It is predicted that in the future, image feature extraction using LDA and linear discriminant analysis (LDA) will be used for the study. The LDA technique makes use of the information

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already available in the image. And, as a bonus, the algorithm may be enhanced with a hybrid form of machine learning (a method that consists of different machine learning techniques) with an adaptive activation function, which can be used to explore other use cases in the IoT sector [33].

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