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OverFeat Network Algorithm for Fabric Defect Detection in Textile Industry

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Abstract

Automation of systems emerged since the beginning of 20th century. In the early days, the automation systems were developed with a fixed algorithm to perform some specific task in a repeated manner. Such fixed automation systems are revolutionized in recent days with an artificial intelligence program to take decisions on their own. The motive of the proposed work is to train a textile industry system to automatically detect the defects presence in the generated fabrics. The work utilizes an OverFeat network algorithm for such training process and compares its performances with its earlier version called AlexNet and VGG. The experimental work is conducted with a fabric defect dataset consisting of three class images categorised as horizontal, vertical and hole defects.

Keywords: OverFeat network, textile automation, fabric defect detection, computer vision on fabrics, AlexNet

1. Introduction

Automation systems are classified into three types namely fixed automation, programmable automation and soft automation. The fixed automation systems are also represented as hard automation, where a system is planned to do a repeated task irrespective of any control orders. The fixed automation systems are not cost effective in terms of installation. However, the system will generate a huge yield at the time of production and it saves a lot of human efforts in the production line. Due to inflexible nature of the fixed automation system, it is always difficult to make changes in the production system. Therefore the fixed automation systems are employed at the places where only the same kind of operation is needed [1, 2].

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The programmable automation systems are the advancement of fixed automation system, where a programmable microcontroller will be included in the architecture of the system. The programmable systems are usually made with a control unit for enabling control signal to the microcontrollers. This overcomes the limitation of the fixed automation systems and allows the production system to operate for different applications and products. The programmable systems are generally employed in the production field, where the products are manufactured with a slight variation. The cost of changing a fixed automation system into a programmable system is quite less when compared to making a new programmable system. However, the programmable automation system requires a trained technician for monitoring and control purposes. Similarly the programmable system can be utilized in the place, where the productions are carried out in batch processes [3, 5]. The soft automation systems are also called as flexible automation systems, where the system is framed to do multiple kinds of production at the same time. This requires a large quantity of control motors and sensors in the production unit. It increases the cost of installation and needs frequent maintenance and verification than the other two automation systems [6, 7]. Figure 1 explores the architectural difference among the different automation models.

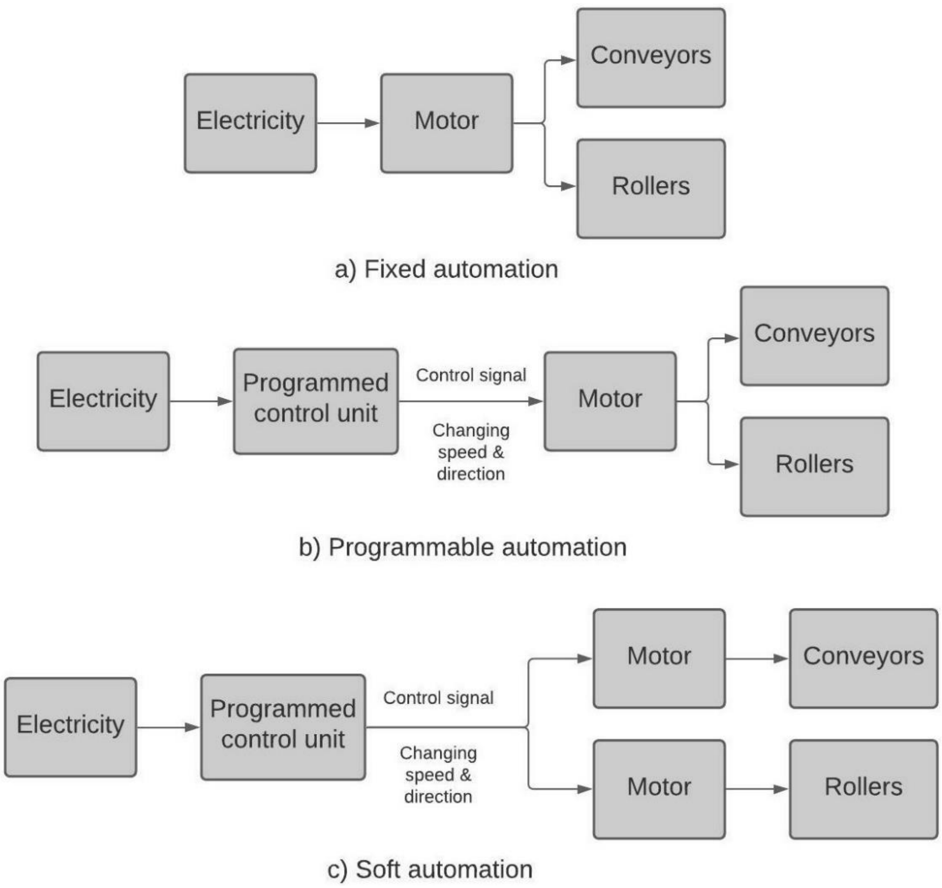

Figure 1. Architectural difference among the various automation techniques

In recent days, the automation systems are incorporated with neural network algorithms to make a self-decision over the connected control units. Therefore the system requires lots of peripheral units like sensors, actuators, cameras etc. for analytic operations. The decision making speeds are very high in neural network based algorithms when compared to manual operations. The installation and maintenance cost for such systems are very high than the traditional method systems. The neural network based automation system also requires a trained profession for monitoring the operation of system [8, 9]. The architectural view of the neural network based automation system is shown in Figure 2. The upcoming section explores the attainments of neural network algorithms in different automation applications.

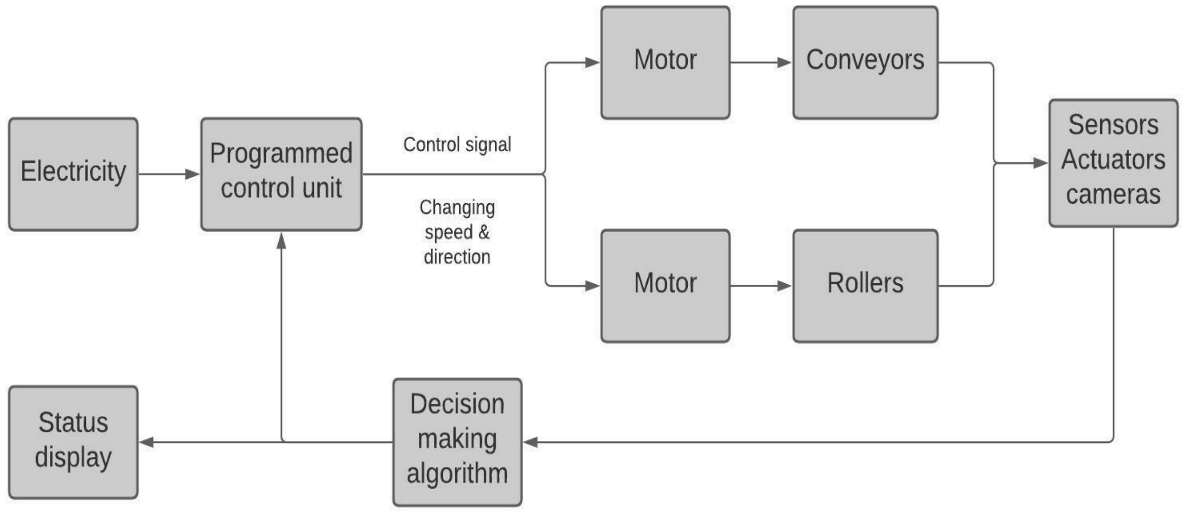

Figure 2. Architecture of a neural network based automation system

2. Related Work

A self-monitoring solar power station was designed to observe the voltage and current changes in the system. The system employed an IoT unit for transferring the measured reading to a cloud based architecture for analysing the work. A neural network based cloud model was incorporated in the work to enable alert signal to the monitoring team on detecting unfair signals [10]. A fabric detect detection algorithm was designed with a low rank decomposition model and verified with a standard dataset. The experimental work includes a structured graphics algorithm for observing the local features of the defective fabrics. A texture based segmentation model was also merged in the work for segregating the defective area from the fabrics. The experimental work explored an acceptable true positive rate of 87.3% and false positive rate of 1.21% [11]. The image based defect detection algorithms are also employed to find the disease category on certain fruits and plants. A hybrid feature extraction based technique was framed by tracing the contours of a leaf at their infected area. The features available in the segmented regions of the leaf are extracted with DWT (Discrete Wavelet Transform), PCA (Principal Component Analysis) and GLCM (Gray Level Co-occurrence Matrices) algorithms and classified with SVM, KNN and CNN. The experimental work indicated a better classification results when the images were employed with CNN algorithm [12].

An automation system for detecting the leakages in pipeline was proposed by the help of SVM classifiers. The system consists of a robotic camera module for capturing images at the faulty areas by the help of a location analysis done with an eddy current model. The images which are collected from the faulty regions are incorporated with a feature extraction model called Histogram of Oriented Gradients (HOG). The SVM model included in the work localized the particular defected area or hole by calculating the discriminate fault signature from an image. The experimental analysis showed a satisfied result on the proposed model in terms of accuracy and precision as 92.24% and 92.04% when compared with traditional SVM algorithms [13]. A weighted double-low-rank decomposition method was developed to address the nuclear norm minimization problem in the fabric defect detection techniques employed with a low-rank representation algorithm. The performance betterment of the proposed model was observed when compared to the traditional model while verifying it with TILDA dataset [14]. An intrusion detection system was designed to predict the presence of internal and external faults in the internet signals. The system was proposed to overcome the limitations of the standard firewalls included in the internet transmissions. However, the experimental work showed a better performance when the intrusion detection model was merged with the firewall setup [15].

A Fibre Bragg Grating (FBG) approach was proposed to monitor the temperature of a glass manufacturing process. The FBG approach makes the light waves to change their wavelength according to the temperature change. The experimental performance of the proposed technique was verified with an OptiSystem simulation tool and found satisfied [16]. A DenseNet based algorithm was structured to observe the defects available on the fabrics at the time of production. The DenseNet algorithm was improved with an optimized cross-entropy loss function to overcome the compatibility challenge on edge operation in the traditional DenseNet model. The performances of the proposed system was compared with a CNN architecture and found satisfied with the proposed one [17]. A license plate detection algorithm was designed by merging the CNN algorithm along with the K-means clustering model. The

K-means clustering model was employed in the work for segmentation process of the license plate and the CNN was included in the work of recognising the numbers in the number plate. The performances of the proposed model indicated an accuracy of 98.1%, which is comparatively better than the VGG and ResNet architectures [18].

A remote sensing image change detection model was developed by implementing an Efficient-GAN algorithm. The noise presence in high resolution images are tackled in the work with GAN approach and it improved the performances of the change detection process in high resolution remote sensing data [19]. A Faster R-CNN algorithm was employed over a general fabric defect dataset to prove its efficiency on the defect detection process. A dilated convolution layer was also included in the work to extract features from the training image. The comparative analysis performed in the work indicated a better accuracy and reduced computational complexity [20]. The neural network algorithms were also implemented to observe the fault detections in the software tools. The experiment was associated with a Z-score technique for removing the noisy information in the dataset. The system is also employed with an oversampling algorithm for balancing the dataset. The understandings from the experimental work indicated a better accuracy in random forest algorithm over the KNN, decision tree and logistic regression algorithms [21].

An unsupervised fabric defect detection algorithm was proposed by having a two dimensional entropy to explore the spatial distribution of images with single dimension entropy. The given images are reframed in the work based on the generated entropy value and image textures. The experimental result indicated a better accuracy on the dot and box defects and a slightly reduced accuracy on star defects [22]. A multi-feature extraction detection approach was designed to observe the faulty parts on leather products. The hybrid feature extraction model includes HOG, GLCM, Hu moments and HSV approaches on the training process and the testing process explored a better accuracy of 89.75% when it is incorporated to a random forest algorithm [23]. The HOG features are combined with local binary patterns for identifying the building presence in the given image. The experimental work showed a better accuracy when the system was combined with CNN algorithm [24]. The literature work carried out in the paper indicated that the neural network algorithms show an improved accuracy when it is combined with a feature extraction model. The upcoming section explores the methodology proposed in the work with OverFeat network on identifying the defects from fabric defect dataset.

3. Proposed Methodology

The architectural view of the proposed fabric defect detection model is shown in Figure 3. The system is employed with a high resolution camera to focus over the surfaces of the fabric roller. The camera unit is framed to record the fabric moving process in video format and forwards it to the primary computer. The primary computer is a local storage unit that contains the information regarding the fabric role and it is synchronised with the time. The primary computer generates a video format dataset and forwards to the dataset folder by mentioning the fabric name and other details. A preprocessing step is included in the work for segregating the video files into several image frames at regular intervals. The preprocessing step is also further extended to modify the resolution of the image frames along with the contrast and bright adjustments. The pre-processed images are forwarded to a network trained with OverFeat algorithm. The algorithm is trained to identify the image frames with defective parts and it classifies the type of defects as hole and horizontal/vertical line defects.

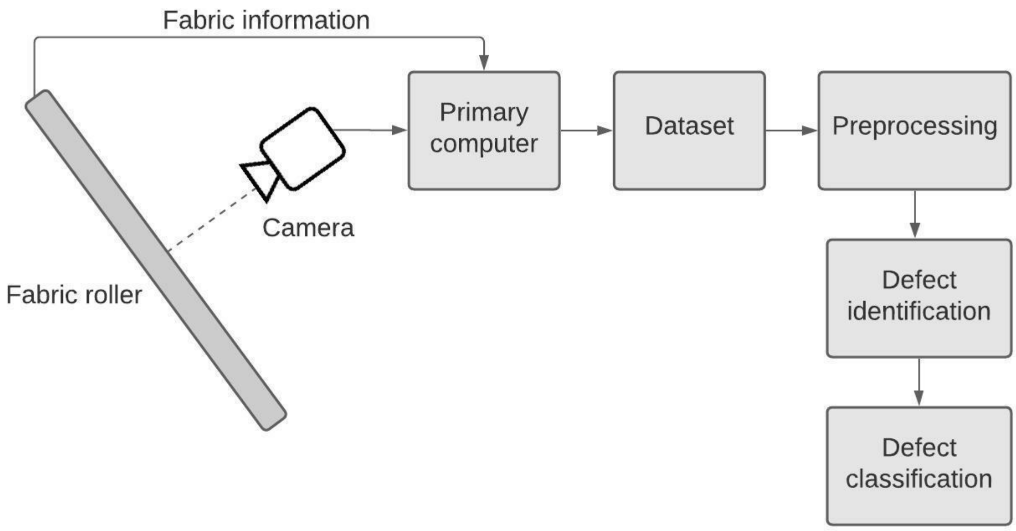

Figure 3. Design of the proposed fabric fault detection model

The OverFeat networks are designed for multi-scale classification that can be used for classification, localization and detection applications at the same time. To achieve this, the network architecture is updated with a boundary regressor for localization and detection processes. However, the work first classifies the images with defect before going for localization process. The computational burden of the OverFeat networks are compensated by adding the spatial feature of CNN to the model.

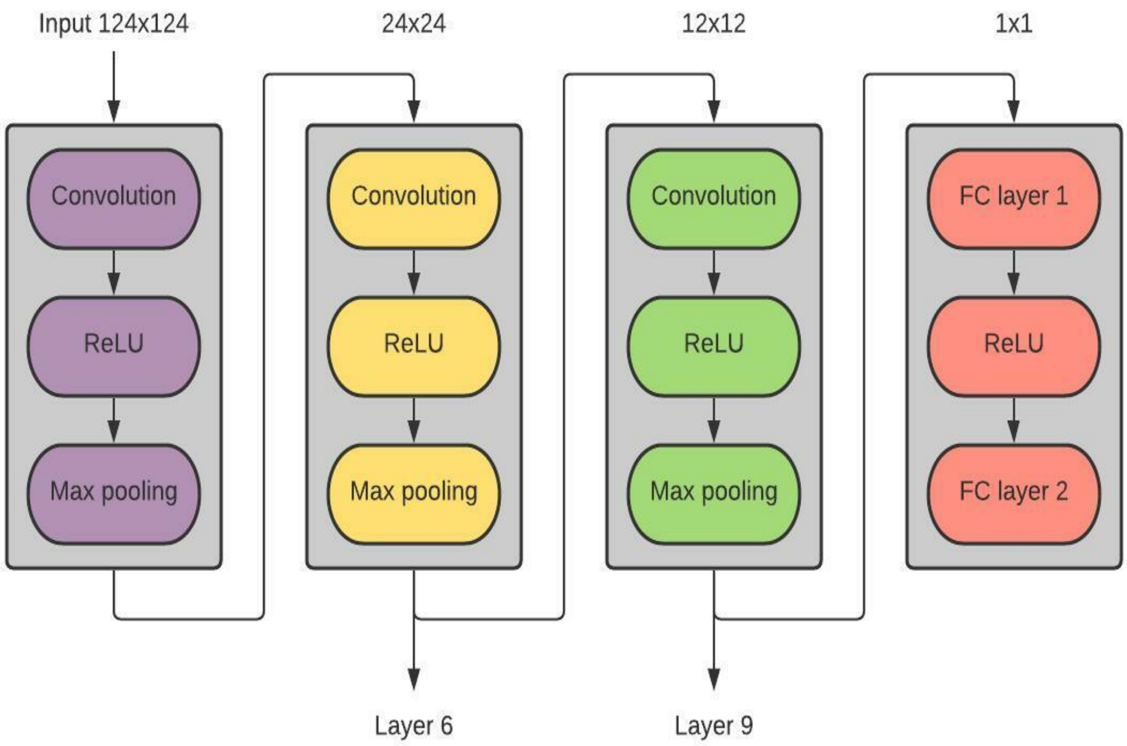

Figure 4. Architecture of an OverFeat network

The architectural view of the OverFeat network is shown in Figure 4 and the work utilizes the architectural model of OverFeat which was used for gene expression pattern model [25] with slight variations. The architecture of the OverFeat networks have multi-stage layers that includes convolution layer, rectified linear layer and max pooling layer. The OverFeat network employed in the work consists of 12 stage layers and the features are extracted from the network at the 6^{th} and 9^{th} layers.

4. Results and Discussion

To verify the efficacy of the proposed approach, the performances of the proposed model is compared with AlextNet and VGG models. A fabric defect dataset [26] downloaded from kaggle website is employed in the work for such analysis work. The dataset contains 97 images of hole defects and 157 images on line defects. As there are no images found in the dataset without defects, a set of images are collected from various online sources to the dataset. The final images included in the dataset are 500 and the dataset split-up ratio followed for the training and testing process are 75% and 25%. Figure 5 explores the confusion matrix chart of the verified approaches and Table 1 represents the performance comparison among the verified algorithms in terms of accuracy, sensitivity and specificity.

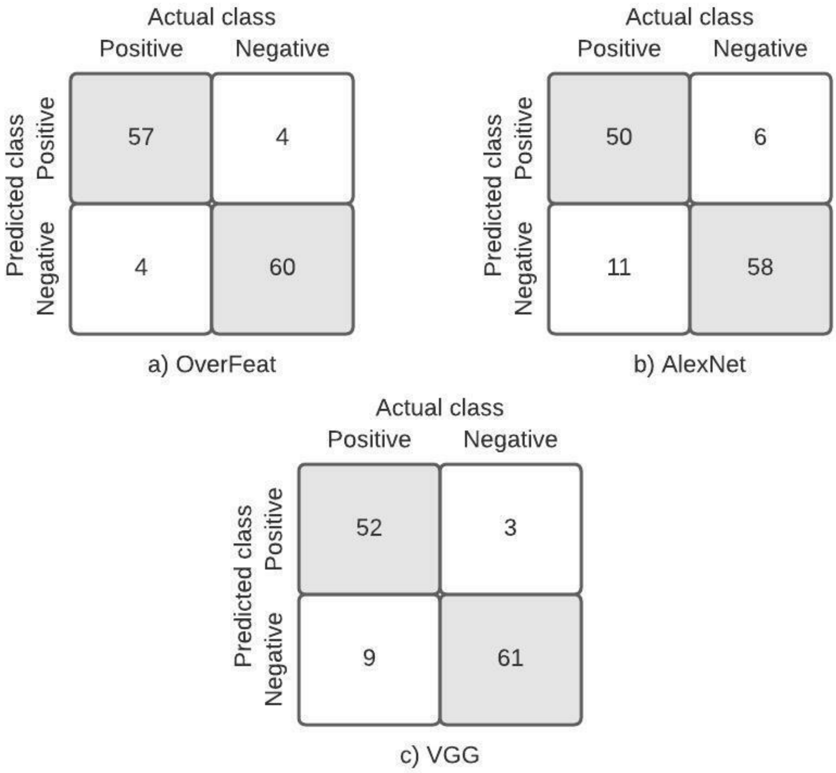

Figure 5. Confusion matrix chart of the verified algorithms

Table 1. Performance comparison of the proposed OverFeat model with AlexNet and VGG

Algorithm	Accuracy	Sensitivity	Specificity
OverFeat	93.6	93.44	93.75
AlexNet	86.4	81.97	90.63
VGG	90.4	85.25	95.31

The work observations shown in Figure 5 and Table 1 explores that the proposed OverFeat network performs better than its previous version AlexNet and VGG. However, the confusion matrix chart explores that the VGG network performs better than the OverFeat algorithm on identifying the defective fabrics but it fails in recognizing the regular fabrics. Therefore the work recommends the OverFeat network algorithm for a better classification process on fabric defect detection applications.

5. Conclusion

Quality maintenance is one of the primary role for any manufacturing process. Processes like fabric manufacturing, needs a prime attention on the products for ensuring its quality. Verifying the fabric products with manual eyes may result in error at several times.

Therefore a neural network based model is employed in the work by the help of OverFeat architecture. The performances of the proposed algorithm is verified with an openly available dataset and found satisfied with its observations on accuracy, sensitivity and specificity. The experimental work needs a better preprocessing technique along with a separate feature extraction model for increasing the current accuracy rate from 93.6% and it may be performed in the future.

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