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Classification of Industrial Components using Image Processing and Machine Learning Techniques.

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ABSTRACT: Artificially intelligent robots have become increasingly important in Industrial Technology in recent years. The key thing that robots do today is to do difficult and time-consuming activities in an efficient manner. Many components or pieces of equipment are installed in any industry. Humans handle this equipment, and they frequently keep track of it by recognizing and classifying it for further action. This process takes a long time to complete because we have to visit each and every component, but it does not require human intervention. As a result, vision systems and Intelligent Robots are now used to perform these duties. This research focuses on finding a solution to this issue. This work gives a thorough view of these machine learning and image processing techniques in this research, which can be used to improve the intelligence and classification skills of numerous industrial elements. This paper presented a model which identifies various industrial elements with the help of Ensemble Bagging Supervised Classification Machine Learning algorithms with feature extraction using Resnet-101 pre-trained Deep Convolutional Neural Network Model. The proposed model provided a solution where the industry is hazardous and wants to evolve in automation field to make the process safer and easier.

Keywords - Artificial Intelligence, Image Processing, Industrial Component, Machine Learning, Object Detection.

INTRODUCTION

Because of its popularity, Artificial Intelligence (AI) has exploded in popularity, and this field is on the verge of improvement. Artificial general intelligence varies from human general intelligence in that it is a flexible type of intelligence that can learn to execute a wide range of tasks. This broad topic of research may be divided into Machine Learning subdomains. Because of the fast advancement of Internet technology and media, the amount of visual material available on the Internet is increasing substantially every day. The traditional picture classification method requires manual intervention and has a low efficiency but low detection accuracy. The manual retrieval of the target image is difficult for massive data picture categorization. As a result, we'll have to rely on algorithms to extract the information we need from this data. Differentiating the faulty image from the image of industrial components is critical in engineering. To address the drawbacks of artificial image classification, researchers have begun to use computer methods for defect picture classification in recent years. With the improvement of machine learning and deep learning technology, certain strategies may be used to defect picture classification and detection, which may improve detection accuracy and boost efficiency growth.

Artificial intelligence (AI) and, in particular, machine learning (ML) has grown in popularity in recent years in the context of data analysis and computing, allowing applications to function intelligently. Because it allows systems to learn and develop from experience without having to be explicitly coded, machine learning is widely regarded as one of the most popular current technologies in the fourth industrial revolution (Industry 4.0). Machine learning algorithms are therefore critical for intelligently assessing these data and building the corresponding real-world applications. The popularity of these learning approaches is expanding by the day, according to Google Trends data collected over the previous five years. These data motivate us to investigate machine learning, which, as a result of Industry 4.0 automation, has the potential to play a large role in the real world.

LITERATURE REVIEW

Multiple researchers analysed relevant literature related to categorization problems using artificial intelligence and image processing methods. This section provides a summary of some of the most recent research.

Sarker Iqbal [1] provided a comprehensive overview of machine learning techniques that can be used to improve an application's intelligence and capabilities. Sunil et al. [2] looked at a machine learning approach based on an object detection framework. Object detection's uses have been summarised. Shakya et al. [3] suggested an artificial intelligence-based image classification system for quickly identifying veggies and fruits through a camera. The suggested approach outperforms the existing classifiers Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Random Forest (RF), and Discriminant Analysis in terms of accuracy (DA). Hwang et al. [4] conducted a study of mainstream studies that employed or built machine learning algorithms. Xin Mingyuan et al. [5] developed a novel depth neural network training criterion for maximum interval minimum classification error. To get better results, the cross entropy and M3CE are examined and integrated at the same time. Li Yanfei et al. [6] introduced a novel model based on convolutional neural networks (CNN) for rating apple quality that was both accurate and fast. The proposed model collected specific, complicated, and relevant visual properties for detection and classification. The suggested model outperformed previous methods in learning high-order features of two adjacent layers that were not in the same channel but were closely connected.

Sengottuvelan P. et al. [7] introduced a wavelet neural network-based classification technique termed substance based image classification (SIC). Wu Hao et al. [8] suggested a deep learning-based artificially intelligent system capable of rapidly training and identifying incorrect photos. A pretrained convolution neural network based on the PyTorch framework is utilised to extract distinguishing characteristics from the dataset, which are then used to perform the classification task. C Guada et al. [9] reviewed some of the most used image processing techniques and proposed a classification based on the results. Because, while an image analysis approach can be supervised or unsupervised, and can allow or not allow the existence of fuzzy information at some point, each technique has been intended to focus on a specific purpose, and the outputs are in reality different depending on the objective. By continually re-training the Inception-v3 model, Soyeon Park et al. [10] built a deep learning model. With an accuracy of 85.77 percent for the Top 1 and 95.69 percent for the Top 5, the final model is quite accurate. The final model was applied to the whole dataset to examine the tourist-drawing regions and their perceptions of Seoul. The suggested machine vision model in this study by Marouane Salhaoui et al. [11] combines the identification of defective items with the continuous improvement of manufacturing processes by predicting the best appropriate parameters of production processes to obtain a defect-free item. Transfer learning was used by M. Shaha et al. [12] to fine-tune the parameters of a pre-trained network (VGG19) for an image classification task. They compared the hybrid learning strategy, which consists of robust feature extraction using CNN architecture followed by a support vector machine (SVM) classifier. An empirical analysis of the performance of popular convolutional neural networks (CNNs) for detecting objects in real-time video feeds was presented by Neha Sharma et al. [13]. Anand Paul et al. [14] proposed a highly efficient model for automating central processing unit system production lines in an industry, in which images of the production lines are scanned and any abnormalities in their assembly are highlighted by the model, with information about this being sent to the system administrator via a cyber-physical cloud system network.

PROPOSED METHODOLOGY

The entire working process of the presented method is shown in Fig. 1. The presented model consists a series of processes which are discussed below.

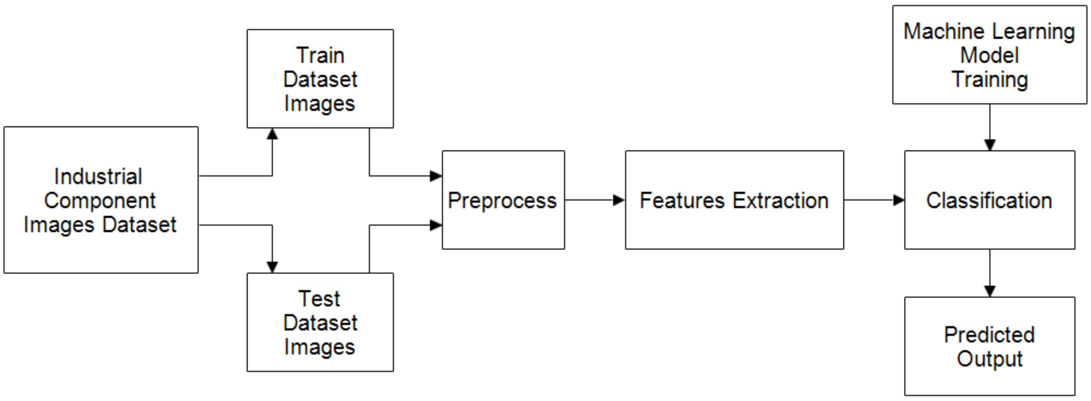

Fig 1: proposed methodology of system

Industrial Component Image Dataset, Dataset Splitting

In our proposed work, standard benchmark image database or images from google is used for identification of industrial component. The dataset has a collection of color images which consists of multiple classes, Gauges, Pipes, Valves and Vessels. Mainly project operation divided in two phases, first is training and then testing. So it is necessary to split the dataset images for two parts. Purpose of training, is to get the trained model using machine learning classifier by extracting and preprocessing the train images and testing, is to test or predict the input test image by applying test features to trained model.

Preprocess

Pre-processing is the name used for operations on images at the lowest level of abstraction. The aim of the pre-processing is an improvement of the image that suppresses unwilling distortions or enhances some image features, which is important for future processing of the images. This step focuses on image feature processing. Process is performed. Main operation performed is image resizing. The images used by dataset and query image need to resize as per size of image given in the pre-trained deep CNN model.

Feature Extraction

Feature extraction is the preliminary step in image classification. Sometimes the input data size is too large, which is tremendously hard to procedure in its raw form. For solving this, the input data can be transformed into a set of features. Feature extraction is the method by which unique features of industrial component images are extracted. This method reduces the complexity in classification problems. The purpose of feature extraction is to reduce the original data set by measuring certain properties, or features, that distinguish one input pattern from another. In proposed system, image features are analysed based on the pre-trained deep convolutional neural network (resnet-101).

Feature extraction is the easiest and fastest way to use the representational power of pre-trained deep networks. First, we load a pre-trained network which is trained on more than a million images and can classify images into several object categories. As a result, the model has learned rich feature representations for a wide range of images. The network constructs a hierarchical representation of input images. Deeper layers contain higher-level features, constructed using the lower-level features of earlier layers. To get the feature representations of the images, use activations on the global pooling layer at the end of the network. The global pooling layer pools the input features over all spatial locations, giving final features.

ResNet network uses a 34-layer plain network architecture inspired by VGG-19 in which then the shortcut connection is added. These shortcut connections then convert the architecture into the residual network as shown in the figure below:

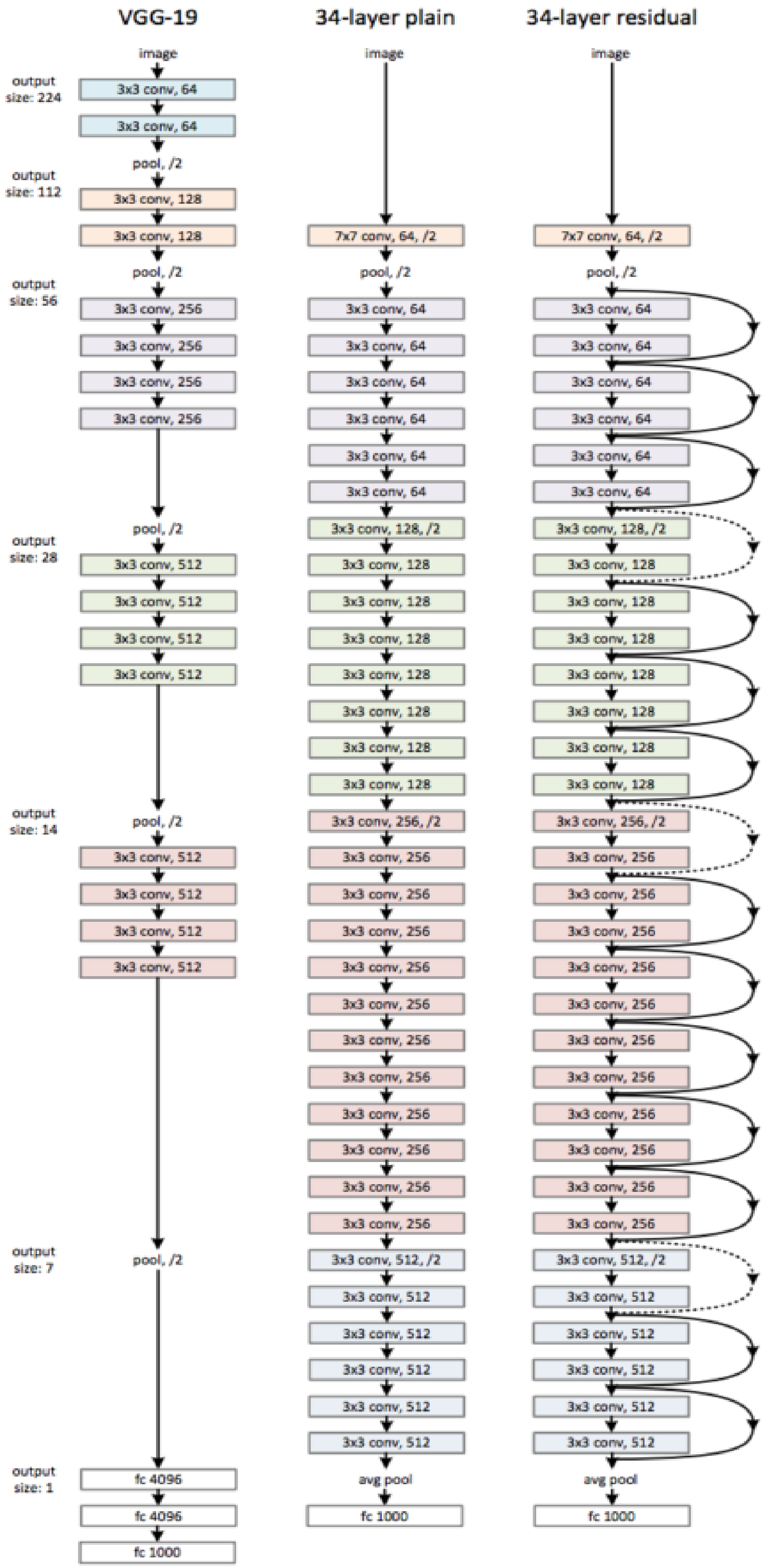

Fig 2: Resnet architecture

Machine Learning Model Training and Classification

Machine learning model is first trained and then trained classifier is used to classify various industrial component images. To classify feature data into a given number of classes, we have used machine learning technique. In this project, the ensemble bagging classifier, are used to train the various component images. Classifier takes set of images, create trained model and predicts for each input image belongs to which of the various categories of industrial components labels.

In statistics and machine learning, ensemble methods use multiple learning algorithms to obtain better predictive performance than could be obtained from any of the constituent learning algorithms alone. Bagging, also known as bootstrap aggregating, is the aggregation of multiple versions of a predicted model. Each model is trained individually, and combined using an averaging process. The primary focus of bagging is to achieve less variance than any model has individually. Decision Tree Bagging are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees. Tree Bagging correct for decision trees' habit of overfitting to their training set. Tree Bagging is a supervised learning algorithm which is used for both classification as well as regression. But however, it is mainly used for classification problems. As we know that a forest is made up of trees and more trees means more robust forest. Similarly, Tree Bagging algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result.

RESULT AND DISCUSSION

The proposed work is implemented on Intel CORE processor i5, 8GB RAM Laptop configuration and operating system is Windows 10. MATLAB R2018b software was used to write the programming code in this we used Image processing, Statistics and Machine Learning toolbox and Deep Learning toolbox. The input images is taken from Kaggle Dataset and Google photos for experimentation. Performance of systems is evaluated using confusion matrix and its related parameters as shown below.

$$\text{Accuracy (ACC)} = \frac{TP+TN}{TP+TN+FP+FN}$$

$$\text{Sensitivity or True Positive Rate (TPR)} = \frac{TP}{TP+FN}$$

$$\text{Specificity or True Negative Rate (TNR)} = \frac{TN}{TN+FN}$$

$$\text{F1 score (F1)} = 2.\frac{PPV.TPR}{PPV+TPR} = \frac{2TP}{2TP+FP+FN}$$

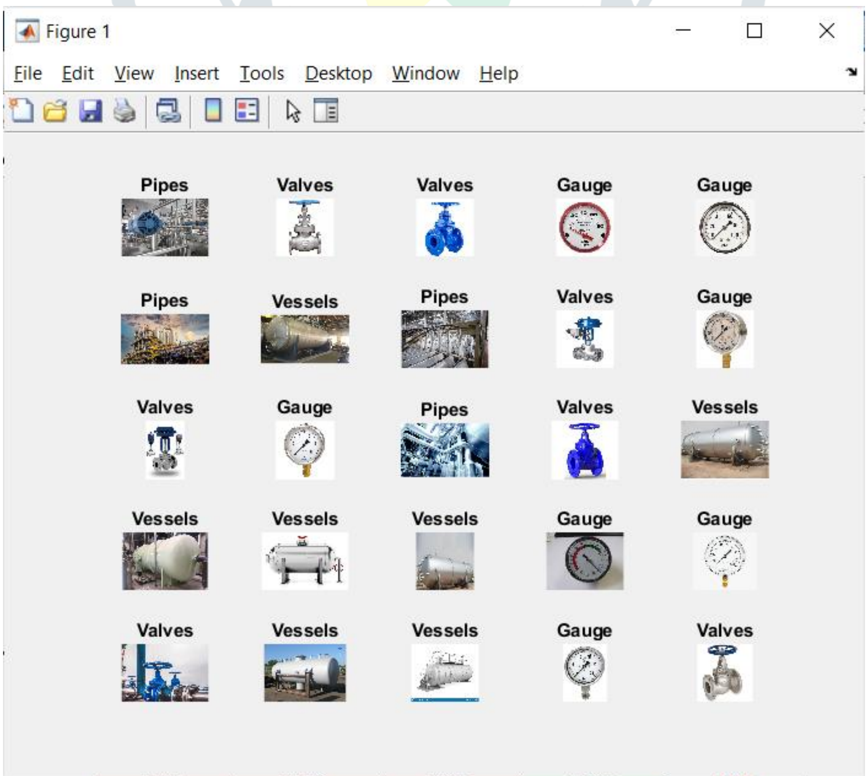

Fig 3: Samples Images of Industrial Component Image Dataset

```
Command Window

net =

  DAGNetwork with properties:

         Layers: [347×1 nnet.cnn.layer.Layer]
    Connections: [379×2 table]


inputSize =

   224   224     3

  Name                  Size                 Bytes  Class     Attributes

  featuresTrain       87x2048               712704  single
```

Fig. 4: Resnet-101 architecture and train feature Information

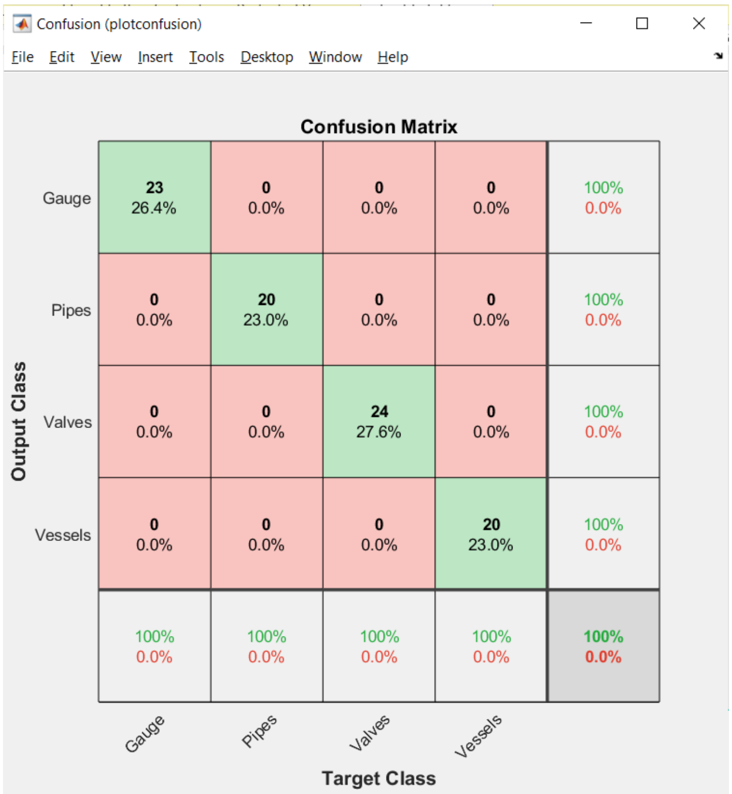

Fig. 5: Confusion matrix of Train Images Dataset

```
Command Window
  Name                  Size                 Bytes  Class     Attributes

  featuresTest        1x2048                  8192  single
```

Fig. 6: Feature information of test dataset

Fig. 7: Sample Test Images a) Gauge b) Pipe c) Valves d) Vessels

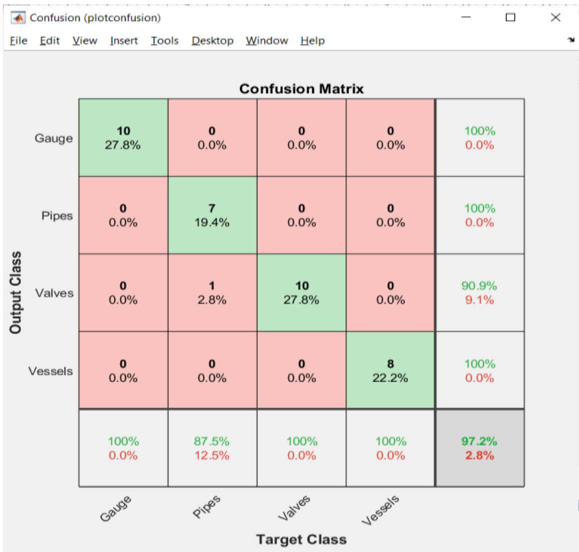

Fig. 8: Confusion matrix of Test Image Prediction

Table 1: Evaluation Parameters

Parameters	Guage (%)	Pipes (%)	Valves (%)	Vessels (%)
Sensitivity	100	87.5	100	100
Specificity	100	100	96.15	100
F-Score	100	97.22	92.59	100

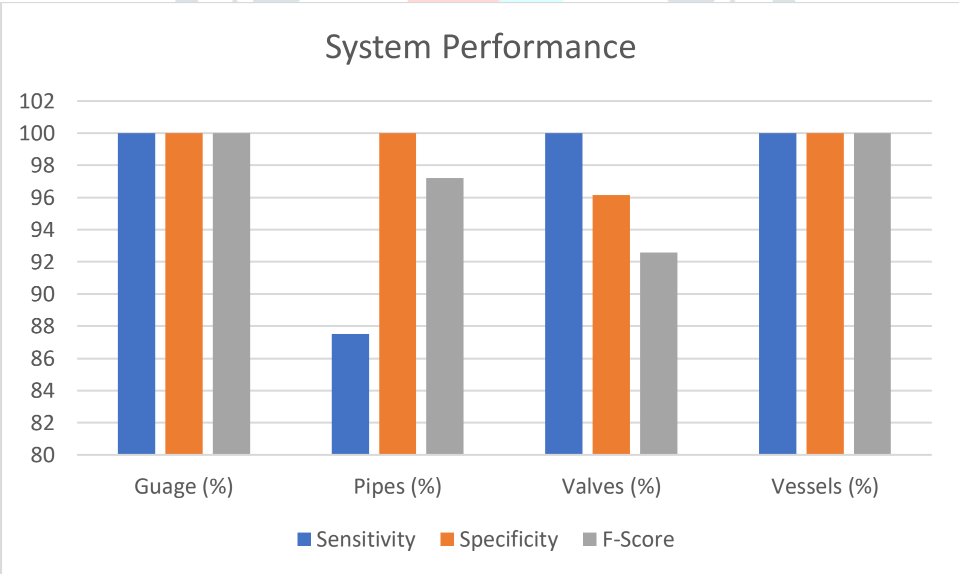

Fig 9: Evaluation performance parameters analysis

CONCLUSION

Industry Elements/Equipment identification and classification is a very important task in Industry. The use of Image processing in the production industry provides a rapid, economical, consistent and objective assessment. Even though adequately efficient and accurate algorithms produced but till now real time system not available for some cases. An attempt to develop such a system may also be of great interest to researchers in this domain. The industrial component images are taken as input and after training of machine learning classifier, input is tested on trained classifier to get the predicted label of industrial component. The proposed approach provided an efficient solution to classify different elements into their respective categories. The proposed model is trained using ensemble bagging classifier techniques with pre-trained deep convolutional neural network features resulting in best results and improvised accuracy. The proposed model exhibits classification accuracy of 97.2%. Moreover, higher accuracy is achieved by the proposed model when identical dataset is used for training as well as testing during real time industrial implementation. Further implementation in this project can include various industrial component category of different application domain.

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