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Ceramic and surface defect detection

Mr.Sarvesh K Rai[1], Miss. Zarin Khan[2], Mr. Sufiyan Khan[3]
[1]Student, Dept. Information and Technology, A. C. Patil college of engineering, Maharashtra, India
[2]Student, Dept. Information and Technology, A. C. Patil college of engineering, Maharashtra, India
[3]Student, Dept. Information and Technology, A. C. Patil college of engineering, Maharashtra, India

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ABSTRACT - Image classification is a branch of computer vision that uses a computer to acquire image data and interpret them by mimicking human biological systems. This is a very important topic in today's situation because every second a large number of image data are acquired and used for various purposes around the world. One application of image classification is to detect defects on the surfaces of industrial products. Quality inspection is usually the final stage in a production line, and so far it is mainly conducted by human experts. This can be time consuming and mistake-prone. In this study, we investigate the possibility of replacing, fully or partially, human experts with a machine learner when the product defects are visible. In this study, we investigate several methods based on deep learning. The first one is to use a deep learner directly to detect the existence of defects in a given product surface image. The second one segments suspected parts first and then uses the deep learner to classify the segmented parts. The third method employs an ensemble of deep learners. Results show that the third method can provide the best results, and can be practically useful if we introduce a proper rejection mechanism.

Key Words: Deep learning; Defected Ceramic Surface; Surfaces.

I. INTRODUCTION

Engineering structures like concrete surface, beams are often subjected to fatigue stress, cyclic loading, that leads to the defects that usually initiate at the microscopic level on the structure’s surface. The defects on the structure reduce local stiffness and cause material discontinuities . Early detection allows preventive measures to be taken to prevent damage and possible failure .

Defect detection is the process of detecting the defect in the structures using any of the processing techniques. The defect detection can be made in two ways. They are Destructive Testing and Non-Destructive testing.

By incorporating the visual examination and surveying tools, surface condition deficiencies are evaluated .

The objective of the type, number, width and length of the defects on the structural surface shows the earliest degradation level and carrying capacity of the concrete structures.

For fast and reliable surface defect analysis, Automatic defect detection is developed instead of the slower detection can be done using some of the Non- destructive testing techniques like digital deep learning. There is an increasing interest in image-based defect detection for non-destructive inspection. Because of its simplicity in the processing, many of the deep learning detection methods were proposed.

In this research, a detailed survey is conducted to identify the achievements till in the field of defect detection. Accordingly, a few research papers are taken related to defect detection, and those research papers

are reviewed. The organization of this survey initially starts up with the general architecture of deep learning based defect detection, and then survey of the various papers based upon the image type used.

In the recent times, deep learning has proved to be exceptionally successful in object detection and classification, facial detection, pattern recognition, fault diagnosis, target tracking, and a wide variety of other image-based applications. It has proved to be robust to background, lighting, color, shape, sizes, and intensity in the detection of patterns in images. This is especially desirable when detecting complex surface defects in industrial settings. Challenges for defect detection in such wide ranges of settings have been shown in Fig. 2. Moreover, defects not only have to be detected but also, there is a need to obtain the exact size and type of defects. Deep learning-based defect detection provides flexibility in terms of the network to detect custom defects based on the data set. Moreover, the parameters of the network learned for one network can be used for similar networks to generate high rates of success for surface defect detection. Furthermore,

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there is no need for a custom code needed for training different types of defects. The labeled data for different defects with the appropriate network provides a significantly flexible defect detection mechanism, as described in several works discussed in this paper.

A large number of papers have been published in the recent past focusing on deep learning in defect detection. This survey paper aims to provide readers a framework to categorize different methods and help them identify previously published works that are related to their needs. Defect detection can be performed using a wide variety of sensor data. To keep the scope tractable, this paper will focus on imagebased defect detection using deep learning. There are several survey papers published on defect detection using traditional feature detection and learning methods [15, 16]. We will not cover these methods in this paper. Survey papers have also published on anomaly detection using deep learning [17]. Our focus is on surface defect detection and, therefore, will need to focus on methods that are capable of classifying and locating defects in an image. There have been highly specialized application domain based survey papers on defect detection that include pavement defects [18], flat steel surface defects [19], fabric defects [20], metal defect detection [21], industrial applications [22] and corrosion detection [23]. We are interested in exploring a wide variety of manufacturing applications in the surface detection area and make general observations of the methods used in these applications. Therefore, the focus of this survey paper is different from what has been published until now. We mainly focus on applications related to inspection, quality control, and process modeling in manufacturing. For image-based defect detection using deep learning methods, there can be several ways in which the existing literature can be classified. We have discussed three specific classifications in this paper.

II. LITERATURE SURVEY

The existing system is manual system humans can make mistake,the reliability of human judgment is a matter of debate. These mistakes can end up being costly. Its hard for human eye to catch all kinds of defects, humans are slower than computer. Using deep learning fast results can be obtained. Human errors can cause great loss and is too time consuming. Digital systems which are present in market are mostly focused on one type of surface or one type of defect.

In this segment various types of fault recognition procedures in various surfaces are reviewed and described briefly as follows. The titanium coated surfaces may contain small defects, which can be detected by contrast adjusted Otsu's method [1]. Here, the defect can be analyzed by threshold method, converting the grey scale image into binary in the prepossessing. The areas of the image containing similar properties are segmented initially, so that a black and white binary image is obtained. The threshold converts the image pixels in terms of zero and one, a specific value less than zero is considered as black and pixel values beyond certain standards are assumed as one (white). The above mentioned thresholding method calculate a maximum cut off value for image dissimilarity and then calculate the threshold using Otsu's thresholding. The threshold is calculated by separating the image in to two sections based on the threshold value as the extreme cut off value for image which provides a uni modal histogram. Then the image is transferred to a binary illustration, the otsu's approach espouses that the histogram of the image is bimodal and split the uni modal distribution. This thresholding technique separates the segmented image into two regions, coated regions and uncoated regions. The various kinds of cracks in TFT LCDs (Thin Film Transistor Liquid Crystal Display) can be identified by optical interference pattern sensing technique and neural network classification technique [6]. The optical interference pattern sensing scheme [7] identifies the interfering borders, then further processing can be done by image processing tools. The various types of defect occurred in TFT LCDs can be identifed based on the neural network classifi cation method [8]. For producing the interference patterns in TFT LCDs fluorescent lamps or sodium lamps are used. The image is transformed then to greyscale image and also histogram equalization would be completed. The extracted features are then used for classifi cation purposes. The neural network would be classifi ed on the premise of the trained set of images. The grouping is predicated on the width of the fringes, area of the fringes and ratio of the interference fringes obtained. By using neural network classification method the area containing defects and the types of defects occurred can be identified [9]. By using this process the mean square error can be reduced. The defect detection based on interference pattern detecting scheme and neural network classification method is found to be very robust and reliable.

Terminology The following definitions will be used in subsequent sections. Artificial neural network (ANN): A computing system inspired by the biological neural network of the brains [24]. It consists of multiple layers of highly

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interconnected neurons (processing elements). Shallow neural network: Neural networks have an input layer, hidden layers, and an output layer. Shallow neural networks have only one hidden layer [24]. Deep neural network: Neural networks with two or more hidden layers are called deep neural networks [24]. Autoencoders (AE): Autoencoders [24] are a type of unsupervised neural network to learn effective data coding. It can consist of an encoder, coder, and decoder. Convolutional neural network (CNN): CNN [24] is a type of neural network which includes a mathematical operation called convolution in one of its layers. Generative Adversarial Network (GAN): GAN [25] is a machine learning model that contains two neural networks, generator and discriminator. Self-Organizing Map: Self-organizing map (SOM) or selforganizing feature map (SOFM) [26] is a type of ANN trained using unsupervised learning. Unlike other ANN networks, SOMs do not learn by backpropagation, but it uses competitive learning to adjust weights. Softmax layer: Softmax layer [24] is a squashing function which limits the output values in the range of 0 to 1 and can be considered as a probability.

III. PROPOSED SYSTEM

The system uses deep learning to find defect in various given images using data set provided, it inspects the image for the defects and gives the result using various algorithms.

1.Svm

Support Vector Machine” (SVM) is a supervised machine learning algorithm which can be used for both classification or regression challenges. However, it is mostly used in classification problems. In the SVM algorithm, each data item is plot as a point in n-dimensional space with the value of each feature being the value of a particular coordinate. Then, we perform classification by finding the hyper-plane that differentiates the two classes very well .
SVM or Support Vector Machine is a linear model for classification and regression problems. It can solve linear and non-linear problems and work well for many practical problems. The idea of SVM is simple: The algorithm creates a line or a hyperplane which separates the data into classes.

2.Linear Regression

Linear Regression is a machine learning algorithm based on **supervised learning**. It performs a **regression task**. Regression models a target prediction value based on independent variables. It is mostly used for finding out the relationship between variables and forecasting. Different regression models differ based on – the kind of relationship between dependent and independent variables, they are considering and the number of independent variables being used.

3.GridSearchCV

GridSearchCV is a library function that is a member of sklearn's model_selection package. It helps to loop through predefined hyperparameters and fit your estimator (model) on your training set. So, in the end, you can select the best parameters from the listed hyperparameters.

3.1 Flowcharts

1. SVM

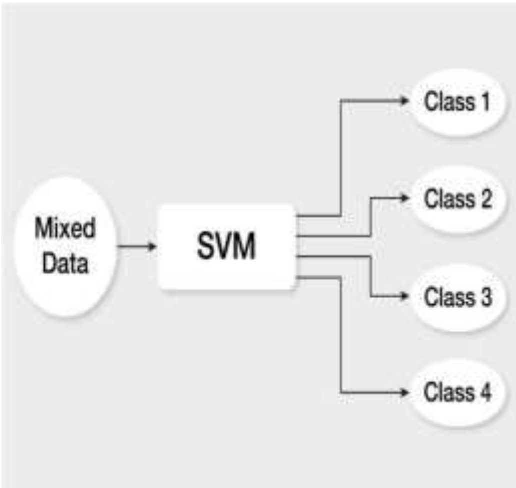

Fig 1

2.Linear Regression

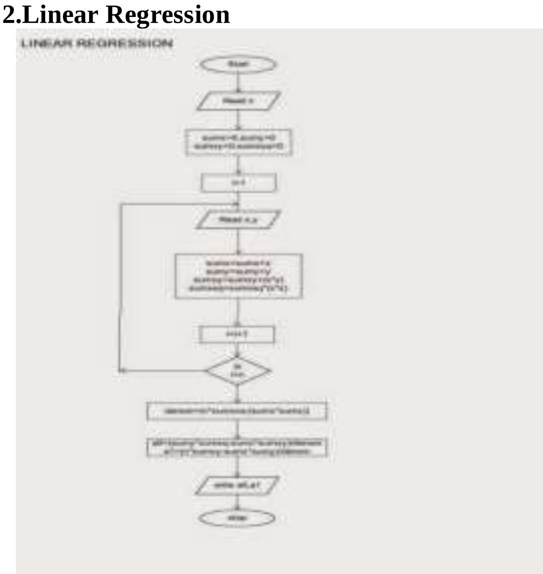

Fig 2

3.GridSearchCV

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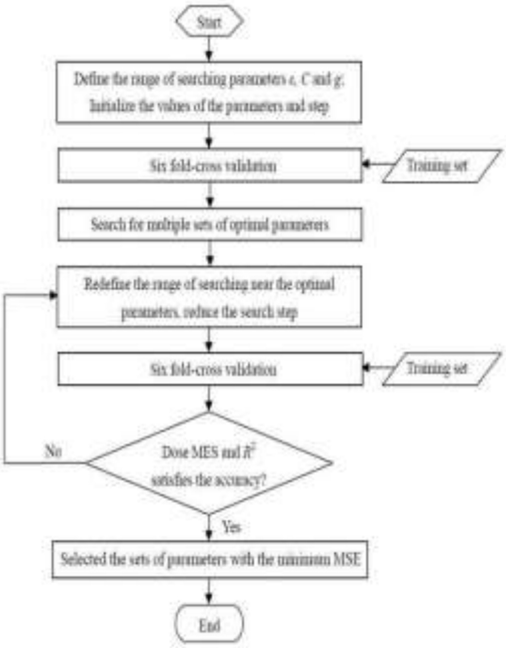

Fig 3

IV. RESULT AND DISCUSSION

In this section, the result of the proposed defect detection.

Fig 4

The image has to be provided to the system.

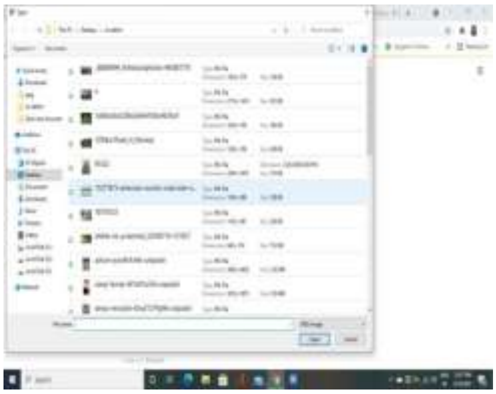

Fig 5

Select the image for inspection.

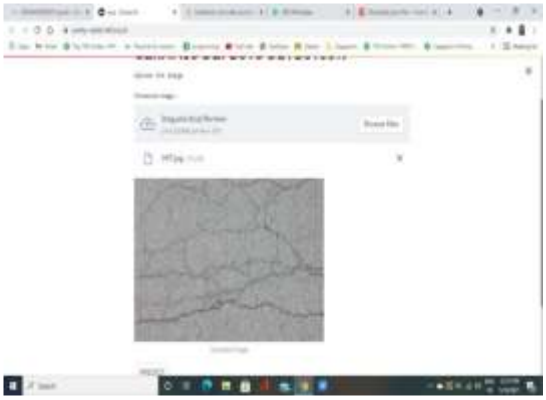

Fig 6

As can be seen in the fig image has defect.
The image is matched with the data sets and accordingly the result is given.

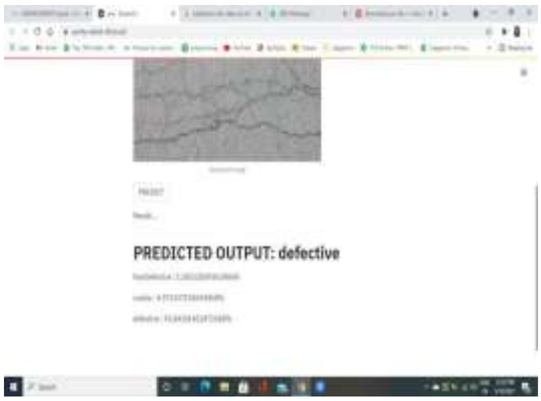

Fig 7

And the result is obtained with the specifications.

V. CONCLUSION

Deep learning is gaining popularity in the defect detection community. This paper presents three different perspectives for examining the existing literature. The first perspective is based on identifying the scope of different detection problems based on application contexts and requirements. This perspective helps us define and understand different types of defect detection problems. The second perspective examines the literature from a machine learning perspective and explains why certain learning approaches are useful for certain kinds of problems. Finally, the system architecture perspective explains different types of approaches used to localize and classify defects from a system architecture point of view. We classify literature using these three perspectives. Imagebased surface defect detection using deep learning is a fast emerging field and presents unique challenges compared to other image analysis and object detection problems. We also identify and present directions for future research.

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[9]. Yasir Aslama N. Santhib and K. Ramarc a Research Scholar, Dept. of ECE Noorul Islam Centre for Higher Education, Kumaracoil, India