Automated Identification and Rejection of Defective Ceramic tile using a Machine learning Approach

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***Abstract* — Ceramic tiles come in a wide variety of colours, textures, and sizes. The process of crack detection and rejection is very laborious, costly and time consuming and is less efficient due to harsh industrial environment and human errors.The quality control plays major role in delivering a quality tile and yet it is done manually. Manual inspection is labor intensive, costly and less efficient.Hence, some fast, efficient and reliable automated process is required to perform tile crack detection and rejection. Many methods are used viz., simple visual image analysis, infrared visionand ultrasonic characterizations. This paper proposes an automated defect detection and rejection system for ceramic tile using machine learning approach. A dataset containing 80 images with crack of different sizes and different orientations, 60 images with different textures, and 60 images without crack for training a neural network and Support vector Machine (SVM) classifiers are used. A set of 50 independent test images are used to test the results and found to be promising. A comparative study among different methods i. e Threshold based detection, neural network based and SVM based classifier is carried out. SVM classifier works faster in comparison with neural network based method. The efficiency of these methods is compared.**

Keywords—Image processing, Feature extraction, Defect detection, classifiers, neural networks.

I. INTRODUCTION

The main compounds used to make the ceramic tiles are clay and other natural materials such as sand, quartz and water. Proper mixtures of all these compounds are then pressed under very high pressure into squares, rectangles, or even ovals then these blocks are baked for particular time at controlled temperature[1].

On large scale preparation there may always be a possibility of non-uniformity. Hence, not all the tiles get the required treatment which causes the development of flaws and the type of Flaws varies depending on the factors that have been compromised. Quality control in ceramic tile manufacturing is hard, labour intensive and it is performed in a harsh industrial environment with noise, extreme temperature and humidity and inspection contains variety measurements such as colour analysis, dimension verification, and surface defect detection.In this paper an efficient defect detection technique has been proposed. The second section explains about the Literature Survey. The third section proposes robust detection of defective ceramic tiles,the fourth section describes the hardware setup. The fifth section presents the results and the sixth section presents the conclusions and future scope..

II. LITERATURE SURVEY

G.M. Atiqurrahamanet. al[1]proposed a defect detection method which uses pre-processing followed bysobel edge detection. After the edge detection method the number of white pixels of reference image and the number of white pixels of test image are counted. If the count of white pixels is greater than the reference image, a defect is detected.

Yasantha c. samrachakrawam et.al [2]proposed that after pre-processing, a canny edge detection is performed and then counted the number of white pixels of reference and test images. If the count is greater than in reference image, it will predict it as defective otherwise non-defective.

These methods fail to differentiate between the defective tiles and textured tiles and require a reference image to supplied every time, which may not be possible.

Baig et.al [3] proposes image pre-processing steps such as resizing. The RGB image is converted into a grey scale Contrast of the image is is to be enhanced and a median filter is applied to remove noise. Morphological operations like dilation and skeletenizition is done. A canny edge detector is used to identify holes (cracks).These holes are filled e. The number of these white pixels is counted and stored in variable count. If the count is greater than a threshold, a defective tile is detected.The main fault in this method is it is not possible to calculate an adaptable threshold value for all kinds of tiles. Threshold value varies for different kinds of tiles. Selection of threshold itself is a difficult problem

III. PROPOSED METHOD:

Machine learning plays a very important role in detection and classification problems. In this section two methods are proposed to detect the defective tile. They are:

1) Using SVM classifier
2) Using Neural network (feed forward probabilistic neural network)

Method 1- Using SVM Classifier

Support Vector Machine (SVM) is a classification technique. It uses a supervised learning algorithm. It is mainly used for classification problems. The steps involved in classification are as mentioned below

a) Image pre-processing*:*Image processing is a method to perform some operations on an image, in order to get an enhanced image.

b) Featureextraction:Contrast,Mean,Variance,Entropy , Homogeneity,Energy,RMS,IDM,smoothness of these are the features extracted from the image.

c) Training: The SVM classifier is trained with these 9 features for 200 images. A dataset is generated by the classifier with these inputs.
d) Testing:During testing an image is chosen from test set, same 9 features are extracted, which are fed to the SVM classifier for classification.

When this method has been tested with textured images some of the textured ceramic tile images resulted to be defective even thougl
that SVM classifier dc

S.NO	FEATURE	
1	Contrast	
2	Energy	
3	Entropy	$\sum_{i,j=0}^{N-} p(i,j)^2 \log p(i,j)$
4	Homogenity	$\sum_{i,j=0}^{N-1} \frac{p(i,j)}{1+(i-j)^2}$
5	IDM	$\sum_{i,j=0}^{N-1} \frac{p(i,j)}{1+(i-j)^2}$
6	Mean	$\frac{\sum_{i-0}^{l-1}(i,j) * p(i,j)}{\sum_{i=0}^{l-1}(xi * p(xi))}$
7	Variance	$\sum_{i,j=0}^{l-1} p(i,j) * (i-\mu i)^2$
8	RMS	$\sqrt{\frac{1}{T}\int_{t0}^{t0-T} v(t)^2 dt}$

Table.1 Statistical Features

Method 2- Using Neural networks

A feed forward perceptron neural network is used for classification. Various steps involved are as described

a) Image pre-processing: Image Pre-processing is a method to perform some operations on an image, in order to get an enhanced image.
b) Featureextraction:Statistical features like Contrast,Mean,Variance,Entropy, Homogeneity,Energy,RMS,IDM,smoothness are being extracted from the image.
c) Training: The Neural network (NN) classifier is trained with these nine features for 200 images.
d) Testing: A random image from test set is picked up, all the nine features are extracted and fed as input to neural-network classifier for classification

METHODOLOGY:

Data-set plays an important role in efficiency of a neural network. A dataset of 200 images consisting of cracked,textured and plain images has been collected. The process is explained with the help of a block diagram has been shown in Fig.1.

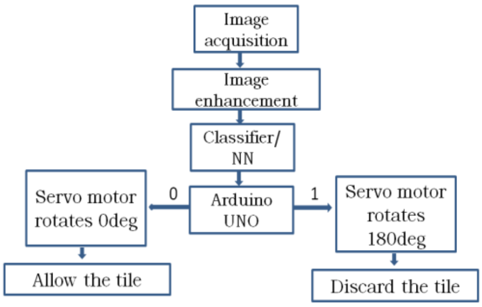

Figure 1: system block diagram

The flow of process for training is as shown below.

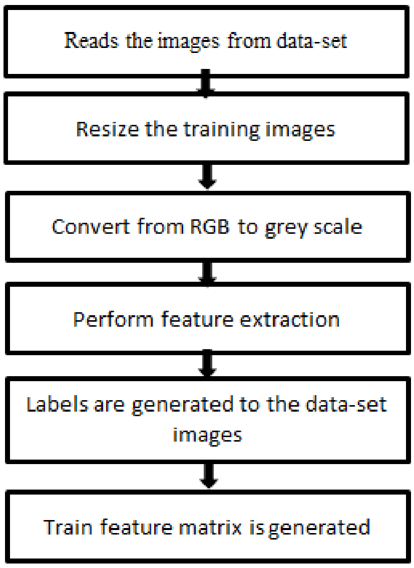

Figure: 2 SVM classifier flowchart

As in fig. 2, the images from dataset are resized after reading. Resizing means the scaling down of the image. Due to this the execution is reduced considerably. Images are converted from RGB to grey scale. This is important because calculation of features becomes simpler for grey scale values compared to RGB because of its complexity. The next step is to extract the features. Here statistical features are extracted to train neural network with the characteristics of tile images. Contrast, mean, variance, RMS, IDM, smoothness, homogeneity, entropy and energy are calculated for every image. The mathematical reference to these features is given in table 1. A matrix of size 9x200 is created to store 9 features of 200 images. This matrix is used as the data by neural network during its testing. During training of the neural network the images in dataset are allotted with a label, i. e, images from 1-70 (defective ceramic tile images) are labeled as 1 and the rest (non-defective) as 2.

A) Testing phase:

The flow of process for testing is as shown below.

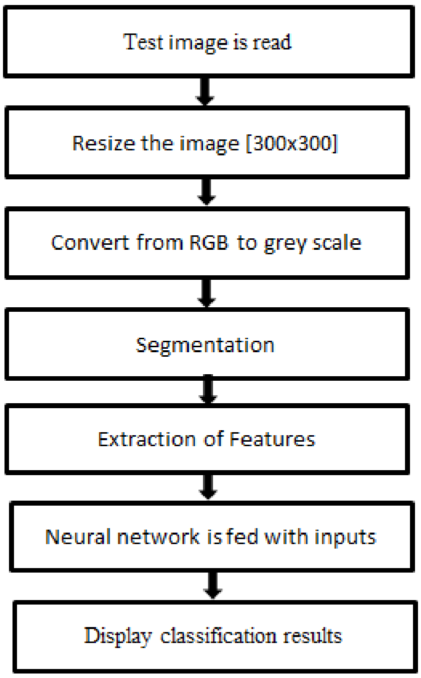

Figure: 3 Neural Network classifier flowchart

As shown in fig. 2, the image that is to be tested is read and resized to same size as the training images are sized to. RGB image is converted into grey scale as features have to be extracted here also. To increase the efficiency of the system, pre-processing operations are done during testing. Contrast stretching is done to improve an image by stretching the range of intensity values it contains to make full use of possible values. This image is passed through a median filter; it is used to remove noise from images. This preserves the edges and removes the noise from image. Canny edge detector is used on image to detect the cracks on a test image. This is done by identifying the discontinuities in the image. Next, image is skeletonized, Skeletonization is the process for reducing the fore-ground regions in a binary image. After pre-processing operations are done same features as of training are extracted. These features again form a matrix of order 1/9. The two matrices generated are fed to neural network and a result is obtained.

IV. RESULTS

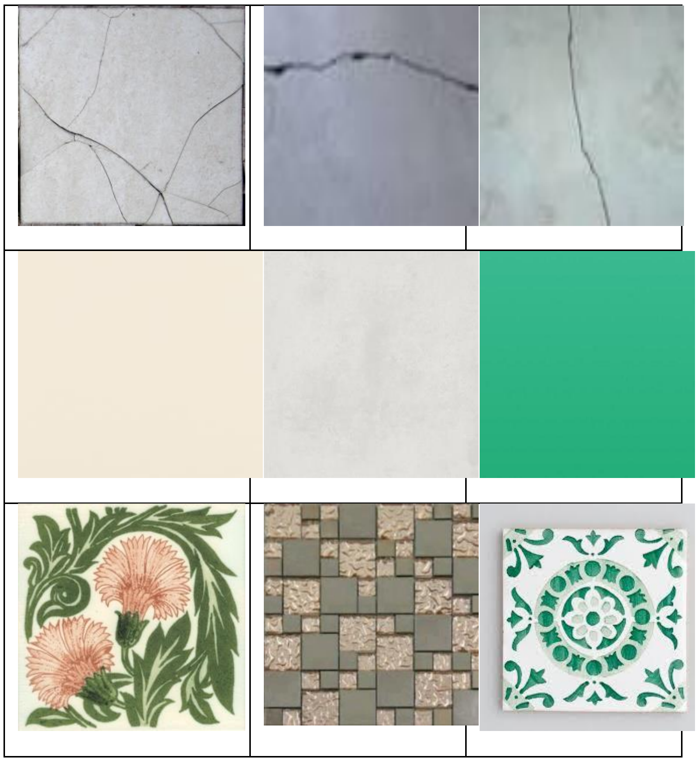

Figure: 4 Training Sample

Figure: 5 Testing Sample

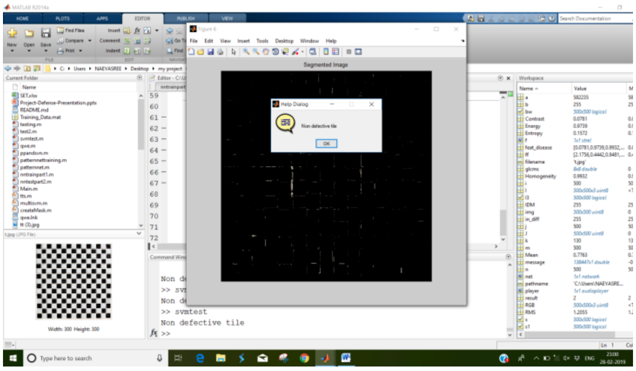

Figure: 6 SVM result

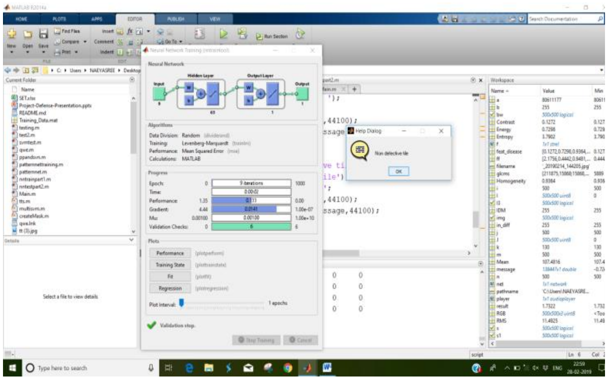

Figure: 7NN result

COMPARISION

A confusion matrix is drawn to analyze the performance of the classifiers. The accuracy is calculated.

$$\boldsymbol{Accuracy} = \frac{\boldsymbol{TP+TN}}{\boldsymbol{TP+TN+FP+FN}}\boldsymbol{*100}$$

Recall is the ratio between the total number of correctly classified positive inputs to total number of positive inputs.

$$\textbf{Recall} = \frac{\textbf{TP}}{\textbf{TP+FN}}$$

Precision is the ration between the total number of correctly classified positive inputs to total number of predicted positive inputs.

$$\textbf{Precision} = \frac{\boldsymbol{TP}}{\boldsymbol{TP+FP}}$$

classifiers	Accuracy	Recall	Precision
SVM	89%	0.89	0.89
NN	95%	0.95	0.95

Table: 2 performance chart

HARDWARE:

The hardware is used to capture the test image and also to reject/allow the tested tile. The image is chosen while testing the ceramic tile. A servo motor is connected via arduino to a computer. When result is 0(non-defective tile) the servo stands still and allows the tile to move forward and when the result is 1(defective tile) the tile is rejected by rotating servo by 180 degrees.

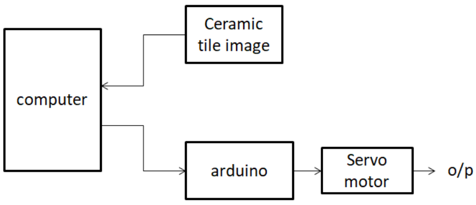

Figure: 7 Hardware setup

The time taken for the complete process to be done is 8seconds. MATLAB software is used to interface hardware to software programme.

s.no	components	specifications
1	Arduino	UNO
2	Servo motor	MG995

Table: 3 Hardware specifications

V. CONCLUSION AND FUTURE WORK :

In conclusion, this system has fulfilled the main aim of detecting a defective ceramic tile. The main aim was achieved by this automated inspection system for ceramic tile industry solving drawbacks of the existing methods. Further enhanced accuracy and efficiency, ability to detect surface defections such as middle cracks, edge damages and corner damages are achieved significantly.

As a continuation to this work, it is recommended to categorize the defects. This system can just segregate between defective and non defective but as an enhancement the number of categorizations can be increased. Categories like middle cracked tiles, edge defected tile, tiles consisting of blobs etc can be done.

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