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Automated System for Defect Identification and Character Recognition using IR Images of SS-Plates

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Abstract*: Defects on the surface of stainless steel(SS) plates are one of the most important factors affecting the quality of SS plates. Problems of manual defect inspections are lack of accuracy and high time consumption, where early and accurate defect detection is a significant phase of quality control. It is indeed in need to distinguish such abnormalities through computer automated classification systems, which would have a persistent vision of identifying and classifying the above mentioned problem with self-trained classification routine. In this paper, develop a sophisticated routine for defect identification and character recognition on SS plates by considering the multiple features of IR images. The proposed method integrates four steps: (1) defect candidate is detected using a Multi-Scale LoG Weighting; (2) features descriptive of defect shape and texture are extracted; (3) defect objects are classified using a classifier based on SVM-RFE model and (4) the character recognition of SS plate is done using pattern correlation. The output of the anticipated routine is assessed by the metrics: accuracy, sensitivity & specificity. The automated defect identification and classifying routine is compared with ANN, Adaboost and Random Forest (RF) classification methods where the classification result of the anticipated routine outperformed the performance of the previous classification methods.

***Keywords*: SVM-RFE, GLCM, LNDP, Multi-Scale LoG Weighting, Edge density enhancement**

I. INTRODUCTION

When considering in the case of industries the main raw materials and the quality on the surface is quite essential to monitor and validate far before they are used to use it on manufacturing activities. In the following years, industries shows a refusal strategy to reject any materials as raw material shows a significant abnormalities found in production procedures because of negligible abnormalities in a production part must consequence in a catastrophe at a later stage of the entire process.

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Thus, identification of defects at its very early stage can possibly wane the product damages and thus the product manufacturing cost is significantly reduced. In contrast with the industry protocol there are several sorts of imperfections on the surface of metals. In common, if the defects on the metal sheets are considered as large then it becomes more crucial than minimum ones, but the concern about the abnormalities where the measurement is only tenths of a dimension. The problem in production still exist on making of metal product at a high speed continuously, it is of course that any imperfections in the quality of metal often causes problems in the stages of production.

The abnormalities found on the surface is formed by several reasons like extreme poor quality of materials used for manufacturing or failure in the process of rolling. Considerably less demanded surface imperfections such as pits, bumps, scratches and holes produce palpable issues for operations which belongs to finishing stages, however the major problem exist until the end of the production is the kind of defects can be visibly seen.

The conventional (visual inspection) quality control method has been outdated with increased demand in the excellent quality necessities and the waned exposure which industries gained. The ultimate challenge is to have computer based systems for accomplishing regular surface valuation automatically. The responsibleness of those systems is essential, since they ought to neither guarantee nor such essential abnormalities can go undiscovered, however while not generating several false sign which build the process unusable. The next challenge consists of inspecting location where it's not previously inspected because of obstacles in the place, such as, waned temperatures [4]. For instance, in the case of mill working in high temperature, where risks for detection of abnormalities are enormous large: without adding further values remove the defected products of stainless steel at earlier stage; reduction in yield due to conventional routine; quick feed-back given to upstream plants [7], [8]. Vision-based automatic method is often anticipated to confront the difficulties in defect identification. This has been matured considerably in the last row of years, enabling the advanced technologies such as sensors, processor, hardware based software integration methodologies, and networking is just a few [10].

Application areas have been increased with the increase in cost, performance and design methodologies [12].On the view of Jia et al. [14], a viable vision-based technique capable to hold cases such as: poor quality of images, online usage, variability in defects, segmentation failures, variations in environmental. In order to compensate this entire problem and attain a quality goal, this system is developed. A system method that can operate on all of the said circumstances except the one said at last. For instance, the images are observed by a single camera and the images are calibrated and stabilized.

In this paper, develop an image processing frame work for automated identification of surface defects in SS plate and also recognize the number given in the plate based on the surface defects identified. The proposed automatic system is based on defect identification using SVM-RFE model and character recognition of SS plate using pattern correlation. For detection of defect candidate a Multi-Scale LoG Weighting and edge density enhancement techniques are used. In addition morphological filtering is used to remove unwanted region and character region. To evaluate the proposed system by the following metrics: accuracy, sensitivity and specificity. The proposed method's performance is compared with ANN, Adaboost and Random Forest (RF) classification methods in which the classification rate of this system outperformed the previous classification methods' performance.

The vital benefaction of this work can be scrutinised as follows.

(A) A strategy for accurate and reliable detection of defect and character recognition of Stainless Steel (SS) plates. The technique performs well.

(B) A novel technique for candidate extraction is used which can extracts the abnormalities of candidates with a prominent improvement in sensitivity

(C) A set of features apparently based on shape and texture is employed which is then performs with an SVM classifier;

(D) Evaluate our system using IR captured SS plates. It is evident that the result of this classification shows the extraordinary classification accuracy.

The rest of the paper content is organized as below. Analysis of reviews of defect is in the section II. Section III, details of our proposed methodology is presented. Section IV deals with the experimental results. Finally, Section V states remarks on the analysis.

II. RELATED WORK

In the last years, some methods were proposed for identifying and detect defect. But it can be seen that these system have some limitations in detection and identification of defects that can be described briefly as follows:

In [9], Chaitali Tikhe1 et al.presented defects detection algorithm in order to detect different defects appear on SS plates. Gabor Filter technique is prominent to detect abnormalities. This technique helps to wane the accuracy of defect detection. However it seems problem because of the uneven illumination and noise distribution on the image.

In [11], the author stated about the abnormalities found on SS plate in terms of detection and classification. Image processing technique is used to detect the abnormalities of steel defects such as, hole on SS plate surface, scratch on SS plate surface, Coil break on SS plate surface and finally the presence of rust. This is eminent that this technique outperforms in defect classification. An average of 90 % has been achieved in the stated work.

The process of analysing the surface edge data of stainless steel sheets roll had been examined [13]. At first, imaging equipment are used to capture the defected candidates on the surface of cold steel roll at first. Then enables these data to the controller unit to enable early stage processing. The operators are assigned to notice the prominent defected candidates of cold steel roll in the third stage. In the final stage localization of candidature and analysis of defects are processed. In the environment of noise LOG operators has a predominant benefit over other operator. Which shows excellent results of SS plate surface faults.

In [3], the authors states the possibility of ANN in identifying the abnormalities on the steel roll automatically. The technique for autonomous abnormality detection is based on (a) Analysis of surface image based on Hough Transform to classify geometric shapes such as clamp, hole, welding and more. (b) Classification methods such as PCA and Self organizing technique to classify defects based on shapes oxidation, exfoliation and waveform defect. The system has an overall accuracy of 87% in real time analysis.

Dan Popescu [2] stipulated the use of decision theoretic method and statistic texture feature are employed to identify and thus classify the textured region. Firstly the features employed from co-occurrence matrices are used such as variance of image, entropy of image, homogeneity of image and contrast of image. In the second category, histogram of grey level, difference in grey level of histogram and per unit area edge density are employed. A work together method of template matching and theoretic decision method is used to detect defect based on texture feature. For texture classification edge density per unit area and difference in image histogram are consumed.

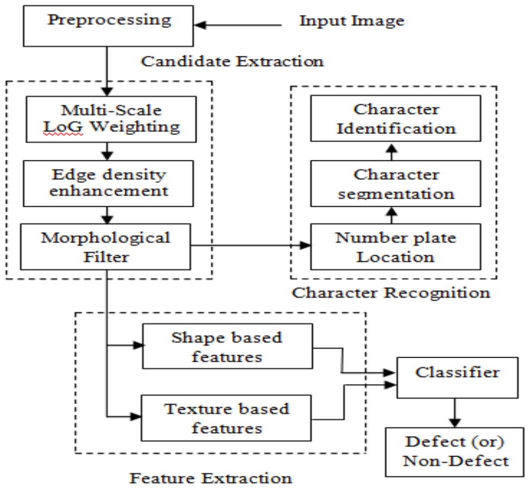


Fig. 1. SS plate Defect identification and character recognition

III. DEFECT DETECTION AND IDENTIFICATION OF SERIAL NUMBER ON PLATES

The proposed system deals with the defect identification and character recognition on SS plates. It is quite critical to accomplish accuracy in identification of defect from images captured by IR system. A Multi-Scale LoG Weighting with a combination of edge density enhancement and Morphological filer is proposed to use for the identification of defects on SS plates instead of using largely expensive computational cost algorithm. Extraction of two feature categories from the final segmentation of concerned region which deliberately characterize the shape and texture. To classify the defect (or) non defect region in the SS plates, an individual classifier is set for each category of features and a sophisticated fusion technique is used to get achieved the final results. Characteristics of the SS plates are segmented separately and finally correlation based pattern matching is employed to identify the particular characters of plates**.** Fig. 1 shows the process of defect identification SS plate and character recognition SS plate of proposed method.

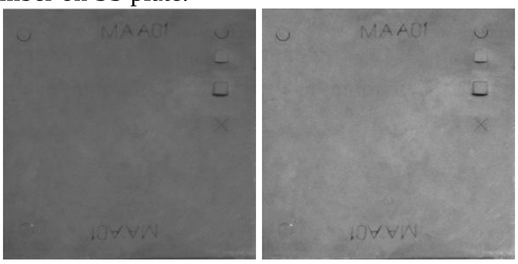
A. Preprocessing

Because of the various abnormalities such as different noises and variability of contrast found on the images got from the industries of steel production, these are not conventional to use. Each image is allow to pre-process using Gaussian filter to deal with the problems such as conversion, noise removing , image resize and quality enhancement [1] and adaptive histogram equalization [5] technique is expressed in Fig. 2.

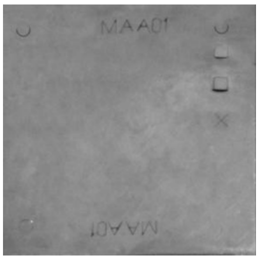
B. Defect Candidate Extraction

In this section, the proposal of a novel scheme for candidates extraction is done. The candidate extraction method consists of Multi-Scale LoG Weighting, edge density enhancement and character extraction and removal using morphological filter.

As illustrated in Fig.3, LOG operator is used in case of the detection of boundaries of images and thus detect the deformation on the surface. In order to measure the edge density of local neighbourhood the method called edge density enhancement is used for SS plate image at candidate regions. Finally, a morphological filter method is to extract the number on SS plate.



(a) (b)



(c)

Fig. 2: Preprocessing results: a) Grayscale Image b) Adaptive histogram equalization c) Gaussian Filter

Multi-Scale LoG Weighting: Based on the enhanced image Laplacian of Gaussian (LoG) operator computation of multiscale weight for each pixel is done. The LoG is sensitive enough to matches the size of the object on the SS plate to be detected since LoG is sensitive to definite scale [19].

$$\nabla^2(\sigma) = \sigma^2 \nabla^2 G(m,n;\sigma), \quad (1)$$

Where $\nabla^2 G(m,n;\sigma) = \frac{\partial^2 G(m,n;\sigma)}{\partial m^2} + \frac{\partial^2 G(m,n;\sigma)}{\partial yn^2}$ is the LoG operator and $G(m,n;\sigma) = \frac{1}{2\pi\sigma^2} e^{\frac{-(m^2+n^2)}{2\sigma^2}}$ is a 2D Gaussian function of scales σ={5,7,9}

To cover different defect sizes, the several scale of the weighted LoG images are attained.Over all selected scales is used to attain the final multi-scale LoG weighted image ILW by the maximum of $\Delta^2(\sigma)$

$$W(x,y) = max \nabla^2(\sigma) \quad (2)$$

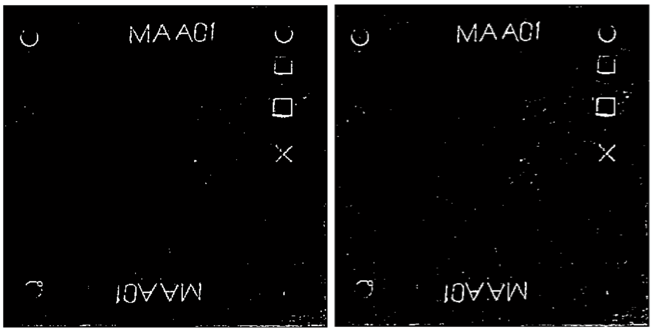
Enhancement of edge density: A discipline of Sobel operator is used to enhance the edge density for the detection of edge. As in Fig. 4, the current pixel is denoted by B0, the closest neighbour pixels of T0 are T1, T2, T3, and T4 are in vertical direction and T6, T7, T8, and T9 are the closest neighbour pixels of T0 in horizontal direction. The edge intensity e_0 for pixel T0 is defined as follows:

$$e_0 = \begin{cases} \tau & if \quad fo \geq \tau \\ do & else \quad fo < \tau \end{cases} \quad (3)$$

Where τ means the threshold value and d0 is calculated as

$$fo = |T_1 + T_2 - T_2| + |T_3 + T_4 - T_0| + |T_5 + T_6 - T_0| + |T_7 + T_8 - T_0| \quad (4)$$

σ = 5 σ = 7



σ = 9 LoG maximization

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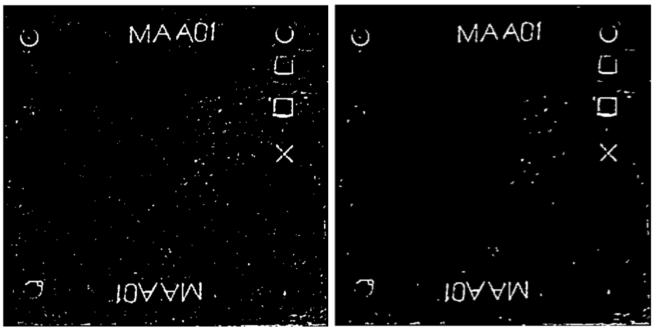

Fig. 3: LoG-weighting image in different scales. The right bottom image shows the maximization results over all scales.

Using Sobel operator, 1x3 convolution mask to estimate the gradient in the horizontal and vertical direction. And also compare to estimate the gradient with 1x5 convolution mask for horizontal direction and 1x5 convolution mask for vertical direction. Among the evaluation it is found that 1x5 convolution mask in horizontal direction and 1x5 convolution mask in vertical direction outperforms for the recognition of the edge. In the experiment the value of threshold τ is set 1.3. Fig.5. show the visual assessment of Edge density enhancement results of our proposed method and Sobel generator

Character extraction using Morphological filer: The abnormalities on the defect plate are significantly dense against clutter parts as the SS plate consists of a number of characteristics on either edges of the image of plate. Construction of a connected component which depict the character on the application of morphological closing against the images at each candidate's neighbourhood.

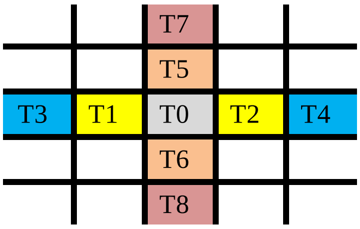

Fig. 4. Convolution mask for edge intensity

A rectangular structuring element [SE] is used in this case. The number of pixels between two characters, height and width of SE is set to 5 respectively. In order to remove the minimally produced region. A post-processing stage employing morphological opening is required**.** The structuring element here is arranged to a rectangular smaller than a character size. Remove the character region from the candidate extraction image for detection of defect of plate accurately. Extracted character region is carried out on character recognition of SS plate as seen in Fig 7(a)

Fig. 5. Edge density enhancement results using our proposed method and Sobel operator and by: (a) Sobel operator, (b) the result of the Sobel operator in vertical direction, and (c) proposed Sobel operator in vertical and horizontal direction

C. Describing Defect with Feature Descriptors

It is indeed importance to extract appropriate features and relevant descriptors for final classification stage. Several shapes and texture features of the SS plates are extracted since the abnormities varies in sizes and shapes. Here, considering two categories (SF and TF) of features to describe the defect.

Shape Feature (SF) (8 Features): Shape features like perimeter, circularity, ellipticity, compactness, distance variance from border points to centroid of defect, solidity, eccentricity and convexity are used to express the irregularity of the border.

Texture Feature (TF) (265 Features): Many feature descriptors are taken to look at the quantification of the texture of the candidate region, they are,

Canny edge detector technique is consumed to take the edge map of the candidate region. For highlighting the feature of edge density, resulted number of counted edge pixels is used.

The characterization of each GLCM candidate region by the calculation of how not more often than not specific brightness values of pixel with orientation in an image occurs. Texture feature descriptor based on GLCM is mostly used technique here [17]. Consideration of each two adjacent pixel with horizontal direction are made for the construction of GLCM. Contrast, homogeneity, correlation, and energy are explained by the extracted features from GLCM**.** GLCM would be a dense matrix in order to attain a rational estimation of the features**.** Henceforth, the values of the pixel are quantized to 32 and 64 levels afore GLCM calculation**.** Which states that computation of 8 texture features from two quantized GLCMs are done.

Local Neighbor Difference Pattern (LNDP) [16] is employed to extracts the local features of image based on differences in neighborhood pixel and forms a binary pattern in order to represent each pixel in the image. In order to give more related information a 3 × 3 block has been chosen for pattern calculation to give more related information since the closest neighboring pixels are less in size. Those neighborhood nearest pixels are moreover vertical or horizontal pixels. Relationship of these two pixels are maintained with nearest neighboring pixel, and a binary number is assigned to it. It is evident that a binary number is obtained for each neighboring pixel. These binary number pattern is used to represent each pixel of image. To construct the image in the form of LNDP histogram is utilized. The dimension of the histogram is 256

$$LNDP(I_c) = \sum_{n=1}^{8} 2^{n-1} \times F_3(k_1^n, k) \quad (5)$$

D. Classifier

Category based feature identification is done such as shape and GLCM, LNDP and edge density based texture feature is fed into SVM classifier. In order to predict the probability of every one candidate as defected or normal using radial basis function (RBF) kernel based Support vector machine (SVM)

Character Segmentation based Plate Recognition: The first phase performs image binarization as shown in Fig 7(b).

Fig. 8. Character Segmentation results

A fine-tuning intensity is applied to the grayscale image such that 1% of pixels as soon as the candidate feature of character on plate is extracted from the raw image. Thus it makes the system capable to increase the image contrast which is technically beneficial for the further binarization of image.

Once the image binarization is done, it is essential to determine which pixels of the binary images are responsible for representing characters, such as the white one or black one. Since the Connected Component Analysis CCA makes blocks based on white pixels. Both white pixels and dark pixels are used by binary images to for foreground and background. It is assumed that the background are of SS plate is comparatively larger than the text area.It is rather in need to convert the binary images if the characters formed by white pixels literally more than the black.

From the binary image, CCA is introduced to create character blocks based on the information of connected elements. As far as CCA is concerned for the above mentioned characteristics it performs simple and robust to character of SS plate rotation.

After segmentation and extraction of each character as shown in Fig 8, template matching is done. The segmented characters are then matched with the already designed templates using correlation function. The character with the maximum value of the correlation with the template image is considered. In the final step, the target of recognizing the characters from the SS plate is achieved.

The two dimensional correlation is the major operation done in the classification process of each character. The similarity between two characters are achieved based on above operation. The function developed for this operation is Corr2 as seen in equation 7.

$$r = \frac{\sum_p \sum_q (A_{pq} - \bar{A})(B_{pq} - \bar{B})}{\sqrt{(\sum_p \sum_q (A_{pq} - \bar{A})^2 (\sum_p \sum_q (B_{pq} - \bar{B}}} \quad (7)$$

IV. PERFORMANCE

The dataset of the captured images of number 525 are collected from the steel industries during the production of 5000mm hot rolling steel line. Out of them 200 image samples are used to train the automated system. Meanwhile the number 225 samples are used in the side of testing set of the automated system. Texture and shape based feature extraction process is carried out thereafter. It is expected that the feature vector is of dimension 273. A metrics of 200x273 dimension samples are in the features of the training sample. The scope of this work in feature extraction and classification are dealt with MATLAB simulation software (i.e., R-2013a) package installed on Windows 10 platform for the diagnosis of IR captured SS plates images.

The first priority of proposed system is candidate extraction (Section III.B) and to detect the defected region in SS plate, feature descriptors isapplied on candidate extracted region (Section III.C). Then the results are reported with the SVM classifierwith RFE procedure (Section III.D) for the identification of defect. Alike to ANN, Adaboost and Random Forest (RF) classification methods, we report following metrics: sensitivity = TP/(TP + FN), specificity = FN/(FN + FP) and Total accuracy = (sensitivity + specificity)/2 to assess the performance of our system.

Table I: Candidate extraction performance using the SS plates images

Method	Sensitivity
Proposed	0.85
Tikhe1 et al. [13]	0.72
Martins et al. [3]	0.67
Yichi et al. [9]	0.61
Sharifzadeh et al. [11]	0.56

A. Results of Candidate Extraction

To reduce the computational complexity candidate extraction is aimed by waning the number of objects in the next step. The candidate extraction process deliberated in Section III.C is employed on the SS Plates to extract defect ROIs.

Table I compares the sensitivity of the proposed Multi-Scale LoG Weighting with the previous methods on the SS plate training set.

As shown in Table I, the value of sensitivity 0.85 is achieved, which us far better than the existing methods.

B. Defect Classification Evaluation

The analysis of concerned features from three categories of features (shape and (GLCM) + (edge) + (LNDP)) to aggregate useful information in SVM based classifier. In order for the implementation of SVM, we employ toolbox having a library for SVM (LIBSVM) [6].

Table II Performance of different classifier

Classification	Accuracy	Sensitivity	Specificity
Adaboost	0.89	0.94	0.83
ANN	0.90	0.96	0.83
RF	0.92	0.93	0.89
SVM-RFE	0.94	0.95	0.90

Depending on the selected features the classifier performance is altered and it is quite hard to speck the adequate number of features for a classifier unit.

For same dataset, the best features for different classification methods have different features. As part of the classification accompanied in final stage here we employ the SVM, ANN, RF and Adaboost in the final stage. SVM-RFE feature selection method is derived from the SVM and it is closely analysed that the SVM outperforms better than the RF, ANN and Adaboost with same number of features.

In order to improve the accuracy of classification feature selection is useful. As seen from Table II, SVM-RFE provides comparatively better accuracies during classification when compared with three existing classification methods. The better improvements are obtained by the optimization of both decision boundary of classifier and set representation in one constant cost function.

K-Fold Cross-Validation Method based Comparative Analysis

In order to improve the performance of the classifier many statistical estimation and evaluation methods are used. Among those round robin (K-fold cross-validation) is the best method.

The apparent motivation of this is to attain the maximum classification accuracy. To measure the classification performance of the system, the total number of data is divided into training set validation set and finally a test set. Training set is used to train the classifier, to stop the training of the classifier the validation set is used. The use of test data plays its role only after training by means the priority goes to which self-governing classification performance can be measured. Based on the error rate the accuracy of the classifier is maximized.

Repeated k-fold cross-validation is performed for the evaluation of the defect detection in the proposed system. Here, we have chosen k = 10**.** It is indeed to divide everyone data set in to equal ten partition. Whilst the 9 partitions are consumed for training the classifier, each partition is consumed as test data. The process of cross- validation is done for 10 times, leading to 10 performance. The attained experimental results using k-fold cross validation shows sensitivity, specificity and accuracy of proposed method in SVM-REF is shown in Fig 9.

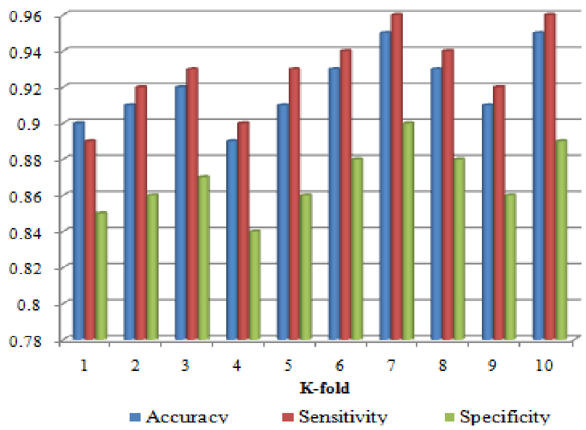

Fig. 9. K-fold validation of SVM-REF

C. Character Recognition Evaluation

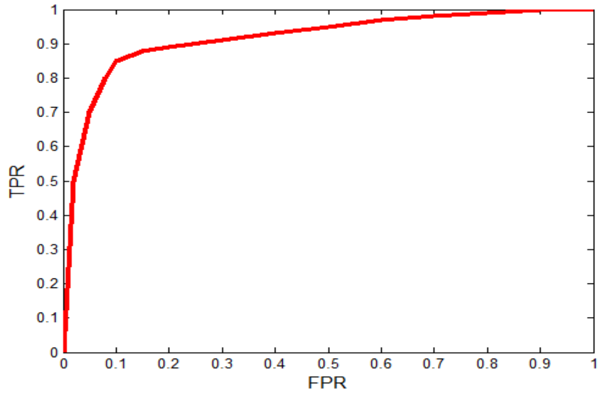

Fig. 10. ROC curves

As discussed in section III-E, character image is compared with database image and the image, which is having best similarity, will be selected from the database. To get found the best similar match a simple method known as correlation is consumed. Matching of character is done pixel by pixel. Recognition is performing by comparing whole string with database and best match is taken out of them. Priorities are given for template matching as templates for each character are loaded one by one. For certain templates higher priority is assign and when that higher priority template is matched then lower priority will be discarded.

Table III Accuracy & F_{score} of proposed character recognition technique

Methods	**Accuracy**	**F_{Score}**
Proposed	92.5	0.91

Receiver Operating Characteristics (ROC) curve is mainly used here to analyse the statistical performance of the proposed system. Which is the drawn True Positive Rate (TPR) (TPR=Sensitivity) and False Positive Rate (FPR) (FPR=1-Specificity). The results showed in ROC in Fig. 10 demonstrate the overall classification performance. With the increase in the training samples the efficiency and recognition accuracy of the system is increased. Table III indicates that the F_{score} and the accuracy of the proposed method is achieved maximum efficiency

V. CONCLUSION

This paper associate identification of defects on the surface of SS plates and character recognition. Problems occur due to manual defect inspection such as lack of accuracy and high time consumption are considerably reduced, with early and accurate defect detection with new system. A robust method for defect identification and character recognition on SS plates by first, defect localization is detected using Multi-Scale LoG Weighting and density enhancement; second, features descriptive of defect shape and texture are extracted; third, defect objects are classified using a classifier based on SVM-RFE model and finally, the number on SS plate recognition is done using pattern correlation. The performance of this shows high accuracy, sensitivity and specificity and outperformed well than the previous classification methods.

These experimental results demonstrated that proposed defect identification system can significantly enhance the recognition accuracy (94.88%) compared with other classifier (RF: 92.72%, ANN: 90.25%and Adaboost: 89.73%).

REFERENCES

1. "Digital Image Process.2nd Edition, Prentice Hall", 2002. R. C. Gonzalez and R. E. Woods et al..
2. "Texture Classification and Defect Detect. By Statistical Features",D. Popescu, and M. Nicolae et al. Int. Journal of circuits sys. And signal processing, vol.1, pp.79-84, 2017.
3. "Automatic Detection of Surface Defects on Rolled Steel Using Computer Vision and Artificial Neural Networks," L.A.O. Martins et al. F.L.C., IEEE Ind. Elect. Society, Dec. 2010.
4. "Automated Detection of Surface Defects on Rolled Steel Using Computer Vision and Artificial Neural Networks", Luiz A. O. Martins, Flavio L. C. P et al. ´ Intelligent Systems Lab.
5. "Adaptive contrast enhancement using gain control clipped histogram equalization," T. Kim et al. IEEE Trans. Consum. Electron., vol. 54, no. 4, pp. 1803–1810, Nov. 2008.
6. "LIBSVM: A library for support vector machines," C. C. Chang et al. ACM Trans. Intell. Syst. Technol. (TIST), vol. 2, no. 3, pp. 1–27, Apr. 2011.
7. On-Line Inspection Techniques of Manufacturing Quality of Rolled-Steel Sheet," Z. Xuezeng, and G. Guangxue et al. Journal of Forestry Research, vol. 5, no. 3, p. 41–43, 1994.
8. "Auto. Visual Inspection of Rolled Metal Surfaces," T. Piironen, O. Silven, and E. Strmmer, et al. Machine Vision and Applications, vol. 3, no. 4, pp. 247–254, 1990.
9. "Defects Detection of Cold-roll Steel Surface Based on MATLAB, Z". Yichi, and L. Xuedong et al. Int. Conf. on Meas. Tech. and Mech. Auto., p. 827-830, 2011.
10. "Trends in Automated Visual Inspection," M. Shirvaikar et al. Journal of Real Time Image Processing, vol. 1, no. 1, pp. 69–74, 2006.
11. "Detection of Steel Defect Using the Image Processing Algorithms," M. Sharifzadeh, S. Alirezaee, et al. and S. Sadri, IEEE Int. MultitopicConf, Dec. 2008.
12. "Auto. Visual Inspection: A Survey," T. R. Chin et al. IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 4, no. 6, pp. 557–573, 1982.
13. "An Algorithm for Defect Detection in Metal Plates Using Improved Gabor Filter," C. Tikhe, S etalInt. Jour. Of Adv. Res. inn Comp.sc and Soft. Engg (IJARCSSE), vol. 4, no. 5, p. 973, May 2014.
14. "An Algorithm for Defect Detection in Metal Plates Using Improved Gabor Filter," C. Tikhe, S etalInt. Jour. Of Adv. Res. inn Comp.sc and Soft. Engg (IJARCSSE), vol. 4, no. 5, p. 973, May 2014
15. "Surface Defects Detection for Ceramic Tiles Using Image Processing and Morphological Techniques" H. Elbehiery et al. , Proceedings of World Academy of Science, Engineering and Tech., vol 5, pp 158-160, April 2005, ISSN 1307-6884.
16. "Local neighborhood difference pattern: A new feature descriptor for natural and texture image retrieval" M. Verma et al., Multimedia Tools and App., May 2017.
17. "Textural features for image classification," R. M. Haralick, and I. Dinsteinet al. IEEE Trans. On Sys., Man, and Cyber., vol. 3, no. 6, pp. 610–621, Nov 1973.
18. "Textural features for image classification," R. M. Haralick, and I. Dinsteinet al. IEEE Trans. On Sys., Man, and Cyber., vol. 3, no. 6, pp. 610–621, Nov 1973.
19. "Feature detection with automatic scale selection," T. Lindeberg, Int. journal of comp. vision, vol. 30, no. 2, p. 116, 1998

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