Detection of Defects on Steel Surfaces Using Machine Learning Techniques

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Abstract: The application of Digital Image Processing is increasing day by day in various real time applications. The detection of defects from metal surface is one of the active research areas. To supply the steel in various industries its surface quality should be tested. Traditional testing methods are not such effective due to its low productivity and lower reliability. The proposed system presents the effective and robust approach to detect and classify the metal defects using computer vision and machine learning. In industries the most important material is the metal. Surface quality should be tested before making the metals available for processing in industries. To avoid further errors metals with surface defects are tested first. Early detection of defects minimizes damage and manufacturing cost of products. We have different metal defects and the large defects are more critical than the small ones. Defects reduce the speed production which in turn affects the market value of products.

Keywords — Gradient boosting (GB), Gray level co-occurrence matrix (GLCM), machine learning, Steel plate defects.

I. INTRODUCTION

Welcome to International Journal for Research in Steel is the material of choice for a large number and very diverse industrial applications. Surface quality is the important parameter for flat rolled sheet. In steel industry manual inspection for defects is most difficult and tedious task hence it is difficult to ensure the guaranty of defect free steel surface. To ensure immediate requirements of customers, automated vision-based steel surface inspection techniques have been found to be very effective and popular during the last two decades. Automatic inspection algorithms are widely used to ensure high quality products and achieve high productivity in steel making industry. To detecting corner cracks on the surface of steel billets, a vision based method existed. Because of presence of oxidized material, the billet surface is non-uniform and varies accordingly with lighting conditions. To minimize the effect of influence of scale, the visual inspection algorithm is proposed. The solution over scale influence is the wavelet reconstruction. Texture and morphological features are used to identify the corner cracks among the defective metal [1].

Manual inspections of end products are not an effective solution as it greatly slow down the production and add to the cost of products. Reasons of surface defect include degraded raw material or rolling process manufacturing. Larger surface defects include crack, cavities, porosity, mis-runs, incomplete fusion fins etc. Smaller defects include pits, bumps, holes, scratches that remain unnoticed until operation is incomplete [2].

The techniques used for surface defect detection are classified into four different approaches. These approaches are statistical, model based, structural and filter based. In statistical approach different approach like Histogram, GLCM, and LBP can be used on the basis of surface properties.

With the help of GLCM, various statistics of texture like entropy, dissimilarity, energy, correlation, Homogeneity, contrast etc can be determined. we have combined Gabor filter and GLCM approach. A technique for detection of defects on metal using two dimensional discrete wavelet transform is demonstrated. For analysis of surface they obtained numerical data from the images. This data are used for performing statistical analysis which includes the calculation of mean, variance, standard deviation, kurtosis and skewness from the acquired image [3].

An automatic defect detection technique for ceramic tiles is described in. The image processing operations such as image acquisition, image enhancement, noise reduction and edge detection are used. After the detection of defects, various algorithms are used to classify the defects. The reflection properties across the steel surface changes strongly due to scale on the surface. To minimized that effect, range imaging based on light sectioning techniques is used to acquire the surface data of the steel block with its embedded flaws

The range accuracy is affected by the variations in the surface defects. An effective deblurring method is proposed in for surface detection of defects on Gaussian blurred images. to preprocess the image, Learned Partial Differential Equation (L-PDE) can be used to diminished the effect of Gaussian noise. A filter learning model is built using 25 filters. Markov random field models are used in binary textures. This experimental method is applied on the factory samples to verify the feasibility of this method [4].

II. PROPOSED SYSTEM

The Fig. 1 shows the experimental blocks of proposed steel plate defect detection system.

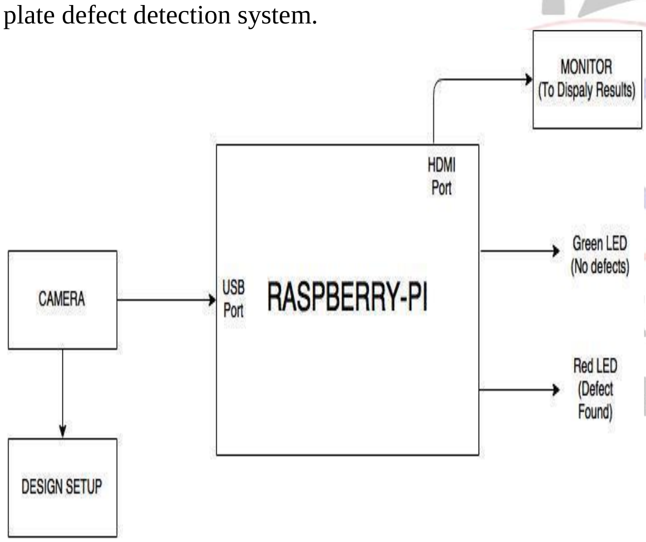
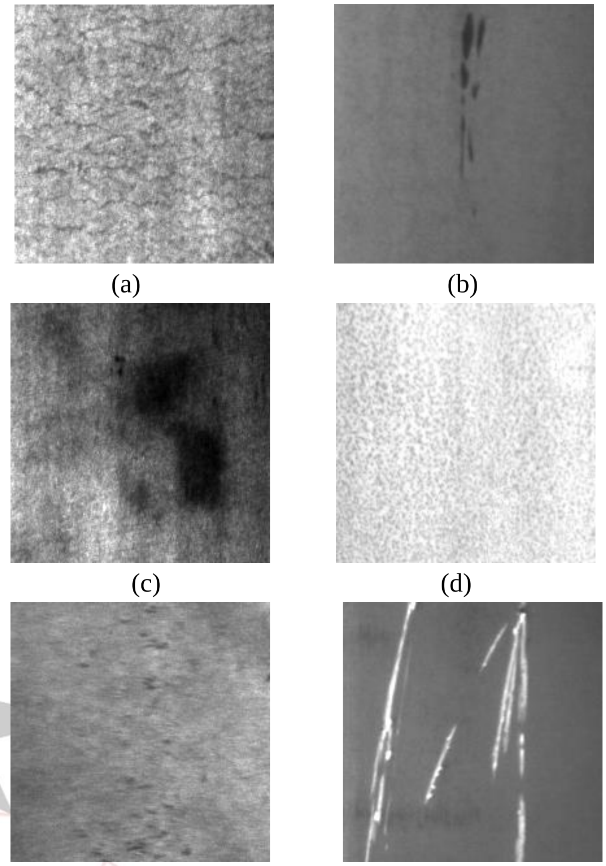


Fig. 1. Block diagram of proposed System including Hardware

The detailed explanation of the proposed system is as explain below.

A. Input image

In this proposed system, the experiment is carried on real time and standard database. Northeastern University created the database for steel plate defect detection database. This includes six types of defects: rolled-in scale, patches, crazing, pitted surface, inclusion and scratches. It includes 1800 defective plate image of size 200x200 pixels in bitmap image format. The six different types of defective images are as shown in Fig. 2.



(a) (b)
(c) (d)
(e) (f)

Fig. 2. NEU surface defect database images (a) rolled-in scale (b) patches (c) crazing (d) pitted surface (e) inclusion (f) scratches

Likewise, the experimentation has been carried on real time images. The steel surface sheets are collected from the industry. The images are capture from web camera and stored in the database. The images for the real time database are as shown in Fig. 3.

(a) (b)

Fig. 3. Real time steel plate images (a) Non defective plate (b) Defective plate

Fig 3(a) shows the normal (non defective) plate and Fig. 3(b) shows the defective plate.

B. Image Preprocessing

Preprocessing is the first step of any image processing algorithm. The captured image contains different noises. To

ISSN : 2454-9150 Vol-03, Issue 02, Apr 2017

remove the noise image preprocessing is necessary task. In this system, median filter is used to remove noise.

Median filter is removed the salt and pepper noise effectively because it appear like a black and white dots. In median filter processing, the kernel having size of N x N is used as a median mask and it is applied over an image. The median of the mask values are assign to the middle element of the mask.

C. *ROI extraction*

After preprocessing of an image, the first step is ROI i.e. (Region of Interest) detection to find out the defects on the metal surface. The input image contains non metal surface part. The steel surface part is cropped for further processing.

D. *Feature extraction*

A standout amongst the most widely recognized issues of pattern recognition in image analysis is the order of an arrangement of components into the correct class. Feature extraction and its selection are main steps in defect detection and categorization. An ideal feature set is to have effective and selective features, while mostly reduce the dimensionality problem. Phase of characterization by CAD plans is feature analysis and extraction.

Feature extraction is the change of an image into its set of features is known as feature extraction. Valuable features of the image are extracted from the image for classification purpose. It is a challenging task to extract good feature set for classification. There are numerous strategies for feature extraction e.g. Gabor features, GLCM for texture feature, Principal component analysis (PCA), Linear Discriminant Analysis (LDA), Decision boundary, spectral mixture analysis.

TABLE 1 FEATURE EXTRACTION

Features Images	1 Autocorrelation	2 Contrast	3 Correlation	.....	20 INV	21 INN	22 IDM
1	15702.3	9.65835	0.99916	.....	0.99722	0.64776	0.99494
2	13696	9.2664	0.9993	.....	0.99733	0.72400	0.99588
3	9246.3	12.693	0.9988	.....	0.98974	0.77760	0.99628
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
226	17383.1	11.078	0.9984	.....	0.99918	0.60098	0.99486
227	14393	10.59	0.998	.....	0.99800	0.66878	0.99508
228	11515	14.266	0.9985	.....	0.99680	0.70077	0.99553

E. *Feature Reduction*

There are many possible techniques for classification of data. PCA and LDA are the commonly used techniques for classification of data and dimensionality minimization. Linear Discriminant Analysis smoothly handles the case where the within-class frequencies are unequal and their performance has been tested on randomly generated test data. Principal components are the projection of the original features onto the eigenvectors and represents to the largest eigen values of the covariance matrix of the original feature set. Principle components provide linear representation of the original data using the least number of components with the mean squared error minimized PCA can be used to approximate the original data with lower dimensional feature vectors. The basic idea is to calculate the eigenvector of co-variance matrix to the original data and approximate by a linear combination of leading eigen vectors.

F. *Classification*

Classification is a technique which divides the image into different group. In the proposed system, steel surface image are divided into defective and non-defective classes. There are different machine learning algorithms which are used to classify images into different classes. The famous machine learning algorithms are SVM, KNN and Adaboost etc. Neural networks are like Back-propagation, LVQ, SOM, feed forward etc. In proposed system we will use SVM for its robustness.

III. IMPLEMENTATION

The specification of hardware and software implementation is given below-

A. **Software specification**

1. OpenCV 3.0
2. Raspbian OS

B. **Hardware specification:**

1. Steel plates : size 10cm x 10cm
2. Camera: Webcam 5MP
3. Raspberry Pi 2 Model B
4. Monitor
5. HDMI to VGA converter

C. Flow chart

The flow chart of the proposed system is presented in Fig. 4. It contains two parts: training and testing part. DIP concerned with manipulation of digital images through a digital computer. It is a type of signals and system but focus specifically on images. The input of the system is a digital image. The training of the database takes place, in which prior it works on the offline database, we have taken 1800 offline images from which 1500 images are for training and 300 images for testing.

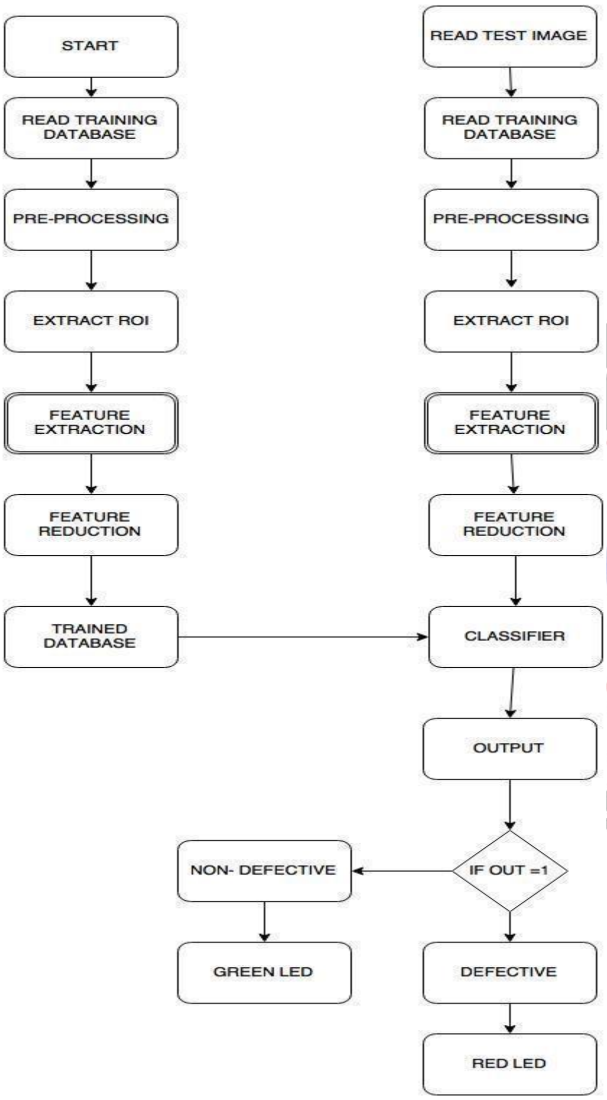


Fig. 4. Flow chart proposed system

The first step of proposed algorithm is preprocessing. The captured noisy images are processed through the preprocessing step using median filter. The part which is defected that will be the region of interest and operation takes place on that region. Features are extracted and a classifier named gradient Boosting is used to classify the defects. It indicates a green LED for Non defective image and a red LED for defective image.

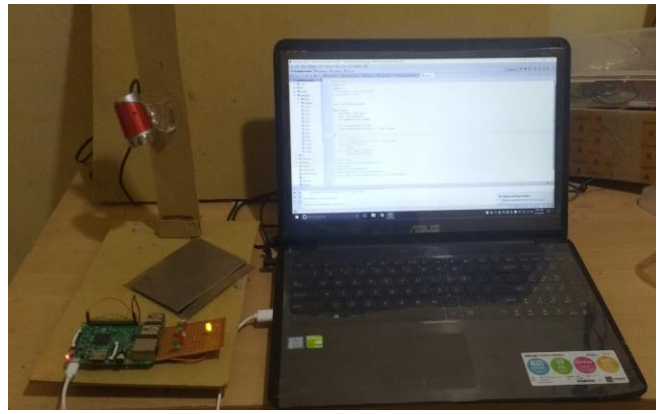
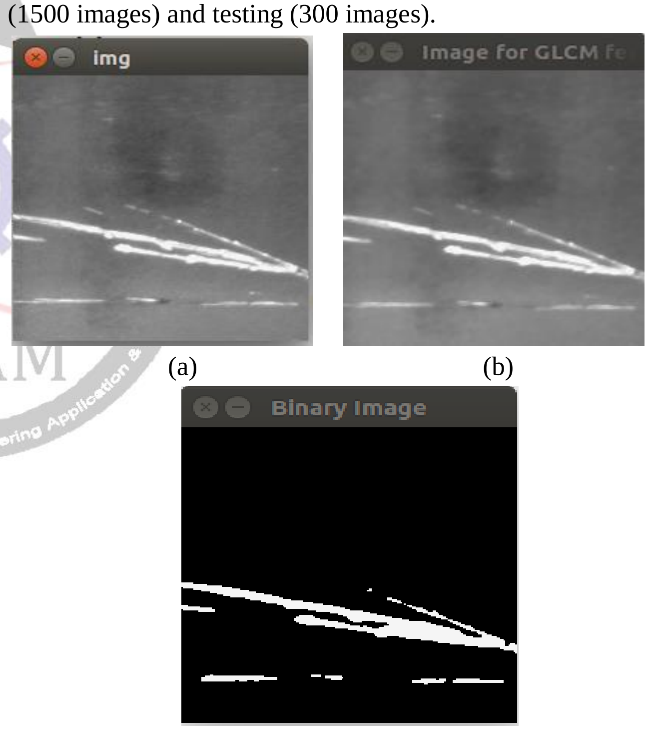


Fig. 5. Hardware Module of the system

IV. RESULTS

A. Qualitative analysis

The input for the proposed system is taken from the NEU surface defect database. These databases contain six types of defects including crazing, inclusion, patches, pitted surface, rolled-in-scale and scratches. It contains 300 images of each defect. The database is divided into training (1500 images) and testing (300 images).



(a) (b) (c)

Fig. 6. Qualitative analysis of proposed system (a) Input steel plate image (b) Preprocessed image (c) Binarization shows the defects

B. QUALITATIVE ANALYSIS

Qualitative analysis is a statistical analysis approach. The qualitative analysis is performing using accuracy metrics. The accuracy of the system is given by Eq. (1)

$$Accuracy = \frac{No.of\ defective\ image\ correctly\ detected}{Total\ no.of\ defective\ images} \quad (1)$$

V. CONCLUSION

From this, one can conclude that metal defects can be detected using image processing algorithm. It can detect defects from images successfully. The present work is being extended to detect other external defects. This method detects the surface defects of metal images and reaches the exact position and it is implemented in OpenCV Python. In this project, the feasibility of automatic detection of surface defects in metal using machine vision and image processing techniques. It does not require any image enhancement, conventional noise reduction, ideal images for comparison, training or instruction.

The proposed system achieves the detection accuracy of 92%.

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