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Multilayer ANN based Algorithm to classify crack on wall surface Images

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ABSTRACT

Detection of crack on concrete is very important for the renovation of concrete structures. Besides, little cracks that seem immaterial ought to develop and sometimes cause extraordinary basic disappointment. This issue identifies with the basic wellbeing and unwavering quality, consequently, it should be settled as ahead of schedule as plausible to stay away from additional loss. Manual review needs objectivity inside the quantitative investigation. Converting an image from RGB to grayscale, image filtering with Gaussian filter, subtraction, blurring, image segmentation, edge detection, etc. many activities of image processing with neural Network. The algorithm is composed of two parts. The First is image processing with neural networks and the second is image classification technique using machine learning algorithms. First Remove the background using filtering and improved subtraction method and morphological operation and then edge detection. Then the next step is identifying the crack and non-crack image. And if the crack image identifies. The purpose algorithm verifies the two-step tested with backpropagation neural network Thus, we tend to expand the version to identify the existence of cracks and we that teach the version to categorize the images using naïve Bayes, logistic regression, and Support Vector Machine type algorithms and decide the fine model to classify concrete photographs as crack and non-crack.

Key Words: Crack Detection, Edge Detection, Machine learning Algorithms, Neural Network, Image Classifications

1.INTRODUCTION

The construction phase is an important phase but the strength or reliability of the structure is also an important factor as well as the maintenance phase. High-rise buildings, long bridges, asymmetric buildings are popular but safety facilities are increased and costly. The civil infrastructure is widely used so interest in the automation of the construction management system has been enhanced. Regular representation is needed to secure continuity in service, cost is very costly. By building up a viable framework lifecycle the board framework through mechanization, it is conceivable to make sure about the dependability of the facility, and reduce inspection time, reduce the export person and maintenance cost.

Image processing is the process of inferencing valuable information from digitized images by variating them into other images using various mathematical algorithms. Now the present year, analysis and imaging techniques have largely used tools for experimental surveillance [9]. Like automatized damage detection, many methods have been created using image processing techniques like edge detection, wavelet transformation, morphological operation-based methods, local percolation-based image processing techniques, histogram-based classification algorithm, etc. [3][1]. Automatic clustering method based on canny and k-means for instate good accuracy of crack detection under different environmental conditions the higher speed [4].

Image can be naturally partitioned into cracked and non-cracked images utilizing various levels in artificial neural networks (ANN). It is important to perceive cracks from ordinary surfaces consequently to decrease the exertion of the human. In this article, ANN removes the human wise or human characterization throughout the visual review. The multi-layer ANN is basically used and backpropagation calculation is utilized for preparing the neural network. Many concealed layers are chosen by the experience. Numerous neurons decrease the estimations speed of the organization. One neuron is made as a yield layer. The yield layer characterizes the characterization of cracked or non-cracked images. The fundamental trademark property of an Artificial Neural Network (ANN) is to create information preparing procedures for a given structure. The ANN can be utilized as an option successful instrument for unraveling the converse designing issues as a result of the example coordinating capacity. ANN is quite encouraging and proves the robustness of the damage assessment algorithm.

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Machine learning calculations are utilized for grouping an image to exercise whether it is crack or no more. This might be cultivated using arrangement methodologies to order the whole dataset and to break down the best model with regards to its exactness and accuracy. The main point of this examination was roughly to study and survey the break recognition gadget basically dependent on image characterization with the utilization of Machine Learning Algorithms.

In this article in section two, we define the system architecture of the cracked and non-cracked image using the image pre-processing technique. The design of the whole calculation appears in fig-1. It might be conceivable to mastermind cracked and non-cracked images genuinely from the principal image by utilizing the Artificial Neural Network (ANN). In any case, the technique utilizing just ANN without image arranging will require more check time, since the course of action images have so different data. Then in section no three define the pseudo-code of the proposed algorithm. Then in section four classification with neural networks with accuracy and loss. In this paper, we are going to build up a supervised learning-based technique used with dataset images. Then evaluate this model to see if it effectively classifies whether the image has "crack" or "non-crack", which means this would be a binary classification problem. Then next section no five Image Classification with Other Machine Learning Algorithm comparison.

2.SYSTEM ARCHITECTURE

Hence it is needed to incorporate the image preparing previous applying ANN steps to create a viable procedure. Image processing steps for wall crack detection of the following (1) Resize the image (2) subtraction Method (3) Choose the threshold value (4) Gaussian filter for smoothing (5) Morphological processing using closing and opening (6) Edge detection the canny method.

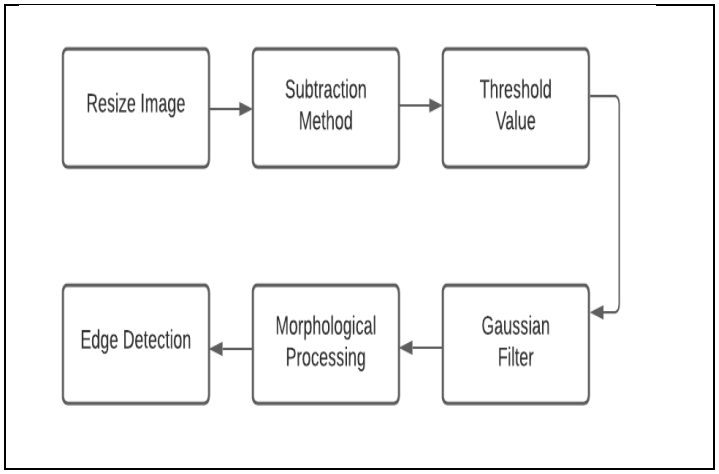

Figure1. Image Pre-Processing steps

2.1. Resize the Image

The dataset has images of structures having a crack. The image facts are partitioned into two negatives (without crack) and positive (with crack) in images. All images have the same size, so we resize the image. we convert the image in 128*128pixel with RGB**.**

2.2 Subtraction Method

After a cycle of resizing the image improved subtraction processing. To begin with, we will in general utilize the median filter, which smooths the underlying image, to get a corrective image. At that point, the underlying image is deducted from the remedial image to get a deducted image in light of the fact that the yield of the pre-preparing. The median filter takes all the neighborhood power circulations and produces a substitution image comparable to the arrangement of median values. If the elements of the filter are ordinarily bigger than the component of crack, breaks are eliminated from the restorative image. In qualification, the slight variety stays inside the corrective image however it's eliminated within the subtracted image. By this, the corrective image is produced from the underlying image by the median filter [08].

2.3 Binary Image by Thresholding

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Binary images are two possible intensity values. These two values are o for black and 1 for white. The main use of binary images allows easy separation of an object from the background. Thresholding is a straightforward and natural strategy in image segmentation. The main objective of thresholding is to extract the foreground from the background.

This development changes over an information dark level image to a matched image where the appraisals of focus are conferred by 0(black) or 1(white). If the pixel regards in a data image are greater than some edge regard T, the yield pixel regards are given out into 1 and the centers are called object points. Right when the data pixel regards are more unassuming than T, the yield regards are consigned into 0 and they are viewed as foundation focuses. The following equation represents this thresholding.

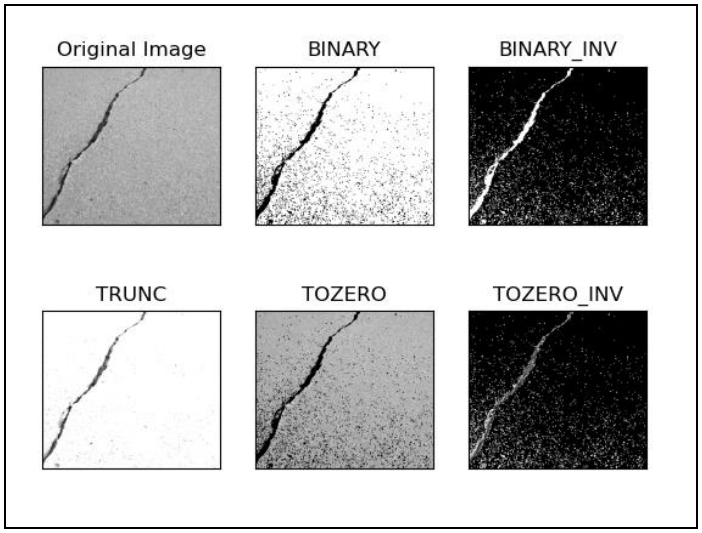

Figure 2. Binary image

$R(x,y) = \{ 1 \text{ if } p(x,y)>T \ ,0 \text{ if } p(x,y) \leq T$ (1)

where p(x, y) is threshold image, p(x, y) is Gray level image. Both cracks and non-trivial noises can define the value 1.

2.4 Gaussian Filter for smoothing

Gaussian filters are highly impressive in eliminating gaussian noise from an image. The objective of this filter is to join the little hole of the crack line. It can even change the mutilation of the broken shape. During this cycle, spatial sifting which is likewise called neighborhood preparing [4], performs the operation with the neighborhood around the middle point (x, y). This cycle is regularly represented by the resulting equation and it repeats for all points.

$R (x, y) = T[p(x, y)]$ (2)

Where p (x, y) is the input image, r (x, y) is the processed image, and T is an operation on p defined over some neighborhood of (x,y). The spatial filter is classified into linear and nonlinear spatial filtering. We use the gaussian type of linear spatial filtering.

2.5 Morphological Image processing

A morphological strategy was applied to address the non-consistency of the foundation brightness of the image. Morphology is the normalization of the successful process of correction of non-uniform background images. Morphological techniques also enhanced binarization and shape analysis developed to improve the detection performance. [6] Morphological transformations are some simple operations based on image shape. The Morphological cycle is ordinarily performed on binary images. Two essential activities are Erosion and Dilation. At that point variation structures like opening, closing, slope, tophat, Blackhat, etc. becomes an integral factor

- **Erosion**: It is utilized for testing and decreasing the shape contained in the input image. It's a demonstration like a local minimum filter. In addition, the setting everything straight parts step back image by stripping endlessly a layer of pixels from both the inward and outside imperatives of areas. By utilizing separating, we can discard the openings

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and openings between various territories to become a greater and little delicacy. The assessment of yield pixels is the base assessment of all pixels in the regions. The binary image is set to 0 if any of the neighbourhood's pixels have regard 0. Morphological disintegration eliminates little items so just meaningful objects remain.

- **Dilation**: It is utilized for examining and extending shapes contained in the input image. It's a demonstration like a local maximum filter. Dilation is the inverse of erosion. It adds a layer of pixel to both the inward and external limits of the region. It constructs the white area in the image or the size of the front-line object increases. Generally, noise removal, erosion is followed by dilation. So, erosion eliminates repetitive noises, it additionally recoils our objects. The Morphological expansion makes protests more obvious and fills in little openings in objects.
- **Opening**: The opening activity disintegrates an image and afterward dilates the eroded image. The opening takes out any limited association and lines between two areas When a large object of image protects the shape and size while a morphological opening is valuable for dispensing with little objects.
- **Closing:** The closing operation first dilating the image then eroding the image. It helps close little openings inside the closer view items or little dark focuses on the objects.
- **Gradient**: The contrast between the dilation and the erosion of the image. A gradient is utilized to discover limits or edges in an image. It is prescribed to apply some separating before ascertaining the tendency since it is extremely sensitive to noise.
- **Top Hat**: The qualification of the source or input image and the dispatch of the source or input image. It includes the tight pathways between different territories. The formal hat change opens an image, by then deducts the opened image from the primary image. The formal hat change can be utilized to improve separation in a grayscale image with non-uniform illuminating.
- **Black Hat:** The contrast between the closing of an image and the input image itself. These features are restricted dark locales in the image. The base cap changes the close image and then removes the first image structure from the nearby image. The bottom cap change can be used to find the power box in a grayscale image.

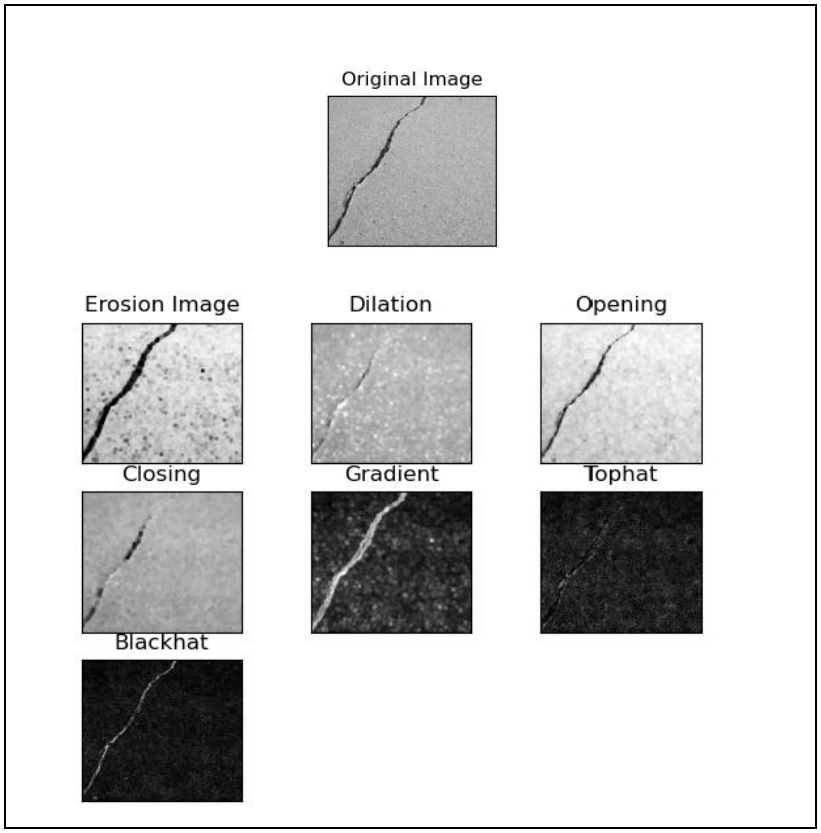

Figure 3 Morphological Images

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2.6 Edge Detection (Canny Method)

Edge identification is an image handling strategy for finding the limits of objects inside images. Canny edge identifier is an edge recognition operation that utilizes multi-stage calculation to distinguish a wide range of edges on images. It Smooths the image to reduce noise. Then the image gradient difference is maximum, which has high spatial differences. The Canny algorithm has 5 steps follow that, (1) Smoothing (2) Finding gradients (3) Non-maxima suppression (4) Double Thresholding (5) Edge tracking by hysteresis.

3. CLASSIFICATION OF CRACK IMAGE USING NEURAL NETWORK

The image can be naturally isolated with cracked and non-cracked concrete utilizing a multi-layer artificial neural network (ANN). In this paper, we proposed a pre-processing step then in the last we can identify the image with crack and non-cracked. A sigmoid function is used in each layer and as an activation function used as a rectified linear activation function (Relu). First, train the dataset with some images. Then fit the model to train and test data. Then predicate the image with a crack or non-crack classifier, and finally achieve good accuracy. After 15 epochs learning, error(lose) is converted into 0.0177 and accuracy is 0.99%. It also identifies the length and width of the crack images.

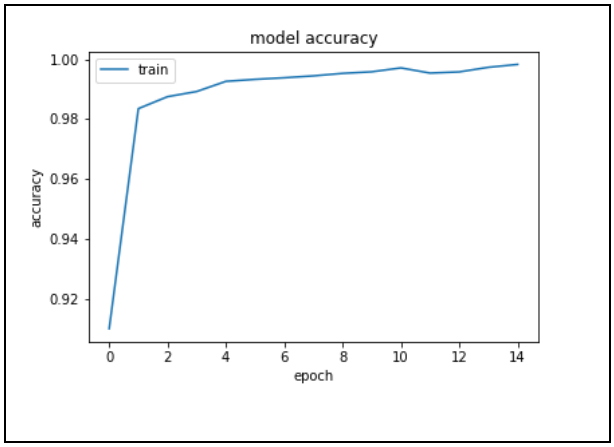

Figure 4. Accuracy Data

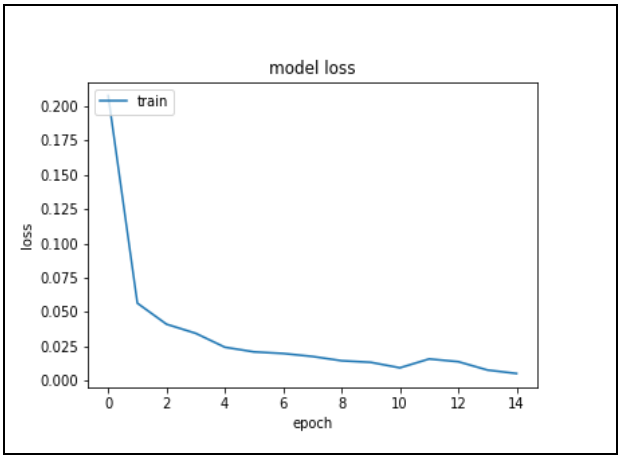

Figure 5. Loss Data

4.IMAGE CLASSIFICATION WITH OTHER MACHINE LEARNING ALGORITHMS

Image classification refers to the task of extracting information classes from raw images to process the

data. Data Processing can be done by loading the images from folders and reading the images. We split a dataset into a training record and check out facts in python ANN.

(1) Training the model with tests that minimize the probability of misclassification.
(2) Fit the model to train and test data.
(3) predict test data using a classifier.
(4) Archive the overall accuracy of each classifier and compare them.

Classification Algorithm

- **(1)** Support vector machine (SVM)
- **(2)** Naïve Bayes
- **(3)** Logistic regression

4.1 Support Vector Machine (SVM)

Support vector machines and artificial Neural Networks both are supervised learning techniques [12]. SVM is a non-parametric classifier that finds linear vectors to separate classes. SVM classifier to identify if a crack is appearing in an image in which the images are pre-processed to extract crack features based on pixel intensity. Artificial neural networks can deal with multi-class issues by delivering probabilities for each class.[7] Conversely, SVMs handle these issues utilizing free one-versus-all classifiers where each produces a solitary double yield. An ANN with an SVM doesn't require kernels. ANN for

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classification single hidden layer and non-linear activation function used. SVM and ANN can handle the same problem of classification and both perform with good accuracy with the same dataset. SVM can consider hyperplane or line between two sets of data for classification [10].

4.2 Naïve Bayes

Naive Bayes is a collection of supervised AI characterization procedures dependent on Bayes' theorem with an assumption of independence among predictors [9][11]. It is a straightforward classification procedure, however has high functionality. Complex classification issues can likewise be executed by utilizing Naïve Bayes Classifier. Naïve Bayes algorithm is a simple and quick anticipate class of test dataset. It likewise performs well in multi-class prediction [11]. Naive Bayes classifiers have small training data to estimate the parameters needed for classification. We utilized Gaussian naive Bayes in classification. When working with continuous data.

4.3 Logistic Regression

Logistic regression is a simple form of neural network that classifies data categorically. Logistic regression works by taking an input, passing it through a function called sigmoid function then returning an output of probability between 0 and 1. This sigmoid function is responsible for classifying the input. Calculated relapse enables the agent to distinguish those factors that might be acceptable indicators of a specific result furthermore, assists with narrowing the number of boundaries included in the neural organization investigation. Calculated relapse additionally permits the specialist to put certainty limits around model yields and boundary gauges after the basic structure of connections among factors are distinguished.

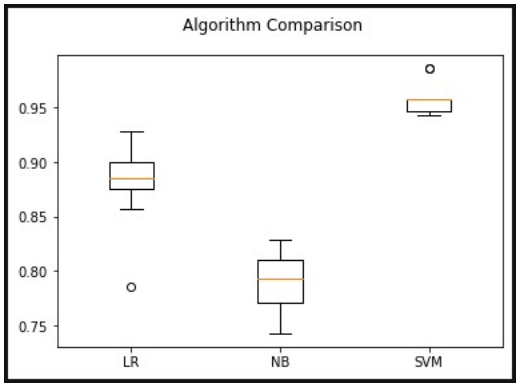

Fig.6 Comparison of classification algorithm

5.EXPERIMENTAL RESULTS

5.1 Dataset Description

Strong surface cracks are enormous blemish in like manner structures. Building Inspection is accomplished for the evaluation of the rigid nature and versatility of the shape. Crack personality accepts basic employment inside the shape assessment, finding the crack and discovering the assistant prosperity. In this research for the experimentation, we used python. Python is the best fit with Machine Learning algorithms.

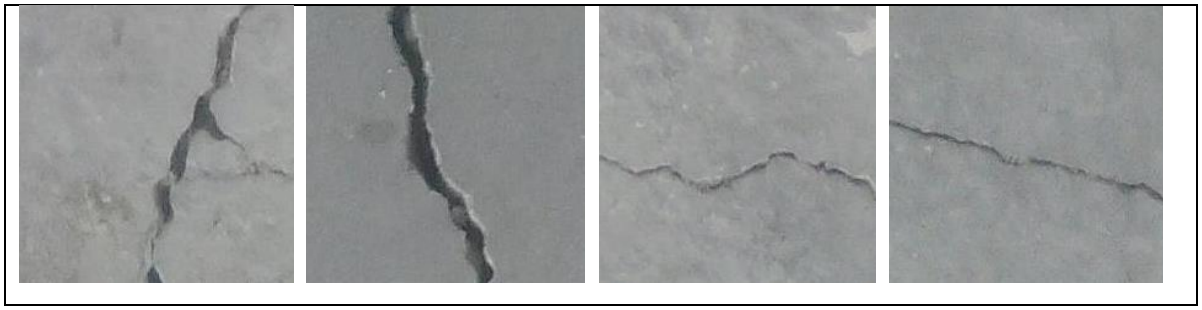

Figure 7. Sample images having crack on surface

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The dataset has images of structures having a crack. The image facts are partitioned into two without crack and with the crack in discrete organizer for image characterization. Total 20,000 images with different pixels with RGB filters. In these datasets, we used 15000 images for the trained model and 5000 images used with test data. CRACK: Determines it as a crack if (c=1) NON-CRACK: Determines it as a non-crack if (c= 0)

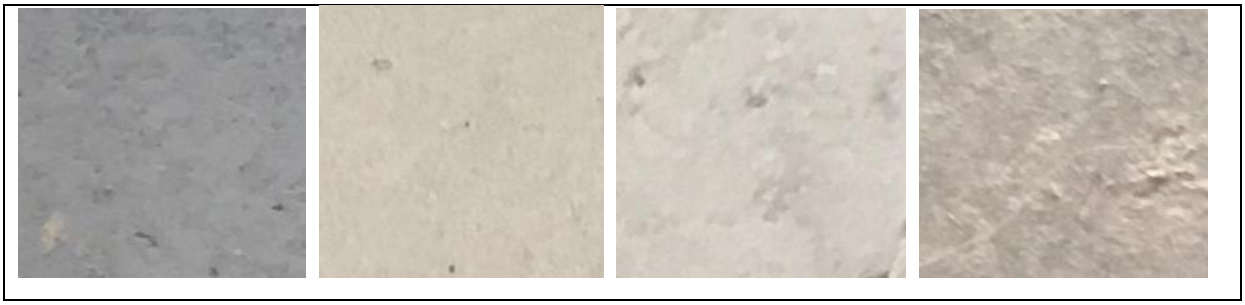

Figure 8. Sample Image having non-crack on surface

5.2 Discussion with Results

In the proposed algorithm we used a wall surface image. Images have gained under the extraordinary enlightenment and background conditions. We change the size and convert to RGB to grey color. We use a total of 20,000 images in these image processing techniques. First, 15000 images are applied for training the artificial neural network and 5000 images are applied for testing. The Proposed algorithm gave accuracy 0.99% and 0.0177% for crack and non-cracked images. To assess the ease of use of the proposed algorithm. This research is evaluated by the following result shown fig-7. Machine learning technique applied 1000 images for the classification. And all classifiers after the process of loading the data. Train and test data with models. It is observed that the performance in terms of accuracy has been increased. Automatically classify the wall image as crack and non-crack. The classification of support vector machines (SVM) is better than Naive Bayes and Logistic regression. And accuracy shows 0.98%.

Table 1. Different Algorithms accuracy

	Total Image	**Trained images**	**Test images**	**Accuracy**
Proposed Multilayer ANN based Algorithm	20000	15000	5000	0.99%
Classification with Machine Learning algorithm 1.SVM 2.Naïve Byes 3.Logistic Regression	1000	700	300	0.98%(SVM) 0.80%(NB) 0.89%(LR)

6. CONCLUSION AND FUTURE WORK

In this paper, ANN based algorithm to classify images in binary classification i.e cracked or non-cracked. We have achieved good accuracy in comparison with other algorithms developed in this category. We have applied algorithm with 20000 images of wall surface with diverse characteristics such as different background conditions, irregular shapes, multiple cracks on same image etc. We trained the machine with 15000 images and tested it with 5000 images. We achieved 99% accuracy to classify images accurately. We have experimented 2000 images with well-known machine learning algorithms existed in literature survey. We have considered SVM, Naïve Bayes and Logistic regression algorithm for comparison with proposed algorithm. Support Vector Machine (SVM) accuracy is better in comparison with Naïve Bayes and Logistic regression. SVM achieved 98% accuracy while Naïve Bayes and Logistic regression achieved 80% and 89% respectively. Support Vector Machine is based on hyper plane in multi-dimensional space so difficult to achieve and not appropriate for irregular shapes kind of images. Our proposed algorithm is based on ANN that is simple to implement and achieve higher accuracy in comparison of SVM. In future we take real image for that algorithms and find crack length and width.

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