A THERMAL SENSOR-BASED DECISION SUPPORT SYSTEM FOR THE IDENTIFICATION OF ROOF LEAKS AND CRACKS

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ANNA UNIVERSITY
PROGRESS THROUGH KNOWLEDGE

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INTRODUCTION

- Recent years, the majority of the commercial buildings in developing countries like India, Pakistan, Bangladesh etc. are constructed with cement material.
- Due to the climatic changes, the cracks and leaks in the roofs/walls are very common since the walls are subjected to several seasons. So, it is mandatory to identify the leaks and cracks of walls at the initial stage to minimize severe effects.
- The early detection of leaks and cracks avoids various drawbacks such as structural damage, repair cost etc.
- In many cases, the paint coating hides the cracks of walls which is occurred internally leads to leaks at later stages. These internal cracks cannot be visualized by normal sights results in development of assistance systems.

A BRIEF SURVEY OF LITERATURE

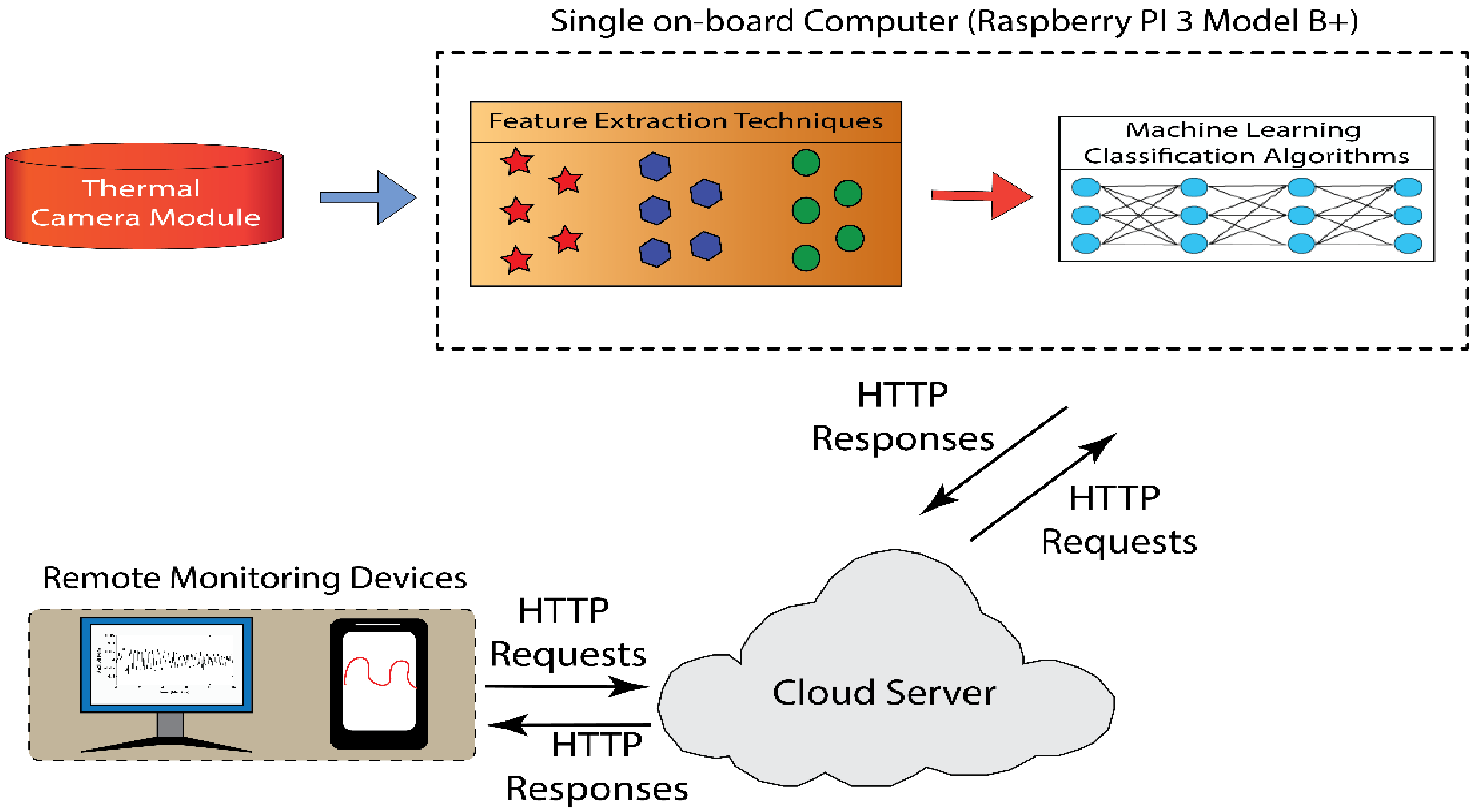
- An automated decision support system has increased significantly over the past few years and algorithms such as Naive Bayes classifier, support vector machines, artificial neural networks, etc. are widely used techniques in approaching the decision support problem.
- Maniruzzaman et al. (2017) have adapted Gaussian Process based classification technique using three kernels such as linear, polynomial and radial basis kernel to classify diabetes. Further, the authors have investigated the performance of a GP-based classification technique in comparison to existing techniques such as Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), and Naïve Bayes (NB).
- Nikam (2015) have discussed the various classification algorithms such as K-Nearest Neighbor, Naïve Bayes, SVM and ANN along with their features and limitations.

OBJECTIVE

- The objective of this work is to develop an automated decision support system to identify the leaks and cracks in walls of buildings.

METHODOLOGY

DESIGN OF DECISION SUPPORT SYSTEM



FEATURE EXTRACTION TECHNIQUES

- Image Entropy is a
  - scalar value which represents the entropy of grayscale image.
  - measure of the disorder or randomness that can be used to characterize the texture of the input image.
- Image entropy is expressed by an equation:

$$IM = -\sum_{i} P_i \log_2 P_i$$

where, P_i is the probability that the difference between two adjacent pixels is equal to i, and log_2 is the base 2 logarithm.

- The GLCM Energy is a sum of squared elements in the GLCM matrix.

$$E = \sum_{i,j} p(i,j)^2$$

SUPPORT VECTOR MACHINE CLASSIFIER

- The proposed research work is a two-class binary classification problem, the adopted SVM classifier finds the most effective hyperplane which is a classification line and divides all input samples into two classes.
- The input samples nearest to the classification line are called support vectors. The training set of the SVM classifier is expressed as

$$X = \{(y^1, z^1), (y^2, z^2), \ldots.., (x^n, y^n)\}, y \in S^n, z \in \{-1, 1\}$$

- The classification line is derived as:

$$X(n) = (w.n) + a$$

- where, *n* is a sample vector represented to a high dimensional space, *z* is the class label of *X*. Further, the SVM classifier estimates and obtains the equation of classification line with the help of *w* and *a* parameters.

SUPPORT VECTOR MACHINE CLASSIFIER

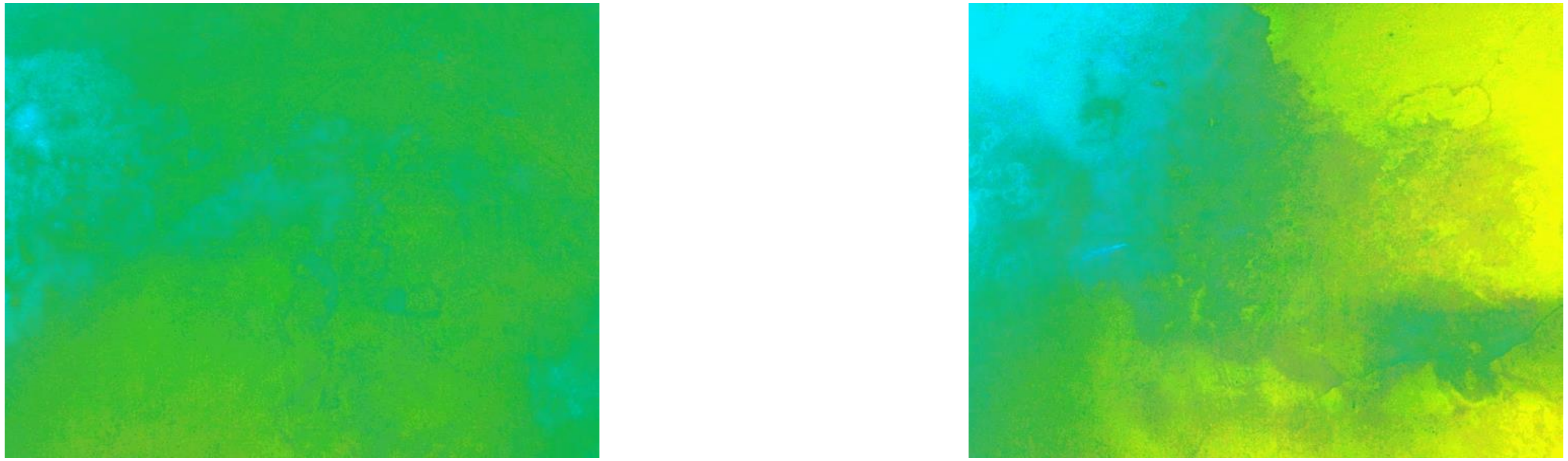
- SVM classifier has different kernel functions such as
  - Linear,
  - Gaussian,
  - Polynomial etc. which can be assigned for the decision function.
- The kernel functions are used to construct optimal hyperplane in the new high dimensional feature space. The Linear SVM (LSVM) maps the non-linear input space into the new linearly separable space and it can be expressed as,

$$K(x_i, x_j) = \Phi(x_i).\Phi(x_j)$$

- where, x_i and x_j are the input feature vectors. Further, the optimal separating hyperplane is constructed and all the vectors lying on one side of the hyperplane are labeled as -1, and all vectors lying on another side are labeled as +1

RESULTS AND DISCUSSION

ACQUIRED IMAGES USING THERMAL CAMERA

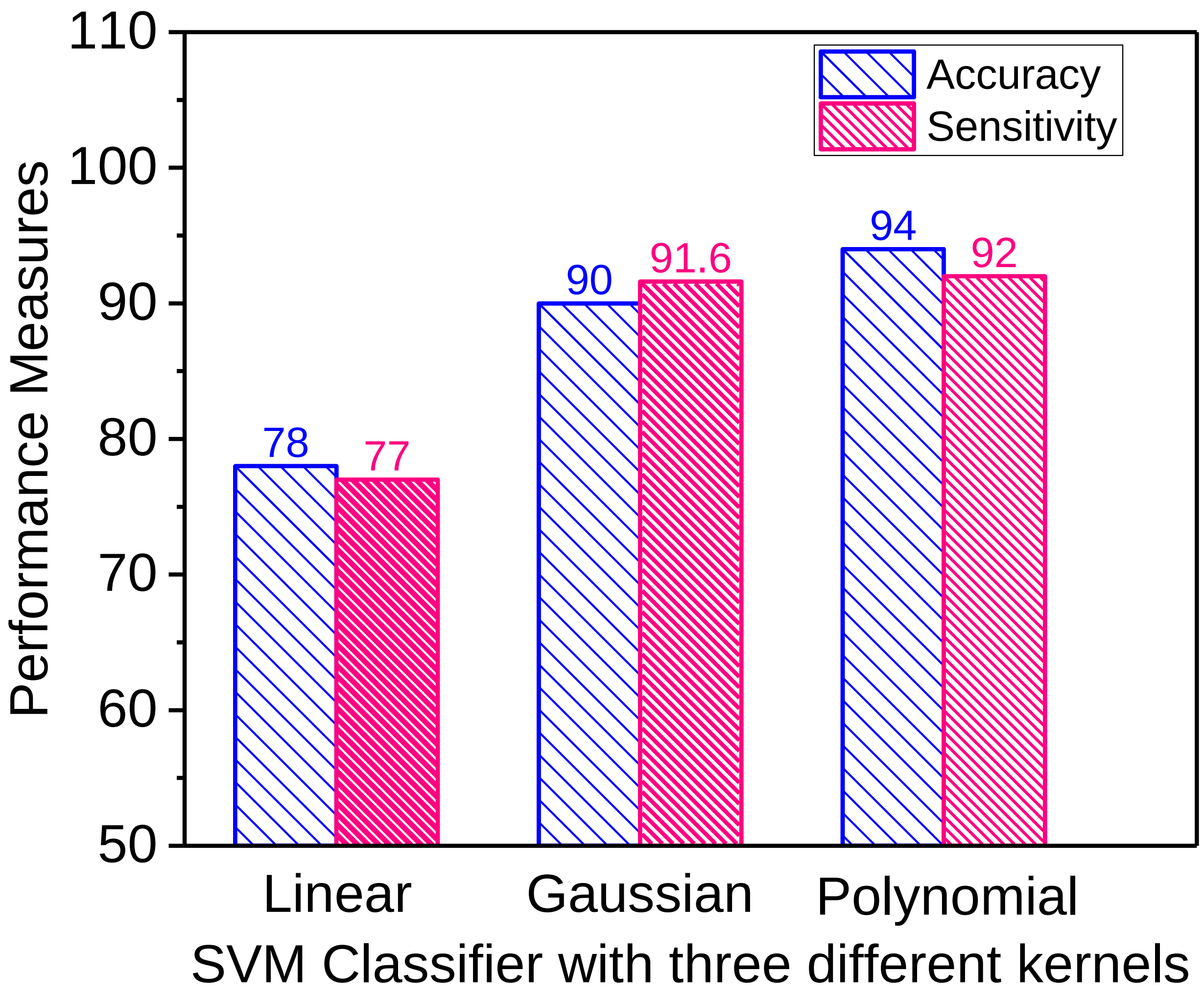


(a) (b)

Typical image acquired using thermal camera (a) with leak (b) without leak.

- The 100 train images with and without leaks were acquired with thermal camera module at different locations were utilized to train SVM classifiers.
- Also, 50 test images were acquired using thermal camera module, in which 25 images were with leaks and 25 images were without leaks.

PERFORMANCE OF SVM CLASSIFIERS



- It is seen that the accuracy and sensitivity of SVM classifier with polynomial kernel is higher when compared to the other SVM kernels.
- Also, it is observed that the SVM classifier with Gaussian kernel has very good sensitivity (91.6%) almost similar to the SVM classifier with Polynomial kernel.
- It is seen that the accuracy and sensitivity of the adopted SVM classifier with polynomial kernel (order = 8) is 94% and 92% respectively. Also, it is observed that the performance of an SVM classifier can be improved by increasing various train images.
- Therefore, the SVM classifier with Polynomial kernel is utilized to design an automated decision support system since it has good performance measures when compare to other SVM classifiers.

CONCLUSION

- In this work, a decision support system was developed to the identify leaks and cracks in walls of buildings. The images of walls with and without leaks/cracks were acquired using thermal camera module.
- Further, the informative features namely Image Entropy and GLCM Energy was extracted from the acquired thermal images and was utilized to develop efficient classification systems.
- Also, the supervised learning-based Support Vector Machine (SVM) with three different kernels such as Linear, Gaussian and Polynomial (order=8) were used for the classification of images with and without leaks/cracks.
- Results demonstrate that the SVM classifier with Polynomial kernel is good when compared to SVM with Linear and Gaussian kernels. It is observed that the accuracy and sensitivity of SVM classifier with Polynomial kernel is 94% and 92% respectively.
- Therefore, the SVM classifier with Polynomial kernel was adopted as decision support system for the classification of leaks/cracks in walls of buildings.

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THANK YOU