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Machine Learning Algorithms with Satellite Image Classification for Damaged Building Based on Support Vector Machine (SVM) and Artificial Neural Network (ANN) classification and comparison

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ABSTRACT

The image pixel values are grouped into meaningful groups using the Machine Learning approach. Machine learning has the capacity to classify remotely sensed images effectively and efficiently. Taxonomy of machine learning Methods may be divided into three groups: 1) supervised, 2) unsupervised, and 3) reinforcement. Machine Learning classification necessitates the selection of the best classification technique based on the demands. Machine Learning methods are the subject of the present research project. The outcomes of two approaches, SVM and ANN, on satellite image categorization methods are compared in this study. Artificial Neural Networks and Support Vector Machines are used to automatically identify and classify damaged structures. The results are then compared to those obtained using traditional change detection methods in a comparative study. It has been discovered that the wavelet-based change detection approach produces better identifying information for damaged structures than traditional methods. In this study, a newly introduced texture-wavelet analysis on roof-tops is used to determine the proportion of each damaged building's damaged area, and the findings are confirmed by personally counting the damage pixels. As the percentage area of damage grows, a positive increase in the retrieved statistical characteristics is

noted, adding to the accuracy of the identification approach.

Keywords: Machine Learning, Classification, Satellite Image Classification, Satellite Remote sensing, Support Vector Machine, Artificial Neural Network, Damage Building, Wavelet-based change detection method, Texture-wavelet analysis

1. Introduction

Machine learning techniques are used to do classification, which is a natural language processing activity. The act of classifying thoughts and things involves identifying, comprehending, and arranging them into predetermined groups or "sub-populations." Machine learning systems classify future datasets into categories using pre-categorized training datasets and a range of techniques.

In machine learning, classification algorithms utilise input training data to predict whether following data will fall into one of the established categories. Filtering emails into "spam" or "non-spam" is one of the most prevalent uses of categorization. In a nutshell, classification is a type of "pattern recognition," in which classification algorithms are used to training data in order to detect the same pattern (similar phrases or attitudes, numerical sequences, and so on) in subsequent sets of data.

Figure 1 shows machine learning is a subsection of Artificial Intelligence. Machine learning may be described as a software or algorithm that can learn with little or no external assistance. Machine learning is an area of artificial intelligence concerned with the creation and development of algorithms that enable computers to evolve behaviours based on empirical data.

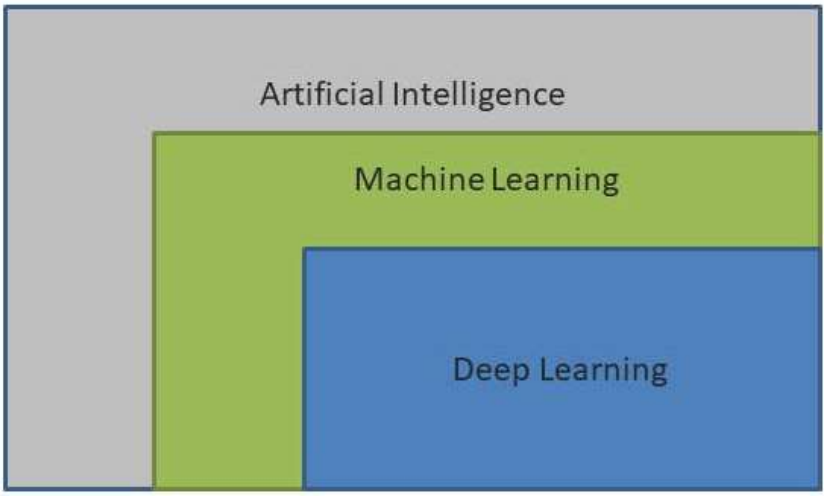

Figure 1. Structure of Learning Methods

Machine Learning (ML) has a variety of applications, the most important of which being data mining. People are prone to making mistakes while doing studies or attempting to create correlations between different features. The goal of machine learning technologies is to provide programmes the capacity to learn and adapt. Machine learning is a computer tool that can learn numerical and visual patterns in data and images and use them to forecast and categories new data using algorithms established in it [1].

Machine learning is one of the hottest fields in computer science, with a wide range of applications. It is the process of automatically detecting meaningful patterns in data. Machine Learning has evolved into one of the cornerstones of information technology, and as a result, a very fundamental, if sometimes overlooked, aspect of our lives. With the ever-increasing amount of data available, there's reason to expect that smart data analysis will become even more prevalent as a crucial component of technological advancement. The categorization of remote-sensing pictures using machine learning has become a key emphasis. Machine-learning algorithms can often model complicated class signatures, take a wide range of predictor data, and make no assumptions about data distribution [2].

A satellite picture is detailed and useful for obtaining geographic information. Remotely sensed photos provide a great deal of geographic data. Different industries, such as government, business, science, engineering, and research institutes, can benefit from geographic data. Geographical data may be utilised for city and regional planning, as well as an examination of a region's natural resources [3].

Quantitative and qualitative information is provided by satellite and remote sensing photos, which minimises the complexity of field work and study time. Data/images are collected at regular intervals using satellite remote sensing technology [4]. A powerful approach for extracting information from a large number of satellite photos is satellite image categorization. The process of organising pixels into meaningful classifications in a satellite picture is known as classification. [5]. Extracting information from satellite images is another term for satellite image categorization. Although satellite image categorization is not difficult, the analyst must make several options and choices during the process.

1.1 NEED OF SATELLITE IMAGE CLASSIFICATION

The extraction and understanding of relevant information from huge satellite images is aided by satellite image categorization. The categorization of satellite images is essential for,

- For an application, extract data
- Interpretation of visual and digital satellite images
- Surveys in the field

- Make effective Decision-making
- Exploration of spatial data
- Making a thematic map
- Disaster management [6].

2. Machine Learning Algorithms

Data interpretation is frequently linked to classification, which occurs when a specific object is assigned to one of several previously defined classes, clustering, which occurs when objects are divided into initially undefined groups (clusters), and forecasting, which occurs when a large volume of initial data describing the process background, for example, is used to predict its future state in space or time. ML approaches are employed widely in all circumstances when no rigorous formal procedures of classification or clustering are applied. Starting with genetic algorithms, and metric approaches like k-NN, SVM, statistical methods, and ending with artificial neural networks, ML techniques cover a wide range of algorithms [7].

2.1 TYPES OF MACHINE LEARNING ALGORITHMS

Machine learning as part of a broad scientific field known as Artificial Intelligence (AI), is putting AI's potential into practise. The major concern with ML is the realisation of demand for flexible, adaptive learning algorithms or computing techniques. Opportunities for machine learning, i.e. the capacity to learn and make expert-level recommendations in a certain application domain, Machine learning algorithms are classified into a taxonomy based on the algorithm's expected output.

- Supervised learning (SL)
- Unsupervised learning (UL)
- Reinforcement learning (RL) [7].

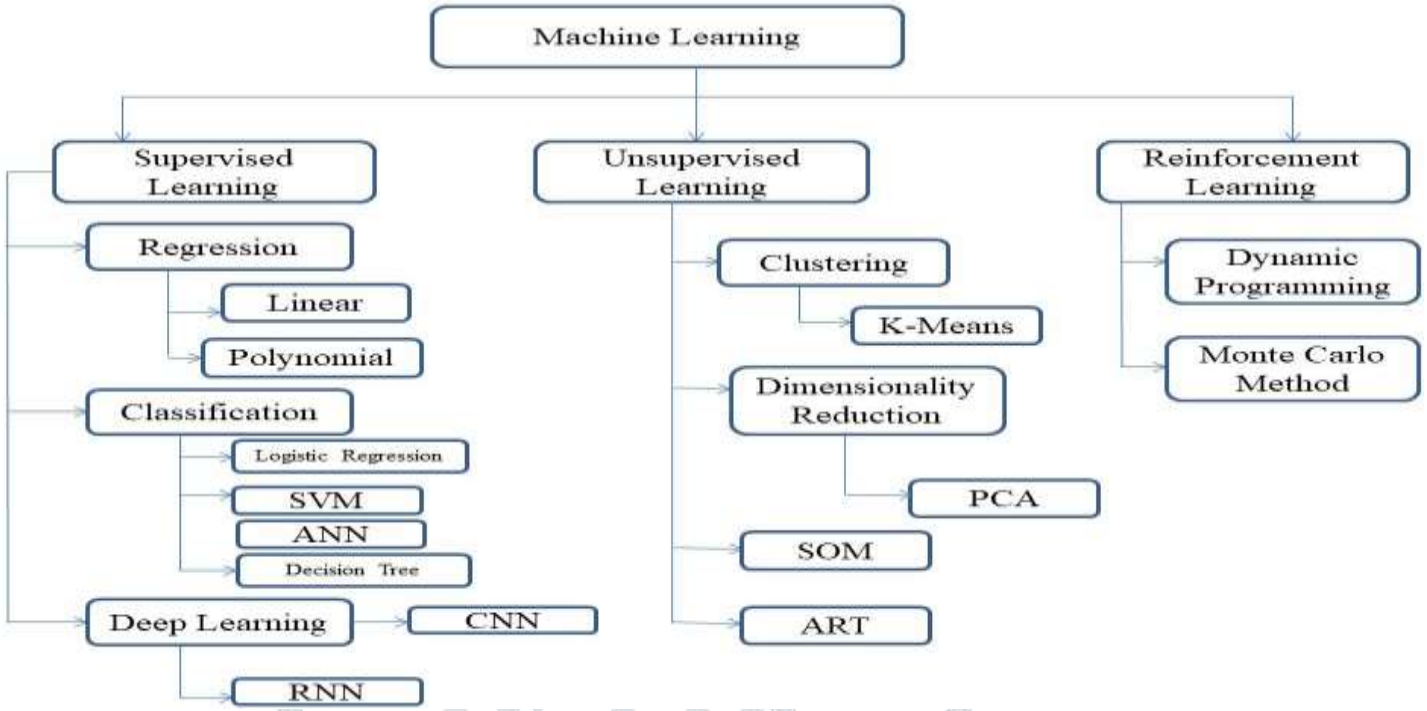

Figure 2. Taxonomy of ML Algorithms

In supervised learning, the predictors and response variables are known for building the model, in unsupervised learning, only response variables are known, and in reinforced learning, the agent learns actions and consequences by interacting with the environment.

2.2.1 Supervised learning (SL)

One of the most common jobs performed by so-called intelligent systems is supervised categorization (IS). The function that translates inputs to desired outputs is generated through supervised learning. Analyst input is required for supervised classification algorithms. The training set is the result of the analyst's input. In supervised satellite image classification algorithms, the training sample is the most significant aspect. The accuracy of the approaches is strongly dependent on the training samples. There are two sorts of training samples: one for classification and the other for ensuring classification correctness. Figure 2 depicts the process of supervised satellite image categorization. Before the categorization, a training set is offered.

Major Taxonomy of Supervised Learning Algorithms used the different techniques. As a result, a significant variety of approaches have been created based on regression (linear, polynomial), classification (Logistic Regression, Support Vector Machine, Artificial Neural Network, Decision Tree), and deep learning methods (convolutional neural network, recurrent neural network)

Supervised learning based of classification

Logistic Regression:

This is a classification function that employs a single multinomial logistic regression model with a single estimator and builds on class. In a specific technique, logistic regression generally describes where the border between the classes occurs, as well as how the class probabilities depend on distance from the boundary. It produces more precise, detailed forecasts and may be fitted in a variety of ways; nevertheless, such precise predictions may be incorrect. Ordinary Least Squares (OLS) regression and logistic regression are two approaches to prediction. Prediction with logistic regression, on the other hand, yields a binary result [8].

A technique called logistic regression is used to forecast a binary outcome: either something happens or nothing happens. This can take the form of Yes/No, Pass/Fail, Alive/Dead, and so on. The binary outcome is determined by analysing independent factors, with the findings falling into one of two groups. Although the independent variables might be numeric or categorical, the dependent variable is always categorical. This is how it is written:

$P(Y=1/x)$ or $P(Y=0/x)$

Given an independent variable X, it determines the probability of the dependent variable Y. This may be used to determine if a word has a good or negative meaning (0, 1, or on a scale between). It may also be used to identify the object in a photograph (tree, flower, grass, etc.) by assigning a probability between 0 and 1 to each thing.

Support Vector Machines (SVMs):

These are the most modern methods for supervised machine learning. Support Vector Machine (SVM) models are similar to multilayer perceptron neural networks in that they use support vectors. The concept of a margin—either side of a hyperplane that divides two data classes—is central to SVMs. It has been demonstrated that increasing the margin and therefore generating the biggest feasible distance between the separating hyperplane and the instances on either side of it reduces the predicted generalisation error [9].

One of the most commonly used approaches is machine learning with SVM, and the result is used to create a classification map. As the classification's basis function, the radial basis function was used. The SVM, on the other hand, does not guarantee proper results, and there are certain classification mistakes. The supervised technique is the most often used method for object-based classification. Another popular method is to utilise Support Vector Machines to simulate the segmentation problem (SVM). The SVM is a machine learning approach that uses non-linear transformers to convert a problem's dataset into a higher-dimensional space, where an ideal hyperplane is created for segregating dataset properties. The optimal hyperplane will be found when the dividing margins

between the designated classes are at their maximum. The greatest separation margins are represented by the support vectors [10].

A support vector machine (SVM) is a type of computer that employs methods to train and categorise input within degrees of polarity, going beyond X/Y prediction. We'll utilise two tags, red and blue, with two data features, X and Y, and train our classifier to output an X/Y coordinate as either red or blue for a simple visual explanation.

Artificial Neural Network (ANN):

An artificial Neural Network is a component of a computing system that is supposed to analyse and make decisions in the same way as the human brain does. Ann is a deep learning building piece that solves problems that humans find impossible or extremely tough. Artificial neural networks function similarly to the human brain. Each neuron in the human brain is made up of a cell body that is responsible for calculating information by passing forward information to hidden neurons and providing final Output.

Artificial Neural Network (ANN) is a computational and nonparametric supervised approach for data categorization that minimises computational complexity [11]. Multi-Layer Perceptron (MLP), Radial Basis Function (RBF), Wavelet Neural Network, Self-Organizing Map (SOM), and Recurrent Neural Networks are examples of ANN architectures (RNNs) [12]. The ANNs are meant to mimic human brain activity and can discover patterns to tackle tough nonlinear issues. The back propagation algorithm (BPA), which is the most often used way for training the ANN method, was utilised in this work to train a multilayer perceptron (MLP) architecture [13]. ANN classification (Artificial Neural Network) Artificial Neural Network (ANN) training is one of the most recent techniques to prediction and assessment utilising computer models that mimic some of the design and processing capabilities of the human brain.

Decision Tree (DT):

A Decision Trees (DT) is a supervised learning technique that is ideal for classification tasks because it can precisely organise classes. Decision Trees are classification trees that order instances based on feature values. Each branch in a decision tree indicates a value that the node might adopt, and each node represents a feature in an instance to be categorised. Starting at the root node, instances are categorised and arranged depending on their feature values. A decision tree is a prediction model that translates observations about an object to inferences about the item's target value in decision tree learning, which is used in data mining and machine learning [14].

Decision Tree operates like a flow chart, sorting data points into two related categories at a time, starting with the "tree trunk" and on to "branches" and "leaves," where the categories become increasingly finitely similar. This develops sub-categories, allowing for organic categorization with

minimal human intervention. Using the sports example, here how the decision tree works shows in figure 3:

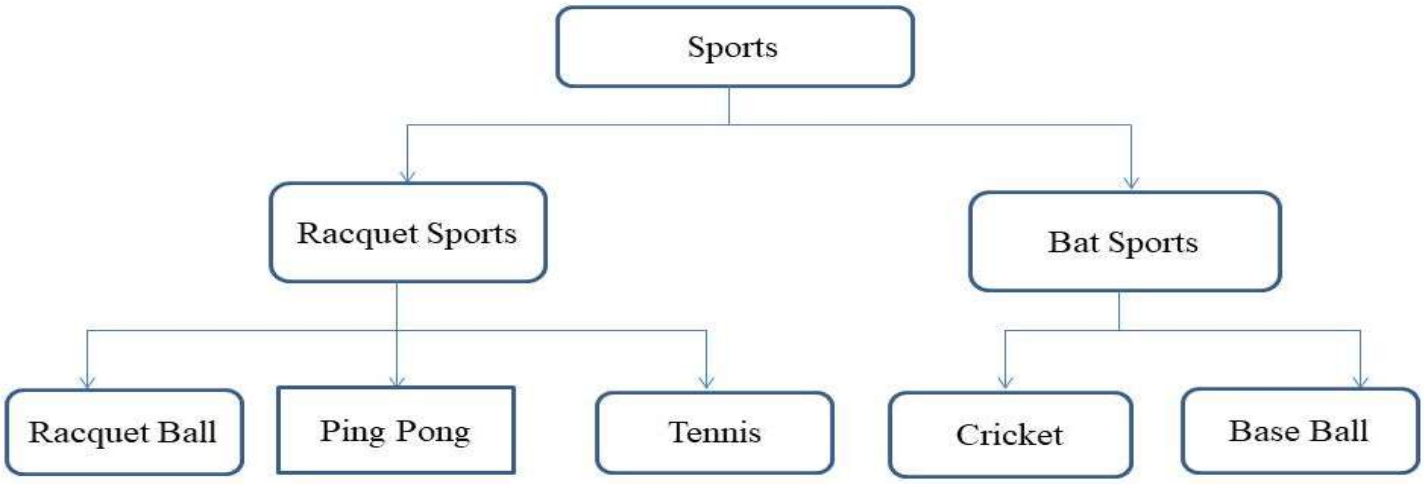

Figure 3. Taxonomy of ML Algorithms

2.2.2 Unsupervised learning (UL)

Clustering techniques are used in an unsupervised classification strategy to organize satellite image pixels into unlabelled classes/clusters. After that, the analyst labels the clusters with relevant labels and creates a well-classified satellite images.

Feature Selection Using PCA

Not all retrieved characteristics have a real association. If the appropriate features are not chosen, a substantial amount of noise will be introduced into the final model, lowering its accuracy. Principle component analysis is one of the most well-known methods for dimensionality reduction. PCA is a mathematical approach for reducing the dimensionality of data while preserving the majority of the variance (information) in the data set. In a nutshell, it's an algorithm for detecting patterns in data and displaying them in a way that highlights the similarities and contrasts. [15].

K-Means Clustering

One of the most often used unsupervised learning clustering techniques is K-means. The purpose of this simple method is to partition the data set into pre-defined clusters depending on distance. We've utilised Euclidian distance in this case [16].

K-nearest neighbours (k-NN) are a pattern recognition technique that finds the k closest relatives in future cases using training datasets. When you use k-NN to classify data, you calculate to place it in the category of its closest neighbour. If k = 1, it will be assigned to the class closest to 1. A majority vote of its neighbours classifies K.

SOM and ART

UL methods handle the problem of clustering, which occurs when a set of originally undefined objects is automatically divided into groups according on their qualities. The number of clusters (groups) can be specified in before or produced automatically. Adaptive resonance theory (ART) and self-organizing maps are two examples of such algorithms. - Kohonen or SOM maps and a large collection of clustering methods (k-means, mixture models, hierarchical clustering etc.) [17].

2.2.3 Reinforcement learning

Reinforcement learning is a category of learning tasks and algorithms based on the notion of reinforcement in experimental psychology. In this paper Taxonomy OF Reinforcement learning methods are divided in to two categories 1) dynamic programming (DP) and 2) Monte Carlo Method.

Here, stochastic optimum control issues are those in which the controller (the learning agent) must identify (or, more realistically, estimate) an optimal feedback control rule (an action policy) using imperfect knowledge about the dynamics of the controlled system (the agent's environment). Despite the fact that these issues have been researched extensively for many years, reinforcement learning researchers are developing ways that add some fresh components to traditional dynamic programming (DP) solution methods. Interleaving stages relevant to the operations of various DP algorithms with steps of actual or simulated control is a common feature of reinforcement learning algorithms based on DP. To put it another way, a DP algorithm isn't strictly employed as an off-line approach for creating policies before they're used for control [18].

3. Classification of ANN and SVM Method

3.1 Artificial Neural Network (ANN) classifications

Artificial Neural Networks (ANN) are one of the most recent techniques to prediction and assessment that uses computer models that mimic some of the design and processing capabilities of the human brain [19]

3.1.1. ANN training

The input, hidden, and output layers of an ANN are built up of processing units called neurons, which are grouped primarily in three layers: input, hidden, and output. The back propagation method of ANN is applied in this experiment. The ANN network is trained using the features taken from the initial batch of samples of damaged and non-damaged building images [20].

3.1.2. ANN classification

The remaining set of samples then divide the trained ANN classifier into damaged and non-damaged buildings. All of the data are classified, and the damaged structures are detected using both traditional feature extraction and wavelet-based feature extraction. Section 5 of this study summarizes the findings. Visual evaluation of the affected region is used to validate the technique.

3.2. Support Vector Machine (SVM) classification

In this study, a supervised classification approach called Support Vector Machine (SVM) is utilised to categorise damaged roof structures from non-damaged roof buildings. It is based on a recent computational statistical learning idea. [21]. the chosen characteristics are organised in an input space in SVM. This input space is translated into a high-dimensional dot product space termed feature space, and the ideal hyper plane in the feature space is identified to optimise the classifier's generalisation ability. A bi-classifier SVM is suitable because the classification only has two categories: damaged roofs and non-damaged roofs. In a bi-classifier, optimization theory is used to find the best hyperplane with the greatest percentage margin of separation. [22].

4. Classification Result and Discussion

ANN classification results

For both conventional feature extraction and wavelet feature extraction, ANN classification is done on all data in order to detect roof damaged structures. The classification utilizing wavelet extracted features was found to be 85% efficient, while the classification using traditional feature extraction was only 61% efficient. The better the categorization effectiveness, the more precise the damage identification.

SVM classification results

For both conventional feature extraction and wavelet feature extraction, SVM classification is done on the full data in order to detect roof damaged structures. It was discovered that for a satellite picture with a resolution of 2.44 m/pixel, classification utilizing wavelet extracted features yielded 93 % accuracy, but traditional feature extraction yielded only 66 % accuracy.

The better the categorization effectiveness, the more precise the damage identification. Compared to traditional feature extraction approaches, wavelet feature extraction gave a more accurate identification of the damaged buildings. At the same time, SVM outperformed ANN in terms of classification. Even with poorer quality satellite photos, 93 % of damaged structures were accurately recognized.

5. CONCLUSION

This study provides an overview of Machine Learning techniques and analyses multiple reviews written by different scholars. Taxonomy of machine learning Methods can be classified into: supervised, unsupervised, and reinforced. Researchers have published a survey of Machine Learning classification algorithms in the literature and evaluated their effectiveness against various data. Based on the criteria, the summary assists researchers in selecting relevant Machine Learning methods or approaches. For 2.44 m/pixel resolution satellite data, a wavelet-based modified change detection approach was used, and the damaged structures were detected with 93 % using Support Vector Machine (SVM) and 85 % efficiency using Artificial Neural Network (ANN). When compared to traditional feature extraction approaches, this method showed to be more efficient and accurate. The percentage area of damaged buildings is calculated using texture-wavelet analysis on the detected damaged structures. This proves the automatic detection of the percentage area of damaged building structures is accurate.

REFERENCE

1) ML Hajeb, M., Karimzadeh, S., & Matsuoka, M. (2020). SAR and LIDAR datasets for building damage evaluation based on support vector machine and random forest algorithms—A case study of Kumamoto earthquake, Japan. Applied Sciences, 10(24), 8932.

2) Karlsson, A. (2003). Classification of high resolution satellite images (No. STUDENT).

3) Shahbaz, M., Guergachi, A., Noreen, A., & Shaheen, M. (2012). Classification by object recognition in satellite images by using data mining. In Proceedings of the World Congress on Engineering (Vol. 1, pp. 4-6).

4) Vaiphasa, C., Piamduaytham, S., Vaiphasa, T., & Skidmore, A. K. (2011). A Normalized Difference Vegetation index (NDVI) Time-series of idle agriculture lands: A preliminary study. Engineering Journal, 15(1), 9-16.

5)Maxwell, A. E., Warner, T. A., & Fang, F. (2018). Implementation of machine-learning classification in remote sensing: An applied review. International Journal of Remote Sensing, 39(9), 2784-2817.

6)Abburu, S., & Golla, S. B. (2015). Satellite image classification methods and techniques: A review. International journal of computer applications, 119(8).

7)Muhamedyev, R. (2015). Machine learning methods: An overview. Computer modelling & new technologies, 19(6), 14-29.

8)Osisanwo, F. Y., Akinsola, J. E. T., Awodele, O., Hinmikaiye, J. O., Olakanmi, O., & Akinjobi, J.

(2017). Supervised machine learning algorithms: classification and comparison. International Journal of Computer Trends and Technology (IJCTT), 48(3), 128-138.

9)Kotsiantis, S. B., Zaharakis, I., & Pintelas, P. (2007). Supervised machine learning: A review of classification techniques. Emerging artificial intelligence applications in computer engineering, 160(1), 3-24.

10) M. Hajeb, S. Karimzadeh, & M. Matsuoka, "SAR and LIDAR datasets for building damage evaluation based on support vector machine and random forest algorithms—A case study of Kumamoto earthquake, Japan" Applied Sciences, 10(24), 8932, pp. 1-18, December 2020.

11) Bakhary, N., Hao, H., & Deeks, A. J. (2007). Damage detection using artificial neural network with consideration of uncertainties. Engineering Structures, 29(11), 2806-2815.

12) Markou, M., & Singh, S. (2003). Novelty detection: a review—part 2:: neural network based approaches. Signal processing, 83(12), 2499-2521.

13) S. Park, C. Choi, B. Kim, & J. Kim, "Landslide susceptibility mapping using frequency ratio, analytic hierarchy process, logistic regression, and artificial neural network methods at the Inje area, Korea" Environmental earth sciences, 68(5), pp. 1443-1464, August 2012.

14) Hormozi, H., Hormozi, E., & Nohooji, H. R. (2012). The classification of the applicable machine learning methods in robot manipulators. International Journal of Machine Learning and Computing, 2(5), 560.

15) Smith, L. I. (2002). A tutorial on principal components analysis.

16) Amruthnath, N., & Gupta, T. (2018, April). A research study on unsupervised machine learning algorithms for early fault detection in predictive maintenance. In 2018 5th international conference on industrial engineering and applications (ICIEA) (pp. 355-361). IEEE.

17) Kohonen, T. (1982). Self-organized formation of topologically correct feature maps. Biological cybernetics, 43(1), 59-69.

18) Barto, A. G. (1995). Reinforcement learning and dynamic programming. In Analysis, Design and Evaluation of Man–Machine Systems 1995 (pp. 407-412). Pergamon.

19) Radhika, S., Sabareesh, G. R., Jagadanand, G., & Sugumaran, V. (2010). Precise wavelet for current signature in 3ϕ IM. Expert Systems with applications, 37(1), 450-455.

20) Radhika, S., Tamura, Y., & Matsui, M. (2010). Using wavelets as an effective alternative tool for wind disaster detection from satellite images. Proceedings of Computational Wind Engineering (CWE2010), North Carolina, USA.

21) Sabareesh, G. R., Sugumaran, V., & Ramachandran, K. I. (2006, December). Fault diagnosis of a taper roller bearing through histogram features and proximal support vector machines. In IEEE international conference on signal and image processing.

22) Radhika, S., Tamura, Y., & Matsui, M. (2015). Cyclone damage detection on building structures from pre-and post-satellite images using wavelet based pattern recognition. Journal of Wind Engineering and Industrial Aerodynamics, 136, 23-33.