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Urban Area Detection from VHR Satellite and Aerial Images Using Image Processing

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Abstract— *In earth observation field, accurate and timely detection of urban area is very crucial for digital mapping, city planning, urban land management, military survey. To detect and record the changes which may occur in forest, desert, agricultural, and urban area is the major responsibility of urban region planners and government agencies. Satellite images and very high resolution images play an important role to resolve this issue. However, these images are not adequate alone because analyzation of such large images is prone to errors and due to dynamic environment of urban area, need of periodic detection is very time consuming. Automatic detection technique is a possible solution to identify the area from these images. There are main two techniques for automatic detection: unsupervised learning and supervised learning algorithm. Repeated pattern helps to distinguish region of interest from other is the motivation behind unsupervised learning and supervised learning algorithm is a process to figure out function from training examples, which is further used to predict output from any other input. In recent years, there are many different methods, which have been proposed by researchers based on these two techniques: nearest neighbor classifier, multiple layer perceptron, support vector machine, k-mean clustering, self-organizing map, Naïve Bayes classifier, Fuzzy logic.*

Index Terms: *k-mean clustering, multiple layer perceptron, support vector machine, self-organizing map, Naïve Bayes classifier, Fuzzy logic.*

1. INTRODUCTION

Detection of urban area is becoming vital now a days for wide range of applications [1] such as emergency safe landing of UAV fight military scrutiny, land exploration, digital mapping, change detection and national construction [2]. As an exemption of an urban monitoring, the buildings and the man-made objects can be effectively indicated in the cities [2]. For updating the information and forming the plan of geographic system, it is very useful for urban region planners as well as for government agencies [1].

The constant development of the countries leads to change of land cover and land use [3]. Due to very dynamic and heterogeneous nature of an environment of the urban area, periodic detection at average cost is essential [4]. The urban area can be automatically detected from VHR satellite images and the aerial images using so many different techniques. Unfortunately, very large urban areas are covered by these images. It is very difficult to inspect these images manually [5].

Fig. 1: Urban area

So, these are not appropriate for some monitoring applications. Considering the dependency of huge number of the applications on accuracy of the data, a proficient solution is required [6]. The recent scope of LiDAR data contributes to detailed coverage of urban area at fine scales [7]. Digital surface model or surface height information acquired from LiDAR is used for classification. Besides height information, LiDAR also offers the intensity information, which exhibits the characteristics of material/objects of urban area [7].

Researchers commonly use two techniques for the detection: unsupervised learning and supervised learning algorithm.

The major approach used for the detection is texture or structure based analysis, as the texture of natural scene is different from object of interest. Repeated texture or frequently persisting pattern helps to distinguish object of interest from the others [8]. Unsupervised learning approach is inspired by this method, which integrate all the cues extracted from multiple remote sensing images to locate the area [8]. Sometimes, texture or structure analysis suffers from deficiency of robustness and not always compatible with all kinds of situations or areas [1]. In that case, supervised learning approach is used. It is a process to figure out the function from training examples, called as regression function or a classifier. Each training example consists of output value with respect to its input object and the function interpreted from training data is used to predict the output for any other input data [9].

2. RELATED WORK

Beril sirmacek and Cem Unsalan[2010], [5] worked on urban area detection using local feature points and spatial voting. Periodical detection of urban area is necessary due to its dynamic nature. High resolution aerial and satellite images had been used for the detection. Using gablor filter, firstly local feature points were extracted, which were further used for the formation of spatial voting matrix. Then, optimum decision making approach was used to detect final urban area from the given input images. The results showed that, method used was fairly reliable and fast.

Chao Tao, Zheng-rong Zou, Yihua Tan and Jinwen Tian(2013), [8] proposed research on 'Unsupervised detection of build-up areas from multiple high resolution remote sensing images'. Repeated texture or frequently persisting patterns helped to differentiate build-up area. This proposed work consisted of main two steps. In first step, harris corner detector was used to extract corner from the input image and to locate candidate region, extracted corners were integrated into likelihood function. In second step, graph-cut and spectrum clustering algorithm were used for the final detection of build-up area.

Aparna Taneja, Masc Pollefeys, Luca Ballan(2007), [6] proposed a research on 'Geometric change detection in urban environment using images'. Using panoramic images, a method was proposed to detect geometric changes of a city. The designed algorithm ignored any change in structural appearance and the changes which were not pertinent for the purpose of update such as people, cars etc, but it specifically detected the changes in the environment. To minimize absolute and relative alignment error of each input image w.r.t. 3D model, registration technique was proposed. Instead of using sparsely captured or low resolution image, the algorithm on high resolution and densely captured images was evaluated. 14000 images, in case of large scale setup were used for the evaluation.

Diego González-Aguilera, David Hernández-López, Eugenia Crespo-Matellán, Pablo Rodríguez-Gonzálvez (2013), [10] proposed 'Automatic urban analysis based on LiDAR'. To acquire urban density attributes (like coverage ratio of building and area ratio of floor) and geometric information (like volume, area, height), airborne laser scanner data was used. Validation for building density was performed against "ground truth", derived from field topographic measurement and cadastral data.

Hicham Randrianarivo, Bertrand Le Saux(2013), [11] proposed a research on urban change detection in SAR images by interactive learning in which synthetic aperture Radar imagery approach was mainly used to detect changes in urban environment (like activity monitoring and demolished or new building). The proposed approach delineates the difference between two registered images. First, online learning approach was proposed to identify the relevant change and then CI-HOG was used to acquire both spatial and intensity distribution of the local changes.

Jongho Park, Sungwan Kim, and Youdan Kim (2015), [12] proposed 'Landing site searching and selection algorithm development using vision system and its application to quadrotor'. Non-linear effect was especially considered using quadrotor dynamic modelling. Feedback linearization and linear quadratic tracker techniques were used to design the controller. To acquire the information of flatness from depth map, canny detector was used and then Euclidean distance transformation was performed. The combination of three main measures was used to locate safe landing site that were flatness, depth and energy consumption. The validation of performance was performed using numerical simulation.

Y. Yang, Y. Cao and H. Sun(2004), [13] worked on 'Unsupervised urban area extraction from SAR imagery using GMRF'. Two different models of Gaussian markav random field (GMRF) were proposed. Initially, watershed algorithm was used for the segmentation and then RGMRF was used to extract urban area from images with some missing detection. Applying its result as training sample, conventional GMRF performed extraction over again with some invalid detection. For the final detection of urban area, the results of two models were merged using region growing algorithm.

Corina Iovan, Mats Erikson, Matthiev Cord and Didier Boldo(2007), [14] proposed a work on automatic extraction and classification of vegetation areas from high resolution images in urban area. Two methods were proposed to detect vegetation area: spectral indices and SVM classifier. A region growing technique deployed on digital surface mode, was used to discriminate lawns from treed area through estimating texture operator. Finally, the accuracy of obtained result was compared to the results acquired by random walk tree crown algorithm. Result obtained by proposed method was very optimistic.

LIU Zhifang, Zhang Zuxun, Zhang Jianqing and Fan hong(2003), [doc2]proposed a work on change detection based on DSM and image features in urban area. Height information of houses as well as texture information from an image was used to detect the changes. Old and new DSM were created by image matching method. Both DSM were compared to extract the changes region. Finally, gradient direction histogram was used to examine the extracted region.

Beril sirmacek and Cem Unsalan(2009), [16] proposed urban area and building detection using SIFT keypoints and graph theory. To detect the objects in images under different condition, SIFT was proposed and problem was represented in the form of graph theory, as SIFT alone was not adequate to detect buildings and urban area. Each keypoint was represented as vertex of graph and then relationship between intensity values and spatial distance was used to detect the edges of graph. Finally, novel graph cut method was used to extract different building from the urban area.

Beril sirmacek and Cem Unsalan(2011), [17] proposed urban area detection from remotely sensed images using combination of local features. To overcome uncontrolled appearance (such as viewing angle, illumination etc) of remote sensing images, novel detection methods of urban area based on local features and probabilistic framework was proposed. Firstly, four different types of local feature extraction methods such as harris corner, GMSR feature, gabor feature and fast features were introduced. Increase in the number of local feature, increased the probability of detection of urban area. Probability density function was estimated using kernel based density estimation method, to detect urban area boundaries. Further, results were improved using fusion methods in both data and decision levels, to merge the different information coming from all four feature extraction methods.

Xufeng Guo, Clinton Fookes, Simon Denman, Sridha Sridharan and Luis Mejias(2014), [18] had proposed automatic UAV forced landing site detection using machine learning. Various features like colour, texture etc. were extracted and evaluated using various methods and then classified. Gaussian mixture model and three different kernels of support vector machine such as linear kernel, polynormial kernel and RBF kernel were used for the classification. The results of proposed work were compared with baseline detection system in which edge features were used along with ANN classifier. The results of experiment showed that detection of safe landing site was improved with RBF kernel of SVM classifier and revealed more stable performance.

Yang Gu, Xiuping Jia, Qingwang Wang and Jan Atli Benediktsson(2015), [19] had proposed a novel MKL model of integrating LiDAR data and MSI for urban area classification. Two different data sets: LiDAR data and spectral images used for the detection. A novel MKL model was proposed to fuse the heterogeneous features such as spatial, elevation and spectral attributes of objects from two data sets. Firstly, similarity of samples was measured at different bandwidth using gaussian kernels. Weights of different features were arranged using MKL framework and integrated kernels at different scales. Proposed work revealed better accuracy when compared with other algorithms.

Hao Shi, Fu-Kun Bi, Liang Chen, Ying Yu and He Chen(2015), [2] worked on accurate urban area detection in remote sensing images. Different resolutions for multiple features were used for detection. First, candidate area was segmented from down sampled image and all the extracted corner points were integrated into this area using gaussian voting matrix technique. High resolution images were used to extract edge and homogeneous region. Finally, guided filter and the contrast enhancement accurately detected the urban area.

3. CLASSIFICATION

The classification techniques are:

3.1 k-mean clustering

It is the most popular type of partitional clustering. It performs clustering of input data set into specified k number of clusters using unsupervised learning approach. Each object is assigned to the particular cluster with the closest mean, serving as template of that cluster. It mainly consists of two major steps [20]:

- K-means iteratively allocate objects to the adjacent of k clusters.
- Then, the mean of newly generated cluster is recomputed and updated again.

It repeats the whole process until the number of objects which changes the cluster is lower than that of user-specified threshold.

The main aim of this algorithm is to minimize the squared error function. Mathematically, it can be represented [21] as

$$J(v) = \sum_{i=1}^{c}\sum_{j=1}^{c_i}(\left|\left|x_i - v_j\right|\right|)^2$$

Here, $\left|\left|x_i - v_j\right|\right|$= Euclidean distance between data point x_i and cluster mean v_j.

C_i= number of objects in ith cluster

C= number of cluster means.

Although, it is easier to understand, yet it requires the specification of cluster mean, before starting the process. Randomly selected cluster mean may lead to wrong results.

3.2 Multilayer perceptron

It is a feed-forward network of neurons, which are known perceptron. Feed-forward indicates that direction of flow of data is forward that is from input layer to output layer, with one or more hidden layer between them. The output of ith layer serves the purpose of input for ith+1 layer. With non-linear transfer function of multiple layers of perceptron, network acquires linear and non-linear relationship between input vectors and output vectors [22]. Multilayer perceptron network can be used as both supervised learning and unsupervised learning algorithm. In supervised learning, it is trained using back propagation algorithm and can be used as unsupervised learning algorithm using auto associative structure [23].

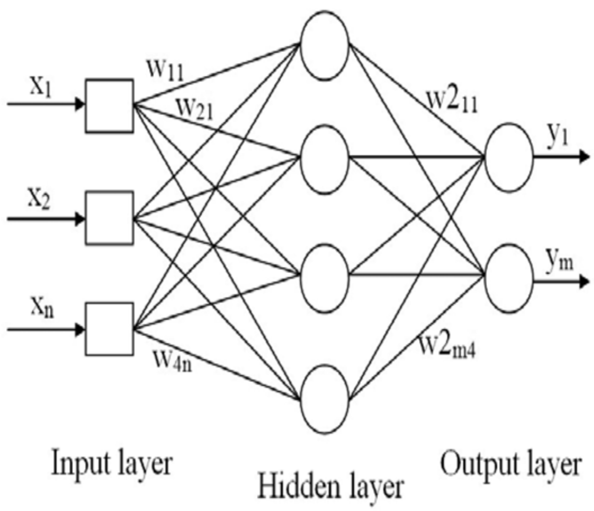

Fig. 2: Multilayer perceptron [24]

Multilayer perceptron is a network in which each node/neuron of one layer is connected with the every node of its following layer with some certain wij weight. Learning in perceptron occurs by varying the connection weight, after the processing of each piece of data. Correction in weight used to minimize the error in output result compared to desired result.

3.3 Support vector machine

For regression analysis and classification of data, support vector machine is among one of the most commonly used supervised machine learning techniques. Support vector machine relies on the decision plane concept which separates the objects possessing different class membership [25]. By inducing the function from convenient examples, it can separate the objects of two different classes. It plots each object into n-dimensional space as a point and uses hyper-plane to differentiate these objects into two different classes with as wide gap as possible. The class of new object is predicted based on side of gap it lies. With the help of kernel function, support vector machine is an efficient to perform non-linear classification also. Kernels are used to separate the non-separable objects. It basically transforms or maps the objects from low dimensional input space to high dimensional space.

Different two class SVMs can also be used to perform multiclass classification. It includes two methods: one versus one and one versus al [22].

One-versus-one, in which classification is performed between each and every pair of classes, with winner-takes-all-strategy.

One-versus-all, in which classification is performed between one of labels class and rest with max-wins using strategy.

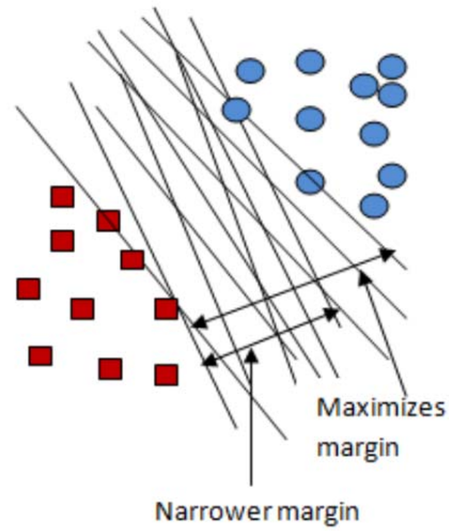

Fig. 3: Support vector machine [22]

3.4 Naïve Bayes classifier

It is a type of probabilistic classifier, which performs classification based on Bayes theorem with assuming the independency between the features. It basically presumes that feature presented in particular class is independent to that of other features. It can be trained very conveniently in supervised machine learning settings by providing definite nature of probability model. During the data preprocessing step, it removes useless data, which does not affect the result of classification or the data which gives same interpretation [20]. This makes data more precise and improves the computational time.

Number of n independent features can be classified using Bayes theorem as

$$\text{Posterior} = \frac{prior * likelihood}{evidence}$$

Mathematically, it can be represented as [26]:

$$p(C_k\,|x) = \frac{p(C_k)\,p(x|C_k)}{p(x)}$$

In the illustrated example, the objects are classified into two classes and the class of newly arrived object is decided, based on existing class of the objects.

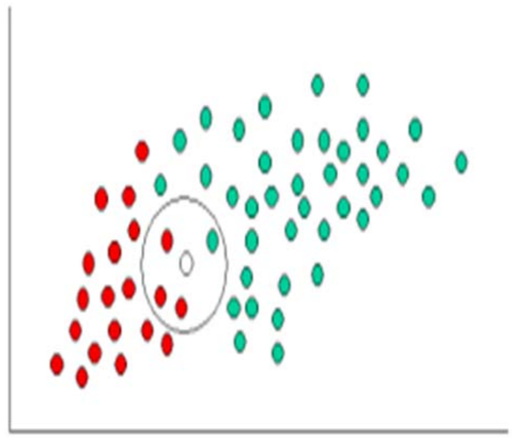

Fig. 4: Example of naïve Bayes classifier [27]

According to prior probability, new (white) object belongs to GREEN class, because number of GREEN objects are more than that of RED objects. Likelihood is measured by drawing a circle around white object and then number of objects of class label is calculated. Here, it depicts that white object belongs to RED class because RED objects are more in the vicinity of white object than that of GREEN objects. Both prior probability and likelihood are combined to produce final classification [27].

There are several methods to evaluate the classification ability of this method: f-measure, precision and recall. Furthermore, it's classification results can be composed with results of other classifier s to evaluate its performance.

3.5 Self-organizing map

This is a type of model based clustering, which sights to clump that objects match a statistical distribution. This type of unsupervised machine learning technique includes neural networks which consist of neurons/nodes. Each node corresponds to a weight vector of identical dimension as input data vector and same position in map space. Usually rectangular or hexagonal grid in two-dimensional spacing is used for the arrangement of the nodes. The properties of input space, which are topological, conserved using neighbourhood function, which differentiates it from other type of artificial neural networks. During competitive learning course, different input patterns of neurons are selectively tuned. For input feature, co-ordinate system on lattice is created by ordering the tuned locations of neurons.

It utilizes two approaches to work: training and mapping. In 'training approach', input examples are used to build the map and a new input vector is automatically classified using 'mapping approach'. It basically performs adaptive transformation of incoming signal pattern of high dimension to low dimension i.e. one or two dimensional map [28]. This procedure is used to find out the node which has negligible distance weight vector to input data space vector.

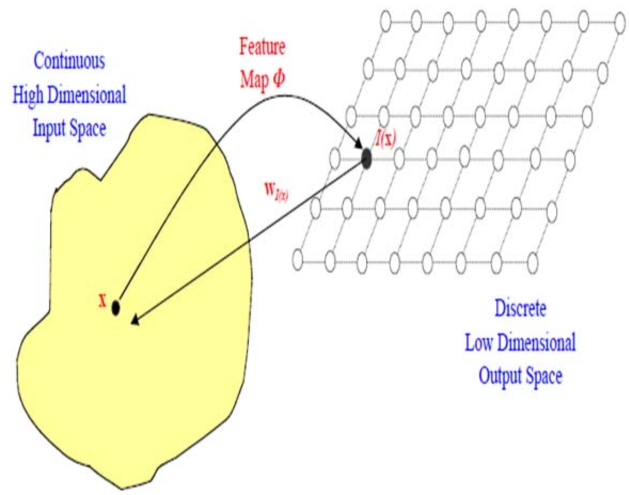

Fig. 4: Organization of mapping [29]

As shown in figure, x points from input space are mapped to the I(x) points in output space and I(x) points from output space are mapped into the input space corresponding to wij weight vector [29].

3.6 Fuzzy Logic

Although Fuzzy logic is comparatively inferior theory yet, many researchers have used this theory in different field to solve different problems. The wide range of application areas are: pattern recognition, operations research, decision making, economics, management, process control and classification. Fuzzy logic theory provides the natural description of problem in terms of lingual, as its advantage over other classifier [30]. This advantage offers a simple way to deal with complicated system, which is the main reason of using fuzzy logic theory for wide range of applications. Better performance is achieved for a specific application with the use of fuzzy systems because of its two main characteristics.

- Under the situation of uncertain or incomplete information, fuzzy systems allow to make decision with the estimated values.
- Fuzzy systems are convenient for approximate or uncertain reasoning, especially in the case, when system is having mathematical model, which is hard to derive.

First, the concept of fuzzy set was introduced by L. Zadeh in 1965, was the starting of fuzzy logic. It is a set of clearly defined boundary without crisp. The fuzzy set can contain element with either partial degree of membership (i.e. membership between 0% and 100%) or full degree of membership (i.e. 100% membership). That is, there is no longer restriction on the value of membership assigned to an element to the just two values, it can be 0 or 1 or can be in between any value. Membership function in fuzzy set is defined as mathematical function, which is use to define degree of membership of an element [30].

There are main three steps to perform fuzzy image processing: fuzzification of an image, modification in the values of membership and defuzzification [22]. Through the use of fuzzy set, fuzzification convert the real world data into a membership function and through the use of membership function, fuzzy logic convert the real world values into the degree of membership. Defuzzification is a opposite process of fuzzification i.e. convert back the membership function to the real world data.

4. CONCLUSION

This paper focuses on the study of rapid and automatic detection of urban area from satellite images and very high resolution aerial images. Time to time range of urban areas varies due to huge human activities. So, periodically monitoring of urban area at acceptable cost is required, which can be done by using two automatic detection techniques: unsupervised learning and supervised learning algorithm. Each existing method based on these two algorithms has their own advantages and disadvantages. Manifold characteristics or uncontrolled appearance of urban area like viewing angle, illumination increase the difficulty to originate automatic detection system. Closely spaced or small building and the building having too large roof top are not detected easily. Further future scope of this work is to detect the type of urban area i.e. homogeneous, dense and well structured.

REFERENCES

[1] C. Zheng, L. Wang, H. Zhao and X. Chen, "Urban area detection from high-spatial resolution remote sensing imagery using Markov random field-based region growing", Journal of applied remote sensing, vol. 8, pp. 083566(1)-083566(14), Aug 2014.

[2 H. Shi, L. Chen, F. Bi, H. Chen, and Y. Yu, "Accurate Urban Area Detection in Remote Sensing Images", IEEE Geosci. Remote Sens. Lett., vol. 12, no. 9, pp. 1948–1952, Sept. 2015.

[3] A. A. Belal and F. S. Moghanm, "Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate", The Egyptian Journal of Remote Sensing and Space Sciences, vol. 14, pp. 73–79, Sept 2011.

[4] F. kressler and K. steinnocher, "Change detection in urban area using satellite images and spectral mixture analysis", International Archives of Photogrammetry and remote sensing", vol. 31, pp. 379-383, 1996.

[5] B. Sirmacek and C. Unsalan, "Urban area detection using local feature points and spatial voting," IEEE Geosci. Remote Sens. Lett., vol. 7, no. 1, pp. 146–150, Jan. 2010.

[6] A. Taneja, L. Ballan and M. Pollefeys, "Geometric Change Detection in Urban Environments using Images", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 6, no. 1, pp. 1-14, Jan. 2007.

[7] W. Zhou, "An Object-Based Approach for Urban Land Cover Classification: Integrating LiDAR Height and Intensity Data", IEEE Geosci. Remote Sens. Lett., vol.10, no. 8, pp. 928-931, Apr. 2013.

[8] C. Tao, Y. Tan, Z.-R. Zou, and J. Tian, "Unsupervised detection of built-up areas from multiple high-resolution remote sensing images," IEEE Geosci. Remote Sens. Lett., vol. 10, no. 6, pp. 1300–1304, Nov. 2013.

[9] D. Kalita, "Supervised and unsupervised document classification-A survey", International Journal of Computer Science and Information Technologies, vol. 6 , no. 2 , pp.1971-1974, 2015.

[10] D. G. Aguilera, E. C. Matellán, D. H. López, and P. R. Gonzálvez, "Automated Urban Analysis Based on LiDAR-Derived Building Models", IEEE Geosci. Remote Sens. Lett., vol. 51, no. 3, pp. 1844–1852, Mar. 2013.

[11]B. L. Saux and H. Randrianarivo, "Urban Change Detection in SAR images by Interactive Learning", Proceedings of IEEE International Conference on Geoscience and Remote Sensing Symposium , pp. 3990-3993, 2013.

[12] J. Park, Y. Kim and S. kim, "Landing Site Searching and Selection Algorithm Development Using Vision System and Its Application to Quadrotor", IEEE Trans. On Control Systems Technology, vol. 23, no. 2, pp. 488-503, Mar. 2015.

[13] Y. Yang, H. Sun and Y. Cao, "Unsupervised Urban Area Extraction from SAR Imagery Using GMRF", Pattern Recognition and Image Analysis, vol. 16, no. 1, pp. 116–119, 2006.

[14] C. Lovan, D. Boldo, M. Cord and M. Erikson, "Automatic Extraction and Classification of Vegetation Areas from High Resolution Images in Urban Areas", Proceeding of Springer 15th Scandinavian Conference, SCIA, pp. 858-867, Jun. 2007.

[15] Hossain and Amin, "leaf shape identification based plant biometric" , IEEE, 2010.

[16] B. Sirmacek and C. Unsalan, "Urban-area and building detection using SIFT keypoints and graph theory," IEEE Trans. Geosci. Remote Sens., vol. 47, no. 4, pp. 1156–1167, Apr. 2009.

[17] B. Sirmaçek and C. Unsalan, " Urban area detection from remotely sensed images using combination of local features", Proceedings of IEEE International conference on Recent Advances in Space Technologies, pp. 188-192, Jun. 2011.

[18] X. Guo, S. Denman, C. Fookies, L. Mejias and S. Sridharan, "Automatic UAV Forced Landing Site Detection using Machine Learning", in proceeding of IEEE conference on Digital lmage Computing: Techniques and Applications (DlCTA), pp. 1-7, Nov. 2014.

[19] Y. Gu, Q. Wang, X. Jia and J. A. Benediktsson, "A Novel MKL Model of Integrating LiDAR Data and MSI for Urban Area Classification", Urban area detection using local feature points and spatial voting," IEEE Geosci. Remote Sens. Lett., vol. 53, no. 10, pp. 5312-5326, Oct. 2015.

[20] D. Kalita, "Supervised and Unsupervised Document Classification-A survey", International Journal of Computer Science and Information Technologies, vol. 6, no. 2, pp. 1971-1974, 2015.

[21] https://sites.google.com/site/dataclusteringalgorithms/k-means-clustering-algorithm

[22] Savita N. Ghaiwat, Parul Arora,"detection and classification of plant leaf disease using image processing techniques", International journal of recent advances in engineering & technology, volume 2, issue 3, 2014.

[23] https://www.hiit.fi/u/ahonkela/dippa/node41.html

[24]https://www.google.co.in/search?q=diagram+of+multilayer+perceptron&espv=2&biw=993&bih=638&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiq4eGd9YXMAhXHnqYKHQ5FC6oQ_AUIBigB&dpr=0.9#imgrc=6uuhfaEsDcnmcM%3A

[25]http://www.statsoft.com/textbook/support-vector-machines

[26] http://www.analyticsvidhya.com/blog/2015/09/naive-bayes-explained/

[27] http://documents.software.dell.com/Statistics/Textbook/Naive-Bayes-Classifier

[28] R. Sathya and A. Abraham, "Comparison of Supervised and Unsupervised Learning Algorithms for Pattern Classification", International Journal of Advanced Research in Artificial Intelligence, vol. 2, no. 2,pp. 34-38, 2013.

[29] John A. Bullinaria, "Self Organizing Maps: Fundamentals", Introduction to Neural Networks : Lecture 16, 2004.

[30] Nedeljkovic, "Image classification based on fuzzy logic", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. 34, part 30.