International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-4, April 2019

Feature Extraction Methods using Image Processing Techniques

R.Sunitha, B Sharmila, K.Srinivasan

Abstract: ***Feature extraction plays a major role in identification of the algae species and also for their classification. The species are identified based on the size, shape, colour and texture. In identification of algal species by biological methods there is more possibility of human error and uncertainty. The task needs more attention and focus. Biological techniques seem to be more expensive, highly time-consuming and tedious for achieving good performance while identifying the species. Identification of algal species at their comparative rank of a collection in a nomenclature and the application in different real time evaluation is a complex process. This has encouraged developing systems to automate the identification algal images. When compared with biological techniques or methods the image processing technique is cost effective and good performance is achieved in very short time. In an image various features such as size, shape, color and texture are taken into consideration. In current days there has been an immense curiosity in the proposing many image classification strategies with respect to texture fora wide range of sectors. This survey paper presents methodologies used in feature extraction using image processing.***

Keywords: Feature Extraction, Image Processing, Texture, Image Classification, Segmentation, Algae, Identification, Recognition, Computation, Convolution Neural Network.

I. INTRODUCTION

Algae have most important position in preserving healthy environment in current era. Algae characterize a huge collection of diverse creatures belonging to various classes, representing various nomenclatures. Algae are vegetation that can be of tiny size to large seaweeds. Microalgae comprise both Cyanobacteria, that is same as bacteria, and previously known as blue-green algae, and also green, brown and red algae. Several collections of algae that exist are Diatoms, Chlorophyta, Euglenophyta, Dinoflagellata, Chrysophyta, Phaeophyta, Rhodophyta, Cyanobacteria.

Algae are used in extracting the biofuel, medicine, controlling the climatic conditions, controlling the global warming, Agriculture - bio fertilizer, soil stabilizers, feeding livestock and hens. Algae can be grown using water resources that do not fit for growing plants. While using dirty water, like metropolitan, sewage and manufacturing overflow, they can help in purifying, at the same time profiting by utilizing the supplements present.

Manuscript published on 30 April 2019.
***** Correspondence Author (s)
R.Sunitha, Research Scholar, Anna University, Chennai, Tamilnadu, India
B Sharmila, Professor, Department of EIE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India
K.Srinivasan, Professor and Head, Department of EIE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India

Image processing is current exploration domain for enhancing the appearance of input image and to obtain some important data from it. The images are identified by the significant characteristics of the features in the image. In basic words features are the distinct signatures of the given image or distinct properties that characterizes an image. Low-level features are small information of the image like lines or points and high-level features are placed above low-level features and the objects and larger shapes in the image are identified.

The problem of selecting the features from the extracted vector should be guided by the accompanying concern :

- features should convey adequate data of the image and do not necessitate any area related information for their extraction.
- features should be simple for estimating and proceed towards the feasibility of a huge image database and quick recovery.
- features have to correlate with a person's interpretation qualities as clients at last decide the correctness of the images retrieved.

II. RELATED WORKS

Many authors used various techniques for the past many years for feature extraction. This section will discuss the methods used by various authors.

The main objective of the current work proposed by Kangkana Bora, Lipi B Mahanta et.al., is to perform Fuzzy Non Sub-sampled Contourlet Transform (NSCT) based classification of Pap smear images which recognizes the cervical dysplasia. Feature vectors are designed by using four pyramidal and directional NSCT filter combinations. Initial step is the collection of the single cell cervical images. Subsequent step is the feature extraction process using NSCT, where feature vector is generated. Next step is the feature selection by using the concept of fuzzy entropy which reduces the feature vector size. Least Square Support vector Machine (LSSVM) and Multilayer Perceptron (MLP) are used to perform the classification of the images is the final step, where the final classes reflect the level of malignancy that occurs in the Pap smear image. This method performs better than other conservative transforms like Fourier Transform and Discrete Wavelet Transform. This method is utilized in recognition of cervical cancer with the category of malignancy. These features help in quantitative transformation of biased morphological features which changes as malignant growth advance.

Extremely intricate (multifaceted) information of the objects (namely nuclei and cytoplasm) with different curves and contours are present in Pap smear images. So the feature vector that can characterize the information can lead to an effective automated system design. Being an advanced multi-resolutional technique which is having property like multi-scale anisotropy, multi-directional expandability, full shift invariance and many more; NSCT can be a wonderful tool for generate the feature vector of the Pap smear images, which inspires to use this method in the analysis of Pap smear images to learn the morphological changes of cervical cells as the cancer advancement in various stages. Utmost accuracy is achieved using the various filter combination and circumvents unwanted surplus features. Complete transformations of the image features are not done by this method; rather the features are ranked based on their involvement to an assigned class. This method facilitates in appropriate observing of the features during feature reduction. Fast computational time is the advantage of this technique. It gives the level of dysplasia that occurs in Pap smear images [1].

The research work proposed by Bora K., Chowdhury et.al., is a smart mechanism for automated classification of Pap smear images for detection of cervical dysplasia. Ensemble technique is used to make cell and also smear level classification, which is a process of discussing with numerous professionals before taking an ultimate decision to achieve the good accuracy. Ensemble technique helps to integrate the decision of three classifiers for enhancing the categorization outcomes. This process is made use of in detecting cervical cancer with the class of malignancy. This form of automized cancer classification scheme will be advantageous in premature malignancy recognition. Ensemble classification helps in attaining higher detection level. The method utilized here is capable of achieving precision and consistency. Ensemble classifier provides a better result when compared to the results of the three classifiers individually. All outcomes show that the proposed strategy is capable of recognizing dysplasia level that occurs in cervical lesion from Pap smear images. The automatic scheme helps in decreasing time taken for monitoring individually, eliminates the observer bias and also enhances effectiveness. This methodology lacks in dealing with some of the factors like age and menstruation that also have an impact on the output of the system. In future it would be concentrated on expanding the span of data collection so that exactness of the system would become steady, while making use of image data having dysplasia at different stages or levels [2].

The scheme proposed by Sergey Kosov et.al, is to develop a system which conducts the Classification of Environmental Microorganisms (EM) by directly analyzing microscopic images. Features are extracted as feature vectors by using Deep Convolutional Neural Network (DCNN). Entirely linked layers are replaced by convolutional layers having upsampled (dilated) filters to Repurpose (using VGG 16) a DCNN pre-trained on a huge collections of image data in order to yield condensed pixel-level feature maps for an image. Image denoising using Conditional Random Fields is carried out. Morphological operators and Hough transform are used to extract Global features. For enhancing accurateness global features are combined with local features for classification. Random Forest (RF) classifiers are trained by using the features that are extracted with that of ground truth data by examining pixel level and also global features in training images. It helps in decomposing the pollutants and establish sustainable ecosystem. Normally the climatic changes affect the features of the Environmental Microorganisms. Combining the local and global features together, it helps to extract the pixel based features and to come up with a perfect classification even if there are changes due to climatic conditions. Top down approach of the process flow and combining global and local features ends in achieving highest accuracy. The noise is removed at the final stage so that the features extracted will be highly accurate. Here the optimization is done manually [3].

The proposed approach by Michał Kruk, Ryszard Kozera et.al., includes image segmentation, feature generation, the most significant feature selection and the finally the recognition phase using five various results of classifiers. Microorganism class recognition issue is solved by proposing the computerized system which is made out of few phases. Segmentation of the unique image data is first stage aiming to isolate the background from the region of interest (ROI) having microbes and considered to be single entity. The approach to microorganism recognition depends on appropriate explanation of the whole group rather than single individuals. It is an entirely dependable technique and conveys stable outcomes for substantial variation of the intensity of the image. In the subsequent phase, numerical descriptors (features) of the ROI are created, that characterize possible input elements to the classifier scheme. These features experience evaluation of their class refinement capacity (selection process). Classification stage treats the selected features as the input attributes, that are responsible for final class recognition. The problem explained in this work is the principal phase in microbe image processing. The exhibited outcomes are inspiring and stimulate the extension of advanced learning. The result to count the quantity of distinct microbes that are visible in the examined image data could be extended as a future enhancement [4].

The paper proposed by Filhoet.al, presents an innovative strategy for detection of tuberculosis bacillus in traditional phlegm smear microscopy. The technique for identification of this species of bacteria comprises of the subsequent phases: acquiring image, segmenting of images and post processing. The proposed system is used for TB diagnosis. The outputs acquired with the combinations of sizing, geometric and rule-based filters were better in comparison with those acquired with above mentioned filters individually. An Automatic tuberculosis diagnosis system has been procured with the images acquired through traditional microscopic strategies.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

An image database has been generated which was not at all existing earlier and now it is made available to be used by all by publishing in the website. The error percentage reduces to 0% and lesser than 4% for all image data. The best sensitivity, 96.80%, was acquired [5].

Sansoen Promdaen et.al, recommended one novel technique for segmenting algae bodies from an image background and estimating texture descriptors from a blurred texture entity. Combination of feature is used to manage a variety of algae shape of similar class. Sequential Minimal Optimization (SMO) is employed as a classifier which gives 97.22% classification accuracy. In the preprocessing process an input image is resized and the input color image is changed to a gray scale output. Subsequently segmentation process is carried out where target object is isolated from background and taken for texture feature extraction. Gray scale values in the region of object are used to compute a Gray Level Co-Occurrence Matrix (GLCM) and texture descriptors are computed using gray scale values. Segmentation image is used as a mask to extract gray level values. Next, GLCM is improved by removing paired relationships with background elements shown up in initial row and column of the matrix. At last, Haralick's thirteen texture descriptors are calculated using the elements of GLCM. Presently, new texture descriptors are computed from the mean of old ones found out from the input having various levels of edge enhancement to highlight blurred texture and also effectively avoiding the highlighted noise in data. For example, it is essential to evaluate the performance of the system over a large image data set. The techniques for selecting the features should be explored and used to condense the number of features used in a categorizing the algae. Also it is crucial for a classifier to have an elimination method in discarding strange algae or irrelevant elements not known to trained classifier rather than categorizing them into any erroneous category so that the recognition system would be made more realistic when compared to other systems [6].

This paper by Robert M. Haralick et.al., elaborates some effortlessly computable textural features based on gray-tone spatial dependencies [7] and demonstrate their usage in class recognizable tasks. The technique proposed for acquiring the textural features of an image is associated to the assumption that the texture information in an image is present in overall or average spatial relationship which the gray tones in the image have for one another. In the proposed procedure, number of tasks needed to process an image is directly proportional to the number of resolution cells present in the image. The angular second-moment feature (ASM) is a measure of homogeneity of the image. The contrast feature is a difference moment of the matrix and is a measure of the contrast or the amount of local variations present in an image. The correlation feature is a measure of gray-tone linear-dependencies in the image. Here Classification Algorithms like Piecewise Linear Discriminant Function Method [8] is used for datasets with comparatively huge number of samples and Min-Max Decision Rule is used for datasets with comparatively lesser number of samples. The proposed system is applied in image category identification tasks in remote sensing (satellites) of Earth resources, in petroleum production studies and Army Environmental Topography namely photomicrographs, aerial photographic images and the satellite images. To compute the entries in the gray-tone spatial-dependence matrices, it is necessary to keep only two lines of image data in the core at a time. Thus no severe storage constraints are levied.

In the proposed work Ethan T. Daniels et.al., tried to identify algae concentration [9]. In the field, researchers have invented a suitable handheld device of low price, employing spectro photometry and optical filtering. For a better effort a pattern recognition method for automatic concentration detection was proposed which employs binary classification to distinguish between low and high concentrations. Features for classification were given by calculated spectral peaks, which were RMS value, distance between edges, variance, and energy. It is used in monitoring harmful algal bloom concentration in marine environments to maintain healthy coastal ecosystem and helpful in aquaculture industry.

Umapathy et.al., had come up with an overview for strategies in the recognition of plant leaf disease which is one of the major demanding tasks to eliminate serious outbreak in the area of agriculture [10]. Some researchers used combination of color and texture features to recognize and categorize leaf diseases. One of the challenges in feature extraction based on color requires more time to identify or classify the diseased part is the tricky one. The diseased leaf is not exactly identified from its characteristics so the color feature extraction technique is used to identify the optimum that could differentiate between the target object and background of the leaves. Different color model combinations have been pursued before for extracting the diseased spot from the leaf is discussed here.

Hrishikesh et al. demonstrated about feature extraction of diseases in leaf. An appropriate quality control is basically needed to acquire value added products [11]. One of the most significant factors of such quality is plant disease. This paper exhibits a few essential characteristics of infected leaves that assist to find the plant disease in a precise manner. To begin with, RGB images of leaves are changed over into Hue Saturation Intensity (HSI) color space depiction. Color spaces are changed over from one space to another space effortlessly. After the transformation process, H component is considered to analyze again. S component and I component are omitted since they do not furnish additional details. The values of hue, saturation and intensity can be acquired from RGB color cube,

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

which means that any RGB point could be converted to a matching point in the HSI color model. For segmentation and feature extraction more discriminative image will be helpful, so Hue image is chosen which is more discriminative. To eliminate these unnecessary areas thresholding task is used. Here every single connected component (objects) that has 30 pixels and less is eliminated from a binary image, creating another binary image. Color features from images are taken by summation and averaging technique. The proposed method makes use of leaf features for recognizing disease where feature extraction is made on segmented infected area. Hue image from HSI provides lucid differentiation of diseased portions from healthy portions, and which is further useful for extracting size, color and centroids.

Sridhar et al., discussed elaborately about color and texture based image retrieval in image processing [12]. Due to rapid advancement in worldwide network technology, images have become an important source of information. There is difficulty in recovering required images from the existing set. An intelligent image recommendation scheme, which initially utilizes color histogram feature and GCLM texture feature to pass on image contents, then a kernel based K-means is utilized to group images into different classes by their visual features, finally based on a feature vectors stored in the database the similar images are recovered.

The HSV color histogram is computed and the joint histogram is obtained by combining hue and saturation from which the color feature is extracted. The match between two images is found using chi-square. Likewise global feature is determined from joint histogram. By considering the neighbor pixels, texture feature is estimated using the GCLM technique. The evaluation outcomes show the exactness of the recovery dependent on the accuracy and review false positive and negative proportion. The comparison of efficiency between color, texture and combination of these both is done from the ROC curve. The proposed technique is used to build an interactive similar image retrieval scheme and assess which color or texture feature is the most effective one to portray the similarity of color images.

The joint histogram is determined by utilizing Hue and Saturation Histogram by figuring the complete number of pixels in both Hue and Saturation Histogram. The k-means bunching is made to group the features of the image. The ROC curve is drawn for computing the performance of the feature extraction. The system helps to retrieve the image depending upon color or texture feature from the internet. The effectiveness of extracted features has been measured by precision and recall parameters. Precision is the ratio of appropriate retrieved images to the total number of retrieved images. Recall is the ratio of retrieved relevant images to the total number of relevant images stored in the database. The system portrays the spatial information of colors in an efficient manner.

Fatemeh et. al. proposed a novel technique for color feature extraction depending upon the concept of dynamic color distribution entropy of neighborhoods effectively describing the spatial information of colors [13]. A significant requirement in the image recovery, indexing, classification and clustering is extraction of efficient features from images. Use of color histogram is usual way for representing color feature which is one of the common visual features. A common disadvantage of the color histogram is it does not consider the color spatial distribution. The image retrieval results show the acceptable efficiency. The key objective of the recommended system is to develop dynamic color distribution entropy of neighborhoods (D-CDEN) concept to categorize images depending upon color feature, which is similar to how CDE portrays the spatial information of an image D-CDEN strategy assesses images content and instead of drawing N concentric circles in CDE it uses neighborhoods of pixels for each color bin of image color histogram. This work explains another difference estimating with exhibiting outcomes by image recovery and these outcomes are compared with I-CDE. Because of attending on neighborhoods of color pixels and their numbers, D-CDEN gives better results.

Santhi et.al. confers about the importance, uniqueness, different methodologies and analysis in various image processing strategies [14]. Image denoising of the input image was done by using median filter. Wiener filter was used for neighborhood averaging, the image enhancement was done using median filter and then morphological features were processed for noise elimination. Top-hat filter used corrects the nonuniform illumination. Image segmentation adopts the Canny and Sobel edge detection techniques. In this paper, Prajakta S. Garud et.al, discussed about the detection of plant leaf diseases [15]. The proposed strategy encapsulates the phases of image processing method. These image processing steps are acquiring images with RGB color value, preprocessing task with filter functions, segmentation using k-medoids clustering, feature extraction of statistical texture features, classification process using a Neural network.

III. PROPOSED METHOD

Extracting features is carried out to distinguish between the various images. The species are identified depending on the features like size, shape, colour and texture.

The size feature defines dimensions of an object in image which is one the basic feature of an image. The color is one of the extensively used visual features in image classification.

Shape is a significant visual feature and one of the primary features for image description. Shape description cannot be expressed precisely because assessing the match between shapes is quite challenging task.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

In retrieving images using the shape few steps are very important. They are feature extraction and similarity measurement between the extracted features. Shape descriptors are classified as region-based which makes use of the entire region of an object for shape description and contour based which employs local features as boundary segments.

Texture feature is one more vital characteristic [17] in an image and dominant regional descriptor that facilitate the image retrieval. Texture, on its own does not locate likely images, but it can classify textured images from non-textured images and then unite with the other visual quality such as color and make the recovery more efficient. Textural features are Statistical measures such as Entropy, Homogeneity and Contrast, Wavelets, Fractals.

2.1. Procedure for Feature Extraction

Task of the feature extraction procedure is to transform an image into a set of parameters that will more economically represent the pertinent information in the original image by removing the irrelevant aspects of the image data.

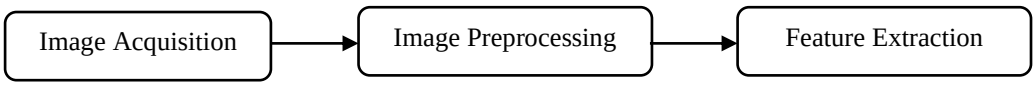

Figure. 1 Basic Diagram of Feature Extraction

Image Acquisition is the first step. Acquisition could be as simple as being given an image that is already in digital form.The input image is captured by a sensor like Camera, and converted to digital image, if the output of the camera or sensor is not in digital form, with ADC. Generally, the image acquisition stage involves preprocessing, such as scaling.

Preprocessing helps to improve the image data by removing unwanted distortions and enhances some of the features relevant for processing further and analysing then it finally brings out the image with good appearance and finer details.

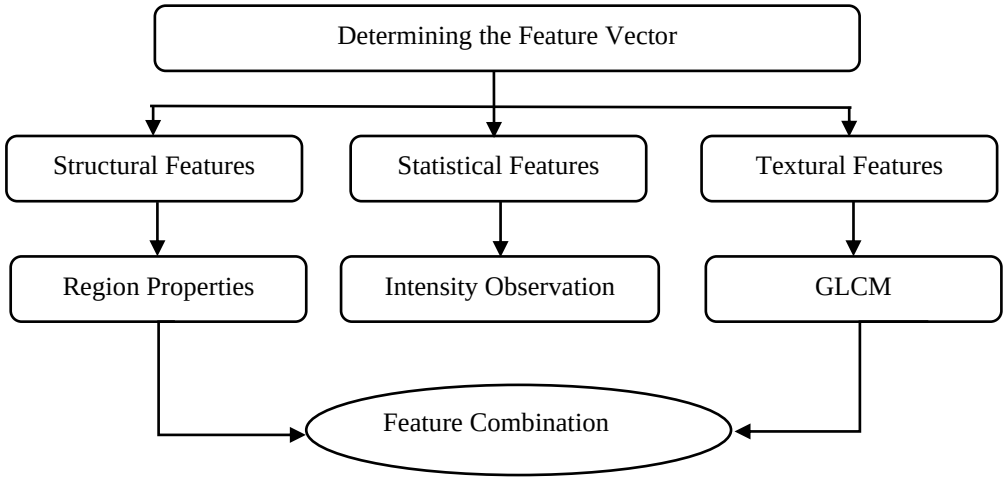

Figure. 2 Taxonomy of Feature Extraction

Feature extraction module extracts the essential features. Information analyzed in the image is the intensity values of the pixels and their spatial inter dependency. Structural Features are Region Properties which includes size, shape and colour, Statistical Features are Intensity Observation which takes the analytical values and Textural Features includes GLCM. These three features determines Feature vector. Any these features or combination of the features helps to identify the species.

The primary objective is generating the features which reveal high level properties such as

- extracting the details from abstract data that is most appropriate to differentiate between classes
- extract features with low within class variability and high between class variability
- discard redundant information.

In most of the methods the colour of the species is ignored because of the climatic conditions and the growth of the species, the features like colour, size and shape may be affected, so mostly the texture feature is considered for identification .

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

A microbiologist usually carries out manual examinations manually for analyzing microscopic images. There are many techniques used to identify the algal species namely DNA Barcoding, Flow Cytometry, Lab onchip and image processing etc.

When compared with biological techniques or methods the image processing technique is cost effective and performs well in very short duration. In identification of algal species by biological methods there is more possibility of human error and uncertainty. It requires a large effort and concentration. Biological techniques are more expensive, highly time-consuming and tedious for achieving good performance while identifying the species. Identification of algal species based on taxonomic level and using in various real time evaluations is highly complicated. This has encouraged developing systems to automate the identification algal images. Various methods used for feature extraction are discussed as a survey in the next sections.

IV. RESULT ANALYSIS

In the current investigation four pyramidal and directional filters of NSCT are mixed and utilized for extracting features which is trailed by feature positioning, that is done by using Fuzzy entropy dependent feature selection method for expelling insignificant and excess features. Later sizes are picked up and seven condensed feature vectors of valid sizes are depicted. Every sized feature vector is used to determine the precision of categorization [1]. The quantity of effectively perceived class instances (genuine affirmatives) and the quantity of accurately perceived examples are processed to access the precision of categorization. The traditional strategy for getting Pap smear is the most profitable and productively utilized procedure, both for genuine victims and for early investigative camps conducted at regular intervals by NGOs and other governing councils . The global features are utilized to help the categorization and enhance the segmentation quality by supplying an extended constancy between pixel markers. The investigative outcomes have revealed nearly 95% of segmentation exactness and approximately 92% mean normal accuracy of the outcomes . The resolved issues are image segmentation coordinated to the considered areas of importance having the microbes; creation of the statistical descriptors associated with the segmented areas of importance, determination of the most significant descriptors as the diagnostic features and lastly the identification of the microbes utilizing few classifier solutions. The projected scheme empowers the identification of the microbes with the precision approximately 98%. This reality affirms the predominance of feature selection in the categorization methodology.

The finest outcomes were achieved with a SVM in segmentation of bacilli related to the usage of the three post-processing filters. An image database is created with 120-sputum smear images from 12 victims with entities labeled as bacilli, clustered bacilli and uncertain elements . The primary methodology is utilizing a solitary object features concluding in low categorization precision. The second methodology is utilizing a combination of several object features concluded in most astounding accuracy of over 90%. Eliminating the strange entities would make the identification scheme more sensible than categorizing them into any inaccurate class. The proposed scheme achieved better recognition accuracy for the photomicrographs, aerial photographic images and satellite images. A class of rapidly processable textural features is depicted here which appear to have general relevance to numerous sorts of images. Extra examinations are needed to decide the span of the subimage area and the distances which ought to be utilized in processing the gray-tone dependence matrices. Every one of these features was chosen since they gave single numerical measurements that could be reliably determined. Random Forest categorization performs extraordinarily for each species. This is promising, however it should to be mentioned that this strategy is computationally costly . The suggested strategy utilizes leaf features for disease recognition where feature extraction is done on segmented affected region. Hue image from HSI gives clear segregation of ailing spots and is increasingly useful for extracting size, shading and centroids . When the client provides the test image, color and texture feature is extracted and is checked for their matching with that of the feature of the images in the database . As a result of taking care of neighborhoods of color pixels and the quantity of them, D-CDEN has better outcomes in the two databases . The computerized recognition rate is expanded by utilizing distinctive segmentation techniques and growing new features for microscopic algae images . Independent unit is conceivable for identifying the infection in leaves .

V.CONCLUSION

In this paper on feature extraction methods using image processing techniques various methodologies have been discussed. Survey is done on technologies which are used in medical field namely in detection of cervical cancer, detection of Bacteria which causes Tuberculosis, identification of microorganisms and detection of leaf diseases. This paper also discusses a few machine learning algorithms. Best results can be obtained by choosing the appropriate techniques to be worked with fewer enhancements or hybrid methods can also be used.

REFERENCES

1. Kangkana Bora, Lipi B Mahanta, and Anup Kumar Das, “Fuzzy NSCT based Feature Extraction Method for Automated Classification of Pap Smear images”, 2018, International Journal of Applied Engineering Research, ISSN 0973-4562, Vol. 13, No. 9, pp. 6709-6716

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

2. Bora K., Chowdhury M., Mahanta L. B., Kundu M. K., Das A. K., "Automated classification of Pap smear images to detect cervical dysplasia", 2017, Computer Methods and Programs in Biomedicine, 138, pp. 137-145.
3. Sergey Kosov, Kimiaki Shirahama, Chen Li, Marcin Grzegorzek, "Environmental microorganism classification using conditional random fields and deep convolutional neural networks", 2018, Pattern Recognition, Vol. 77, pp. 248–261.
4. M. Kruk, R. Kozera, S. Osowski, P. Trzcinski, L. Sas-Paszt, B. Sumorok, B. Borkowski, "Computerized classification system for the identification of soil microorganisms", 2016, Applied Mathematics and Information Sciences, Vol. 10, No. 1, pp. 21–31.
5. C.F.F.C. Filho, P.C. Levy, C.D.M. Xavier, L.B.M. Fujimoto, M.G.F. Costa, "Automatic identification of tuberculosis mycobacterium", 2015, Research on Biomedical Engineering, Vol. 31, No. 1, pp. 33-43.
6. Sansoen Promdaen, Pakaket Wattuya, and Nuttha Sanevas, "Automated Microalgae Image Classification", 2014, Procedia Computer Science, Vol. 29, pp. 1981-1992.
7. Robert M. Haralick, K. Shanmugam, and Its'hak Dinstein, "Textural Features for Image Classification", 1973, IEEE Transactions on systems, man, and cybernetics, pp. 610-621.
8. Chin-Liang Chang, "Piecewise Linear Discriminant functions", IEEE Transactions on Computers, September 1973, Vol. C-22, No. 9, 859.
9. Ethan T. Daniels, Benjamin D. McPheron, "A Machine Learning Approach to Classifying Algae Concentrations", 2017, IEEE MIT Undergraduate Research Technology Conference (URTC).
10. Umapathy Eaganathan, S.Prasanna, Sripriya, "Various approaches of color feature extraction in leaf diseases under image processing: a survey", 2018, International Journal of Engineering & Technology, 7 (2.33), 712-717
11. Hrishikesh P.Kanjalkar, S.S.Lokhande, "Feature Extraction of Leaf Diseases", January 2014, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Vol. 3, Issue 1, ISSN: 2278-1323, PP: 153-155.
12. Sridhar, Gowri, "Color and Texture Based Image Retrieval", January 2012, ARPN Journal of Systems and Software, Vol. 2, No.1, ISSN: 2222-9833, PP: 1-6.
13. Fatemeh Alamdar, Mohammad Reza Keyvanpour, "A New Color Feature Extraction Method Based on Dynamic Color Distribution Entropy of Neighborhoods", September 2011, International Journal of Computer Science, Vol. 8, Issue 5, No.1, ISSN (Online): 1694-0814, pp: 42-48.
14. Santhi N, Pradeepa C, Subashini P, Kalaiselvi S, "Automatic identification of algal community from microscopic images", 2013, Bioinformatics and Biology Insights, 2013 Oct 10;7:327-34. doi: 10.4137/BBI.S12844. eCollection.
15. Prajakta S. Garud , Rajan Devi, "Detection of Diseases on Plant Leaf with the Help of Image Processing", August 2017, International Journal of Engineering Technology Science and Research IJETSR www.ijetsr.com ISSN 2394-3386 Vol. 4, Issue 8.