iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37387

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

A Review on Automatic Soil Classification in Digital Image Processing

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Abstract: ***Soil classification is an essential piece of geology. However, many examinations have assessed the precision and consistency of the soil classification using various techniques. This examination starts by evaluating the verifiable advancement of soil classification science. The verifiable audit contextualizes the wordings and the speculations of soil development factors, which supported soil classification frameworks. This paper is intended to review some research papers on soil classification and analyze the limitations of implemented techniques by their parameters. In the age of digital world, it is beneficial to obtain the information from image without any hassle. Machine learning is an approach through which we can obtain the better level of accuracy and minimize the false alarm rate. But machine learning requires so many samples through which we can observe the correct precision that also requires much storage that may takes much processing time that reduces the feasibility of the system. We have to train a system with limited number of samples with high iterations that produces higher precision rate with minimal errors.***

Keywords: Soil Classification, Support Vector Machine, Image Processing, Soil Analysis, Feature Extraction, Texture Identification, Clustering.

I. INTRODUCTION

It is undeniable statement that land is a significant resource and a way to support job. It is the secret weapon for most human exercises including ranger service, farming, industry, mining, and so forth Land is basic factor of creation firmly connected with the financial development of a country and its kin, nonetheless, as the populace builds, interest for land for use in settlement, development of framework, cultivating and other human exercises additionally increments. As of late the utilization of soil classification has acquired and more significance and ongoing heading in research works demonstrates that picture classification of pictures for soil data is the favored decision. Different strategies for picture classification have been created dependent on various speculations or models. MLC and SVM are hard classification techniques however SP is a delicate classification. Solidifying of delicate classifications for precision eads to loss of data and the exactness may excessive address the strength of class participation. In this manner, in the examination of the strategies, the top 20% creations per soil class of the SP were utilized all things being equal. Results from the dicated that yield from SP was by and large poor in spite of the fact that it performs well with soils, for example, woodland that are homogeneous in character. Of the two hard classifiers, SVM gave a superior yield Soil Classification, Picture Handling, It's anything but an obvious proclamation that 'land is a significant resource and a way to support job'. It is the distinct advantage for most human exercises including ranger service, agribusiness, industry, mining, and so on Land is along these lines a principal factor of creation firmly connected with the monetary development of a country and its people [1]. In any case, as the populace expands, interest for settlement, development of framework, cultivating (horticulture) and other human exercises additionally increments. Fulfilling subsequently, land and its related regular assets like timberland, vegetation, and so forth are being oppressed ceaselessly to changes and t turns influence the biological system. Indeed, even water assets like waterways, streams and wetlands that might be found in regions where such exercises happen are likewise influenced. For instance, when changes happen in vegetation; untamed life environment, fire conditions; an authentic qualities and surrounding air quality, are totally influenced.

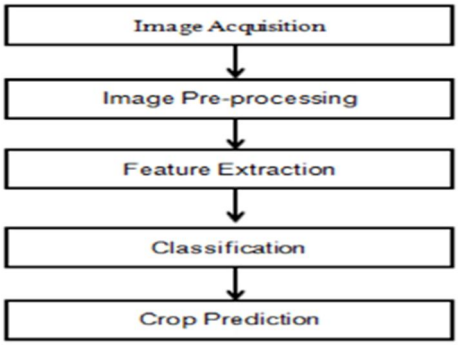

Fig. 1.Soil Classification Steps

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Fig. 1 shows the conventional method for extracting feature or textures. As human and normal powers are changing the scene, asset offices discover it progressively essential to screen and evaluate these adjustments. Land use and soil is hence most significant factor of natural change like deforestation, living space discontinuity, urbanization, and wetland corruption. Soil manages the actual highlights or vegetation as obvious on the land while land use is about what financial movement or utilize the land is put to Exploration in land use. Soil considers have created such a lot of interest locally and universally because of concerns worldwide ashore use. Soil changes and its outcomes to the climate. It has thusly gotten one of the critical components in pictures classification for logical examination and genuine geology applications essentials needed for such investigations are Different techniques are utilized for the creation of these guides, nonetheless, the utilization of far off detecting for map creation is expanding become the moderately modest and fast strategy for procuring up data over an enormous topographical region.

II. LITERATURE REVIEW

A. Related Works

B. Bhattacharya et al. [3] proposed a methodology for computerizing this classification system is introduced. Initially, a division calculation is created and applied to section the deliberate signs. Also, the striking highlights of these sections are removed utilizing limit energy technique. In view of the deliberate information and removed highlights to allocate classes to the fragments classifiers are fabricated; they utilize Choice Trees, ANN and Support Vector Machines. The technique was tried in ordering sub-surface soil utilizing estimated information from Cone Infiltration Testing and acceptable outcomes were acquired. Pramudyana Agus Harlianto et al. [4] proposed a Machine learning calculation that can be applied for mechanizing soil type classification. This paper looks at a few machine learning calculations for arranging soil type. Calculations that include support vector machine (SVM), neural network, choice tree, and credulous bayesian are proposed and surveyed for this classification. Soil dataset is taken from the genuine information. Recreation is controlled by utilizing RapidMiner Studio. The exhibition noticed is the exactness. The outcome shows that SVM, with the utilization of straight capacity kernel, beats the others calculations. The SVM best exactness is 82.35%. P.Bhargavi et al. [5] proposed a use of a hereditary programming framework for classification of choice tree of Soil information to arrange soil surface. The information base contains estimations of soil profile information. We have applied GATree for producing classification choice tree. GATree is a choice tree manufacturer that depends on Hereditary Calculations (GAs). In this paper soil arrangement is performed utilizing GATree, which is a choice tree developer that depends on Hereditary Calculations (GAs). The thought behind it is fairly straightforward however amazing. Rather than utilizing measurement measurements that are one-sided towards explicit trees we utilize a more adaptable, worldwide measurement of tree quality that attempt to streamline exactness and size. GATree offers some special highlights not to be found in some other tree inducers while simultaneously it can create better outcomes for some troublesome issues. GATree utilizes ARFF as its standard source design. An ARFF record is a straightforward book document that portrays the issue cases and its ascribes. By squeezing the Picture Choice Tree button we can envision and cross a ultimate choice tree The measurements tab on the fundamental screen gives a few charts of the advancement cycle. Those diagrams permit us to follow the advancement cycle progressively and find possible issues and patterns. For instance, when the Normal Wellness of the populace will in general be equivalent to the Wellness of the best Genome then there is no place for additional upgrades. An answer here could be to attempt with more ages or greater populace size. The settings tab on the principle screen permits us to control each part of the advancement cycle. There are two kinds of settings; Fundamental settings and progressed settings relying upon their handiness and intricacy. Beneath you can discover a clarification of the offered choices for Soil dataset. The thought behind it is fairly basic yet incredible. Rather than utilizing measurement measurements that are one-sided towards explicit trees we utilize a more adaptable, worldwide measurement of tree quality that attempt to streamline precision and size. GATree offers some interesting highlights not to be found in some other tree inducers while simultaneously it can create better outcomes for some troublesome issues. Trial results are introduced which represent the exhibition of creating best choice tree for grouping soil surface for soil informational collection. Sk Al Zaminur Rahman et al. [6] proposed a model for anticipating soil arrangement and giving appropriate harvest yield idea to that particular soil. The examination has been done on soil datasets of six upazillas of Khulna locale. The model has been tried by applying various types of machine learning calculation. Packed away tree and K-NN shows great exactness however among every one of the classifiers, SVM has given the most noteworthy precision in soil classification. The proposed model is legitimized by an appropriately made dataset and machine learning calculations. The soil classification precision and furthermore the suggestion of yields for explicit soil are more fitting than many existing techniques. In future, giving compost proposal is our anxiety, additionally information of different areas will be added to make this model more solid and precise.

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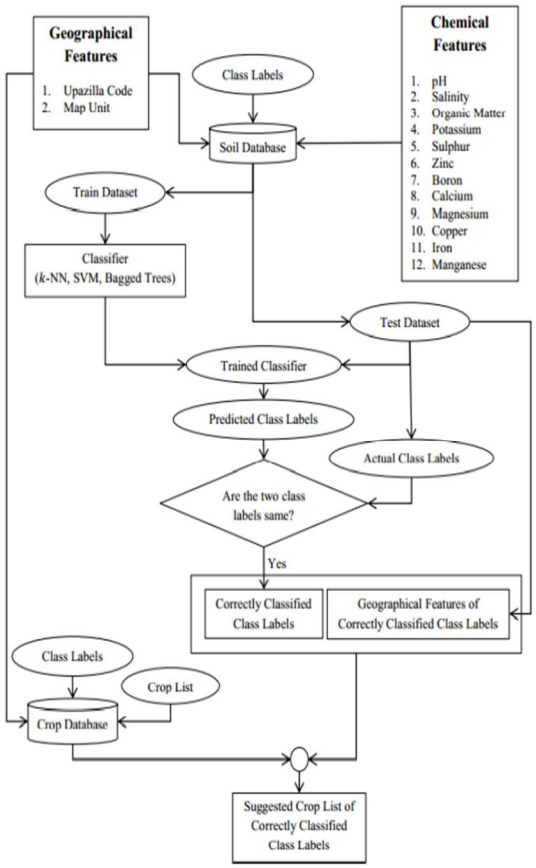


Fig. 2.Proposed System Architecture [6]

The method involves two phases: training phase and testing phase. Two datasets are used: Soil dataset and crop dataset. Soil dataset contains class labeled chemical features of soil. Table I shows the details of the 12 chemical attributes of soil, used in our method. M van Rooyen, N Luwes et al. [7] proposed classification of dynamic soils is a critical part in structural designing ventures. There is a requirement for more precise methods of classification. This paper assesses a hand crafted machine vision classification framework. From writing survey, Stokes' law was distinguished as a potential methodology for the machine vision framework. Stokes' states that the measurement squared of a molecule is straightforwardly relative to the settling speed of the molecule in a liquid. This paper assesses if a force histogram can be utilized as a marker of settling speed. While building the computerized soil classification framework utilizing machine vision it is imperative to control the lighting however much as could be expected. The picture catching box that was built mirrors as minimal light as conceivable within the case where the test tests are found. The case additionally forestalls outside light from meddling with the test. This forestalls conflicting light in the area of interest and is vital for reliable test outcomes. Care ought to be taken when blending the soil so it is done as reliably as could be expected. To build a automated Soil Classification Framework utilizing machine vision, one would require controls tests for alignment. First and foremost, an unadulterated sand test was utilized and examined by the machine vision framework. Tests were blended by adding precisely 50 g of soil to 900 ml of water. Testing was done at room temperature (23oC to 25oC) since temperature additionally assumes a part in the precision of the tests. Prior to testing, the combination was overwhelmingly blended for around 1 moment to ensure it was uniformly spread all through the chamber. The actual estimation was finished utilizing a camera mounted at a fixed distance with backdrop illumination through the chamber, catching the entire molecule settlement measure. A greyscale Basler brilliant organization camera was utilized for picture obtaining. By utilizing greyscale, a higher goal can be accomplished as high goal shading cameras are considerably more costly. The camera was mounted at a fixed distance and point inside an extraordinarily built light verification box to limit commotion from outside sources. Srunitha.k et al. [8] proposed the classifications of non-sandy soils are better ordered with SVM (through WEKA).

Practically all misclassified objects are handed-off close to the portion line. Close to the portion limit Estimations spotted as regularly uproarious and consequently can be concluded that the institution of classifiers was phenomenal. With more information and soil science space explicit tricks, the potential for applying machine figuring out how to soil property expectation would most likely be boosted. It can accomplish a 95% exactness rate for ordering. Binary classifier is utilized to oversee if the dirt sort is sandy. Backing vector machine (SVM) do the grouping of the non-sandy soil. The dirt kinds are better characterized here (with WEKA). Greater part of the misclassified objects are transferred close to the section line. Close to the section limit Estimations spotted as frequently loud and subsequently can be concluded that the institution of the classifiers was astounding.

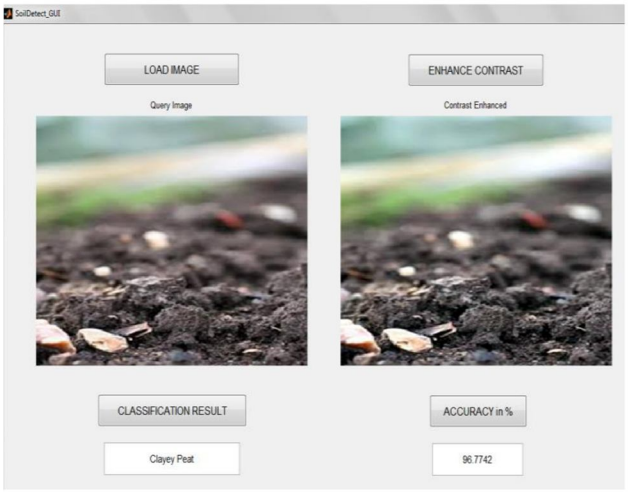


Fig. 3.Proposed GUI [8]

Classification of soil is the disintegration to soil sets to specific gathering having a like qualities and comparable habits. Practically everything nations do item trading, in which those nations sending out higher farming item are especially rely upon the soil attributes. Consequently, soil attributes distinguishing proof and classification is especially significant. ID of the soil type assists with staying away from horticultural item amount misfortune. A classification for designing reason ought to be founded predominantly on mechanical properties. This paper clarifies support vector machine based classification of the soil types. Soil classification incorporates steps like picture obtaining, picture pre handling, highlight extraction and classification. The surface highlights of soil pictures are extricated utilizing the low pass channel, Gabor channel and utilizing shading quantization strategy. Mean plentifulness, HSV histogram, Standard deviation are taken as the measurable boundaries. Hement Kumar Sharma et al. [9] proposed application has more highlights then the current framework like supplements of soil, recommended crop list and proposed urea. These highlights are essential for the laymen ranchers in light of the fact that these are valuable in cultivating and can be see without any problem.

Fig. 4.HSV & Linear SVM based Soil Classification [9]

The proposed application has more features then the existing system like nutrients of soil, suggested crop list and suggested urea. These features are necessary for the laymen farmers because these are useful in farming and can be understand easily. The soil is the just one layer of the earth surface which is essential for the cultivating, planting and ranger service. The cultivating land is diminishing step by step because of industrialization and populace development of any country. It is important to utilize logical technique for cultivating by utilizing most recent innovation like information mining, computerized reasoning, advanced picture handling to make market interest in balance. That is the reason, a few scientists have proposed a few methods to group soil and recommend crop. Be that as it may, they grouped the soil as far as salt, unbiased and acidic. These kinds of classifications are not valuable for rancher since it can't be perceived by ranchers without any problem. A. Bonini Neto et al. [10] proposed a model which depends on ANN and in this examination backpropagation made out of two layers, the center layer and the yield layer, with managed preparing have been utilized. The network has four data sources, that are the actual characteristics of the soil, in the center layer the network contains ten neurons and the yield layer just a single neuron, which has the capacity of educating if the soil was recuperated (R), part of the way recuperated (PR) or not recuperated (NR). The investigated information come from the year 2012, concerning the profundities 0.0 - 0.1 m, 0.1 - 0.2 m and 0.2 - 0.4 m. Thinking about the presentation of ANN, it was confirmed that the network got a sufficient preparing to arrange the corrupted soils, showing low mean square mistake of investigated information. Thusly, ANN is viewed as an intriguing other option and an incredible programmed device to arrange debased soils during recuperation measure.

III. PROBLEM IDENTIFICATION

Sk Al Zaminur Rahman [6] proposed a system that uses machine learning algorithm. It also uses K-NN Classifier for classifying soil textures. Accuracy depends on the quality of the data. With large data, the prediction stage might be slow.

Require high memory – need to store all of the training data. Given that it stores all of the training, it can be computationally expensive. Soil texture is bit complex in nature and hard to specify the pattern and classification is too hard. SVM is the best classifier in soil classification. Certain pre-processing is required to obtain the good accuracy. They have utilized a sacked choice tree outfit classifier (comprising of 30 trees). Stowing creates a bunch of models each prepared on an irregular inspecting of the information (Bootstrap resampling). The forecasts from those models are amassed to create the last expectation utilizing averaging. Two-third of the examples are utilized to prepare the model(s), rest 33% of the examples are utilized to test the models. For accurately characterized tests, crop is suggeted for the relating map unit of comparing upazilla. These two geogrphical includes and proposed crop-list makes the harvest dataset. The all out map units of six upazillas of Khulna area, Bangladesh. In this exploration, they have worked with soils arrangement of six upazillas of Khulna area, Bangladesh. Upazillas are: 'Rupsha', 'Dighalia', 'Fultola', 'Koyra', 'Dakop', 'Terokhada'. There are absolute 15 soil arrangement in this 6 Upazillas.

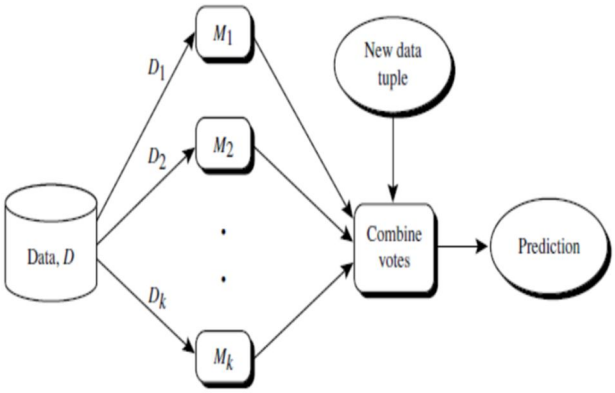


Fig. 5.Ensemble tree [6]

In our work, theyhave worked with 9 soil arrangement; they are 'Gopalpur', 'Isshwardi', 'Ghior', 'Bajoya', 'Barisal', 'Harta', 'Jhalokathi', 'Dumuria', 'Komolkathi'. Consolidating the land type, they get 23 classes which have 438 examples yet they have taken 11 of them which have 383 examples. They have barred different classes since they have not exactly or equivalent 10 examples while other has huge number of tests. That is, class irregularity issue is happened. To eliminate this issue, they expanded our dataset by duplicating the examples of classes which were under tested and haphazardly picked the examples of classes which were over examined. Subsequent to doing that, there were 45 examples of each class and all out 495 examples of 11 classes.

They have made the yield data set by taking the Upazilla code, map unit and class name. Various kinds of harvests fill well in various sort of grounds and soil arrangement of each Upazilla. They have assembled all the data and sort them by Upazilla code, map unit and class names. In this way crop information base is made. Table IV shows some harvest tests that are reasonable for different soil classes of explicit guide units [6].

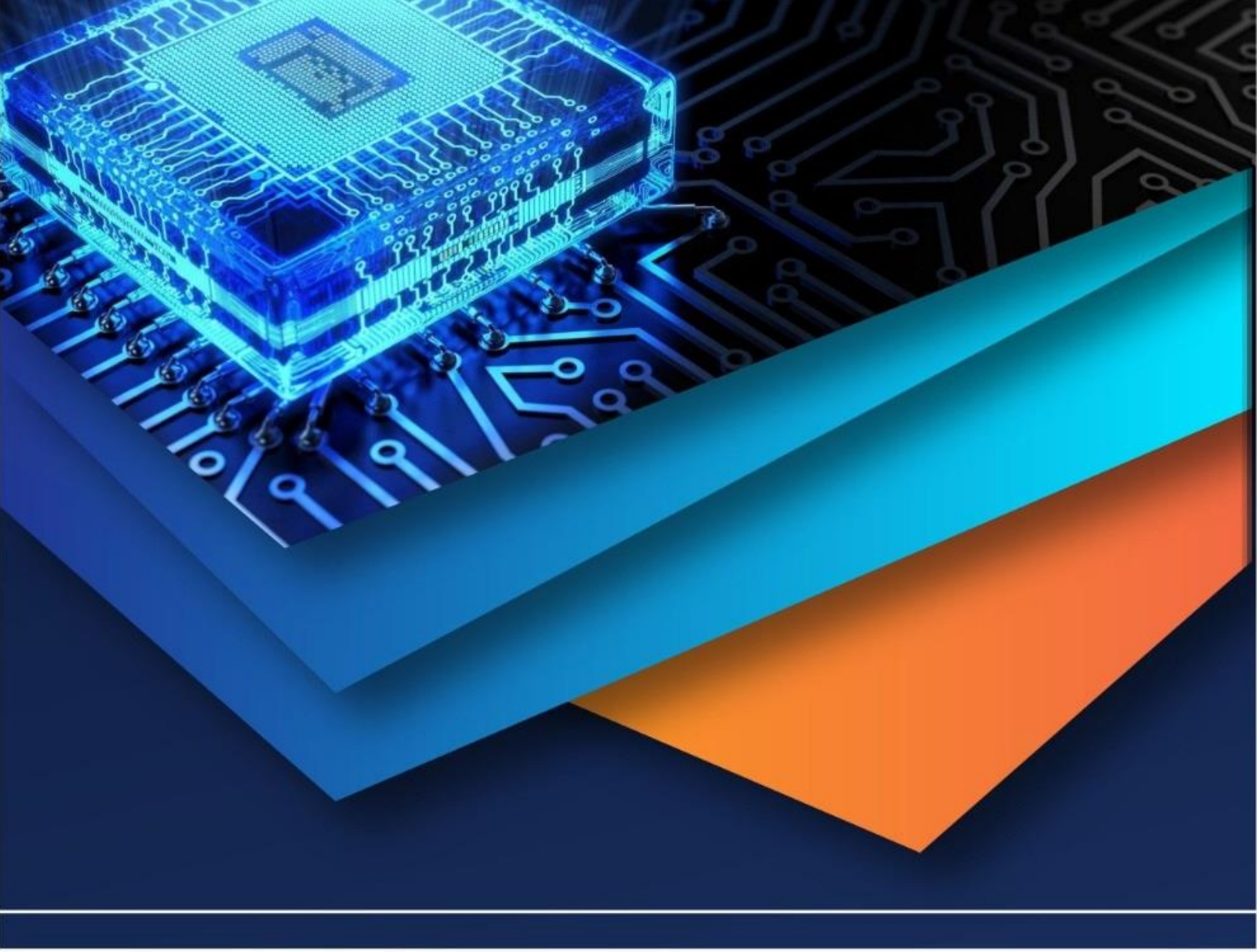
IV. CONCLUSION

This paper reviewed various implemented systems that extract soil's features using SVM, KNN, GAtree, ANN and many more. Most of the system uses machine learning techniques and a training model for creating templates that later match for nearest classification. But there is no appropriate model for feature extraction, instead of that it can be achieved through samples along with various pre-processing models. The extraction of data from studied and ordered soil maps by wanted end-clients have expanded lately because of the significant expense associated with the classification and outlining of such soils by the individual clients, and is likewise a tedious interaction. In certain examples, the end clients don't comprehend the techniques that were utilized in creating the guides, the blunders related with it and the expected limits of use. Information over the course of the years has shown that appraisals contained in some soil maps are not amazing in light of the fact that they are normally founded on restricted information and restricted data. To recognize that soil maps are not liberated from blunders, the vulnerability in the evaluations might be addressed with mistake limits that describe the exactness of the guide. Lately further developed techniques have been presented with high exactness of precision, including the utilization of fake neural organizations, far off detecting and photogrammetric methods, joined with geographic data framework (GIS). In any case, research has shown that, conventional soil review perseveres as the most famous type of soil planning and stock. The need consequently emerges to coordinate and refresh as opposed to overlook the customary soil review procedures for present day insertion methods. The system can be enhanced in future by implementing it with different techniques and filters, which may acquire good accuracy and minimal false alarm rate. Because as per the ideal system, accuracy is an important parameter, that is why accuracy of system can be enhanced in future with different techniques or filters.

REFERENCES

[1] F. Ellis, "The Determinants of Rural Livelihood Diversification in Developing Countries," Agric. Econ., vol. 51, no. 2, pp. 289 2008. 2. H. Nagendra, D. K. Munroe, and J. Southworth, "From pattern to process: landscape fragmentation International Journal of Trend in Scientific Research and Development (IJTSRD).
[2] Chandan and Ritula Thakur. "An Intelligent Model for Indian Soil Classification using various Machine Learning Techniques." (2018).
[3] B. Bhattacharya, D.P. Solomatine, Machine learning in soil classification, Neural Networks, Volume 19, Issue 2, 2006, Pages 186-195.
[4] P. A. Harlianto, T. B. Adji and N. A. Setiawan, "Comparison of machine learning algorithms for soil type classification," 2017 3rd International Conference on Science and Technology - Computer (ICST), 2017, pp. 7-10, doi: 10.1109/ICSTC.2017.8011843.
[5] Bhargavi, Peyakunta & Singaraju, Jyothi. (2010). Soil Classification Using GATree. International Journal of Computer Science and Information Technology. 2. 184-191. 10.5121/ijcsit.2010.2514.
[6] S. A. Z. Rahman, K. Chandra Mitra and S. M. Mohidul Islam, "Soil Classification Using Machine Learning Methods and Crop Suggestion Based on Soil Series," 2018 21st International Conference of Computer and Information Technology (ICCIT), 2018, pp. 1-4, doi: 10.1109/ICCITECHN.2018.8631943.
[7] M. van Rooyen, N. Luwes and E. Theron, "Automated soil classification and identification using machine vision," 2017 Pattern Recognition Association of South Africa and Robotics and Mechatronics (PRASA-RobMech), 2017, pp. 249-252, doi: 10.1109/RoboMech.2017.8261156.
[8] K. Srunitha and S. Padmavathi, "Performance of SVM classifier for image based soil classification," 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), 2016, pp. 411-415, doi: 10.1109/SCOPES.2016.7955863.
[9] H. K. Sharma and S. Kumar, "Soil Classification & Characterization Using Image Processing," 2018 Second International Conference on Computing Methodologies and Communication (ICCMC), 2018, pp. 885-890, doi: 10.1109/ICCMC.2018.8488103.
[10] A. Bonini Neto, C. dos Santos Batista Bonini, B. Santos Bisi, A. Rodrigues dos Reis and L. F. Sommaggio Coletta, "Artificial Neural Network for Classification and Analysis of Degraded Soils," in IEEE Latin America Transactions, vol. 15, no. 3, pp. 503-509, March 2017, doi: 10.1109/TLA.2017.7867601.
[11] Koresh, Mr H. James Deva. "Analysis of Soil Nutrients based on Potential Productivity Tests with Balanced Minerals for Maize-Chickpea Crop." Journal of Electronics 3, no. 01 (2021): 23-35.
[12] Joe, Mr C. Vijesh, and Jennifer S. Raj. "Location-based Orientation Context Dependent Recommender System for Users." Journal of trends in Computer Science and Smart technology (TCSST) 3, no. 01 (2021): 14-23
[13] G. Huluka and R. Miller, "Particle size determination by hydrometer method.," Southern Cooperative Series Bulletin 419, pp. 180-184., 2014.
[14] D. L. Rowell, Soil science: Methods & applications., Routledge, 2014.
[15] P. R. Day, "Particle fractionation and particle-size analysis.," Methods of soil analysis. Part 1, pp. 545-567, 1965 .
[16] W. W. Rubey, "Settling velocity of gravel, sand, and silt particles.," American Journal of Science, vol. 148, pp. 325-338, 1933.
[17] L. Beuselinck, "Grain-size analysis by laser diffractometry: comparison with the sieve-pipette method.," Catena, pp. 193-208, 1998.
[18] P. K. Monye, P. R. Stott and E. Theron, "Assessment of reliability of the hydrometer by examination of sediment.," in Proceedings of the 1st Southern African Geotechnical Conference., Sun City, South Africa., 5-6 May 2016.
[19] B. G. Batchelor, Machine Vision Handbook, Springer, 2017.

[20] P. R. Stott and E. Theron, “Shortcomings in the estimation of clay fraction by the hydrometer.,” Journal of the South African Institution of Civil Engineering, vol. 58, pp. 14-24, 2016.
[21] V. Sudharsan and B. Yamuna “Support Vector Machine based Decoding Algorithm for BCH Codes” Journal of Telecommunication and Information Technology 2016.
[22] B. Bhattacharya, and D.P. Solomatine "An algorithm for clustering and classification of series data with constraint of contiguity", Proc. 3T"d nt. Conf: on Hybrid and Intelligent Systems, Melboume, Australia, 2003, pp. 489-498.
[23] Unmesha Sreeveni.U .B, Shiju Sathyadevan “ADBF Integratable Machine Learning Algorithms –Map reduce Implementation” Second International Symposium on computer vision and the Internet(VisionNet’15).
[24] A.Coerts, Analysis of Static Cone Penetration Test Data for Subsurface Modelling - A Methodology (PhD Thesis),Utrecht University, The Netherlands, 1996.
[25] L.F. Costa, and R.M. Cesar, Shape Analysis and Classification: Theory and Practice, Boca Raton, Florida: CRC Press, 2001.
[26] S. Haykin, Neural Networks: A Comprehensive Foundation, New Jersey: Prentice Hall, 1999.
[27] Gordon, A.D. "A survey of constrained classification", Computational Statistics & Data Analysis, vol. 21, pp. 17-29, 1996.
[28] D.M. Hawkins, and D.F. Merriam, "Optimal zonation of digitized sequential data", Mathematical Geology, vol. 5, pp. 389-395, 1973.
[29] C.H. Juang, X.H. Huang, R.D. Holtz, and J.W. Chen, "Determining relative density of sands from CPT using fuzzy sets", J. of Geotechnical Engineering, vol. 122(1), pp. 1-6, 1996. G.P. Huijzer, Quantitative Penetrostratigraphic Classification (PhDThesis), Free University of Amsterdam, The Netherlands, 1992.
[30] M.G. Kerzner, Image Processing in Well Log Analysis, Dordrecht,The Netherlands: Reidel Pub., 1986.
[31] J. K. Kumar, M. Konno, and N. Yasuda,"Sub surface soil-geology interpolation using fizzy neural network", J. of Geotechnical and Geoenvironmental Engineering, ASCE, vol. 126(7), pp. 632-639, 2000.
[32] L.J. van Vliet, and P.W. Verbeeck, "Curvature and bending energy in digitised 2D and 3D images", in: K.A. Hogda, B. Braathen and K.Heia (Eds), Proc. 8" Scandinavian Confon Image Analysis, Norway,1993, vol. 2, pp. 1403-1410.
[33] R. Webster, "Optimally partitioning soil transects", Journal of Soil Science, vol. 29, pp. 388402, 1978.
[34] I.H. Witten, and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufimann, 2000.
[35] H.J.T. Weerts, Complex Confining Layers, Utrecht University, The Netherlands, 1996.
[36] I.T. Young, and T.W. Calvert, "An analysis technique for biological shape", Information and Control, vol. 25, pp 357-370, 1974.
[37] P. R. Stott and E. Theron, “Some shortcomings in the standard South African testing procedures for assessing heaving clay,” Journal of the South African Institution of Civil Engineering, vol. 57 No 2, no. June 2015, pp. 36-44, 2015.
[38] Z. Zhang, and M. T. Tumay, "Statistical to fuzzy approach toward CPT soil classification", J of Geotechnical and Geo environmental Engineering, vol. 125(3), pp. 179-186, 1999.



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