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FPGA Implementation for Advanced Image Processing Algorithm-Based Cotton Plant Disease Detection

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Research Article

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ABSTRACT

Pests that disrupt the roots and leaves of Indian crops are the main cause of their problems. Plant diseases can harm crops and result in financial losses. Improvements are thus required to reduce plant diseases by early detection, which leads to increased productivity. Every year, a large amount of produce is squandered due to the quick invasion of pests and other insects. Due to the wide range of symptoms associated with the diseases, diagnosing infected cotton plants is quite challenging. In this study, we identified the kind of disease and pest in cotton plants using a novel method. Images of diseased leaves will be pre-processed first. After then, images are subjected to edge detection. Advanced fuzzy K-means clustering will be used to segment the edge-detected pictures. After that, the leaf picture's color, correlation, entropy, and texture features—such as energy, contrast, and edges—will be retrieved and compared to a typical cotton leaf image. Ultimately, the precise illness will be shown. Thus, the diagnosis is rather simple. When compared to other methods, the suggested method is very sophisticated and reduces analysis time by 40% when compared to C-means and 52% when compared to K-means clustering. The Matlab IDE is used to write and simulate the code.

KEY WORDS: Matlab, K-means and C-means clustering, cotton plants, and segmentation.

INTRODUCTION

In maximum image signaling methods, this procedure is crucial. The image is digitally separated if you look at these many sections. Researchers who create such images provide a number of visual signaling strategies that Swash finds simple to evaluate. These serial processors' parallel algorithms struggle with the method. The primary picture signaling approaches connect algorithms on hardware devices are reviewed in a new article that aims to move on.

It is evident from tracking and connecting cells [1] that the Viterbi algorithm provides the foundation for the explanation of the tracks in [2]. Various methods of cell signaling were discussed [3]–[5]. Migration is crucial in the study of cancer Morfalwaji [12] [13], Ambreognisas [14] [15], stem cells [16]–[18], and many other aspects of cell and developmental biology. Time lapse microscopy value and extract [6] can be used to quantify many different aspects of cell behavior, such as [7] [8] (cell division) and Mitosis Apoptosis (cell death). [9] In the first pieces [14] By using hand sketches or circumstances where the primary unit of interest in a plane of record qualities was consistently in the same location, the cell transmitted microscopes and the images were viewed in the right places. Since these phones may detect an opportunity for the cors and four fluorescent proteins or color, as well as skkisance for the use of 2-D or 3-D photos of the camera to capture the indent A chance, a variety of supporting microscopy strategies are now needed. Even if these findings are the appeal of the representative who may create these four subjective wants, the manual can be completed by test run and utilized by the largest, most challenging, reproducible. Due to these factors, either a large-scale operation or the Robotheid semi-Robotheid system of interest will be carried out. It was indicated clearly in the study of several algorithms [19].authorization, search, medical monitoring, a process picture area,

machine-driven business evaluation and many aspects of our everyday lives, such as the dynamic location and the always expanding flood of apps. Additionally, it is identified as an entirely distinct picture and object for the request. In this method, common-purpose programs are performed on a PC that is often easy, but the time is not validated because of eventual limitations on various memory and blond preferred devices.

The most significant sources of human security and

nutrition are agricultural fields. It is crucial to human survival and food consumption, but it also plays a significant part in the nation's economy. However, it tends to produce agricultural products that are problematic in terms of both the amount and quality of plant diseases. Due to the fast changes in the environment and insects, there are many significant issues that need to be addressed in order to improve productivity. Today's farmers must lower the unexpected amount of insects. Millions of dollars are spent on crops, agricultural production, and excellent, healthy production [20] all over the globe. It is important to protect crops against bio-insect pests like wrongdoers that may otherwise cause extensive damage and crop loss. For example, India loses over Rs. 90,000 million [21] in agricultural output annually as a result of insect infestations, accounting for roughly 18% of the total. In the past, manual methods have been employed to monitor black light traps, sticky traps, and insects to locate forms. The use of time for insects to determine a human's availability and manual monitoring methods are both subjective to the expert. is often seen on the trunks of insects, plant diseases, or addresses. Therefore, a crucial factor in the effective development of crops is the plant, its leaves, insects, illnesses, incidents, assaults, and the percentage of symptoms. Generally speaking, there are two kinds of plants that may cause death and devastation. agents that are nonalawang (abaotek) and living (biotic) [22]. Identification techniques for various illnesses have been covered [in 23–28].

It is a concern because of the chip fabric that was made around it. According to Isak, there are ten different kinds of hardware devices and a PC between design and display. Ten For the greatest presentation, this software often requires a dedicated laptop computer running C or assembly code. For the scientific study of nature, which is undergoing rigorous work, it is a highly complicated picture. Hardware design electronic retention, but less often than the desire to discover that an alternative route's design curve is higher on an FPGA technology, such as equality and pipelining, which is the design of specialized DSP capacity. Rikonforabla's image processing methods for the market value of hardware downtime enable quicker and easier Potting complicated troubleshooting and testing. Therefore, FPGAs are the system that uses the real-time image processing alternative.

METHODOLOGY

K-MEANS ALGORITHM

Here we discuss clearly about the basic structure of K-means clustering. Let $A=\{ai|\ i=1,\ldots,f\}$ be attributes of *f*-dimensional vectors and $X=\{xi \mid i=1,\ldots,N\}$ be each data of *A*. K-means clusters which X is SK = {Si | I 1, b..., = k} where M is mi εx = {M = 1, n (SI), the... J |} SI members, where $n(si)$ is number of members for *si*. Each cluster has cluster center of $C=\{ci \mid i=1,\ldots,k\}$. The following steps will be involved in the K-means clustering algorithm [29-31]

1. Generate the random starting points with centroids C.
2. By utilizing the Euclidean separation discover the separation d between X to C.
3. Ascertain the base d(xi,C) from the partition of xi for i=1...N into.
4. Ascertain the new centre ci for i=1...k characterized as:

$$Ci=\frac{1}{ni}\sum_{j=1}^{n(si)} mij \in si$$

5. Rehash the procedure stage 2 until the point that all centroids are concurrent.

The centroids, in case if they do not change their position then they will be said as converged in a particular cycle. It additionally may stop in the t emphasis with a threshold ε if those positions have been refreshed by the separation underneath ε:

$$c^t \quad \left| c^t - c^{t-1} \right| < \varepsilon$$

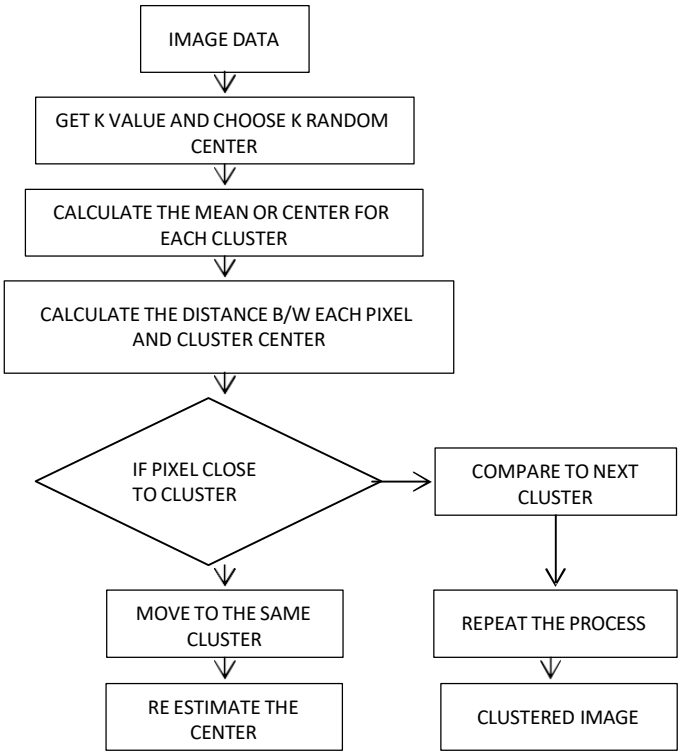


Fig. 1. K –means clustering algorithm

A. FUZZY C-MEANS CLUSTERING

Each pixel value uses fuzzy logic to handle data via partial membership in reflection. The set value's fuzzy membership ranges from 0 to 1. In essence, the fuzzy cluster permits multi-value logical values, like the intermediate I. E., a member of the same member may be placed in fuzzy sets that are blurry. Complete membership; non-membership occurs during any unsuccessful transfer. The Buddha figure serves as both an image of a fosaniss function and a membership in information that has to be defined. Three major characteristics comprise the membership function in question. They have limitations and assistance. The core member is configured to be totally opaque. The subscription is a border with a value between 0 and 1, and it is supported by a non-intermediate or partial subscription [31].

Fuzzy clusters, obscure logic, just one degree away from a cluster at every cluster site. The cluster is on the periphery of the cluster, with fewer points than points. Each point x is given status as we are in the kth cluster$uk(x)$ digital head. The contribution coefficient for any given x 1 is usually clear:

$$\forall x \left(\sum_{k=1}^{\text{num. clusters}} u_k(x) = 1 \right).$$

Fuzzy c-means clustering, which kantroad all points with a cluster of his degree of leverage over it, means:

$$\text{center}_k = \frac{\sum_x u_k(x)^m x}{\sum_x u_k(x)^m}.$$

The distance to the cluster center is related to the inverse state:

$$u_k(x) = \frac{1}{d(\text{center}_k, x)},$$

Then coefficients is a true parameter to fosifed distribution > 1 Sotheiris 1.

$$u_k(x) = \frac{1}{\sum_j \left(\frac{d(\text{center}_k, x)}{d(\text{center}_j, x)} \right)^{2/(m-1)}}.$$

For coefficients to equal their money to 1 along a linear normalization, the equivalent is 2 m. Similar to the K-means method, the cluster nearest to the center at a distance of 1 m is much more weighted than the others.The fuzzy c-means method is comparable to the K-means algorithm:

Choose how many clusters you want.

Lakki coefficients are the clusters that are allocated to each endpoint.

Calculate kanterwads for each cluster using the preceding formula. Repeat procedure (i.e., the modification of the threshold of coefficients sensitivity between two atratance is from someone else).

Determine their coefficients for every cluster site using the given procedure.

K-means for intra-cluster analytics are lower than the algorithm, but there are still issues, such as at least one local minimum based on weights and the initial results selection. In a more ordered fashion, the statistics algorithms Mksmyazaon demand some of the following to be views: Partial membership in classes. They are aware that they have prioritized qualities and basic fuzzy-C-means.

I. PROPOSED SEGMENTATION METHOD

We suggested our hybrid fuzzy K-means cluster abbreviation (AFKM) in this section. First, the typical preprocessing method for digital images is to employ filters to reduce noise and enhance image quality. The product of the first phase will then be able to identify the margins of the image, and then it's K-i.e. the Segmented generated mines of the cluster: image. Now, the fuzzy cluster signaling accuracy and precise detection of the cancer of the capsule will be applied to the product of MR images with the improve K-roots. The tumor's size will be determined. The algorithm that steps up for the proposed system is shown in the diagram of a block.

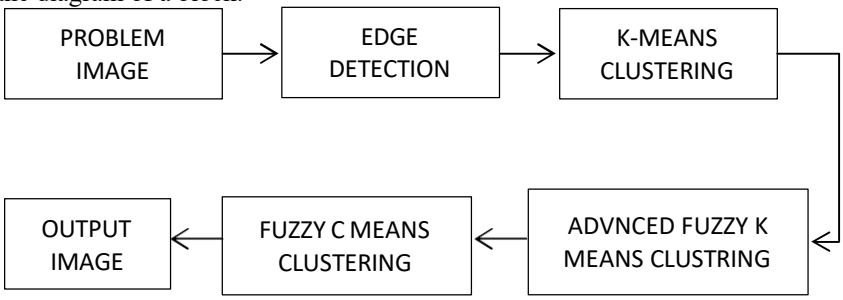


Fig. 2. Proposed system block diagram

II. SIMULATION RESULTS

In contrast to previous systems, we have to keep track of disease-affected leaves in a database. MATLAB R2014a, which operates on Windows 7, 8, and 10, is used to create experiment modules for identified phyto-pathological issues. For the experiment, two kinds of samples are collected, and a camera takes digital pictures of them. The species type and leaf count for these species are shown in Figures 3 through 7.

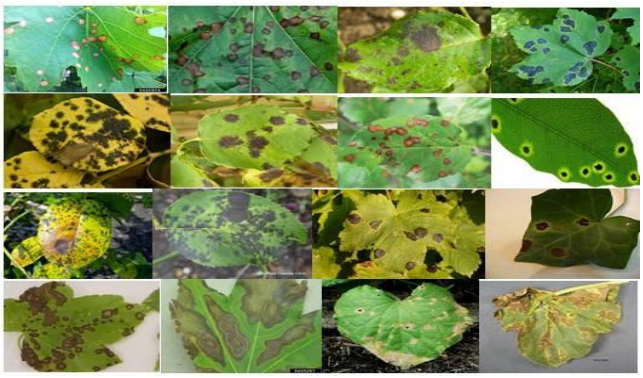


Fig.3 dataset used for disease identification

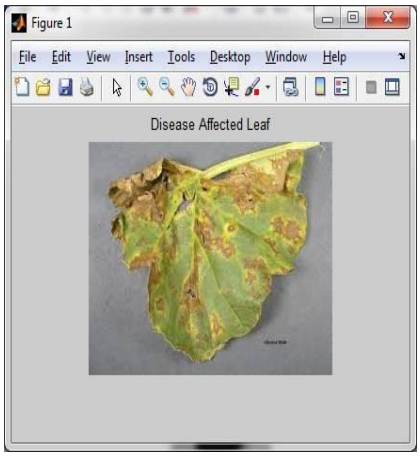


Fig.4 Disease affected leaf from the dataset

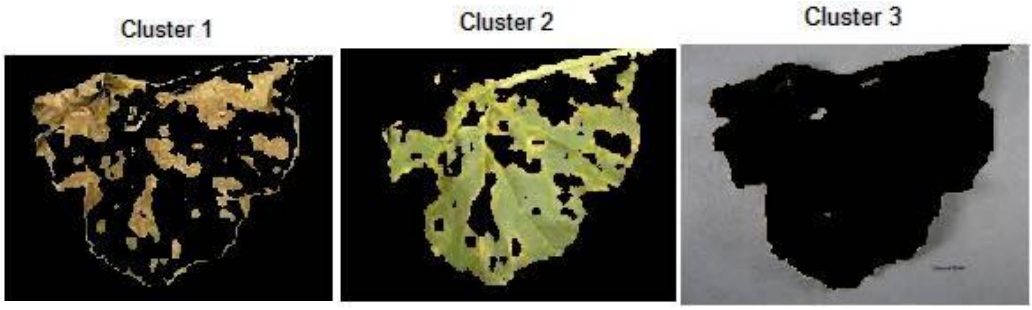


Fig.5 Cluster indexes after segmentation process



Fig.6 Select the cluster index in which the disease is presented

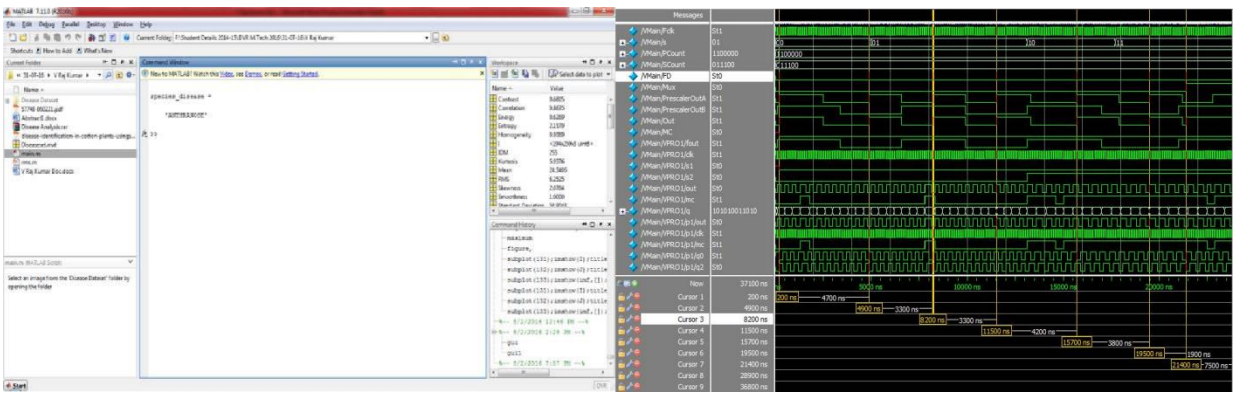


Fig. 6.Output wave forms in modelsim

Fig. 7. Snapshot of MATLAB environment after the execution of program

Table I represents the power results generated in the Xilinx. We use Spartan 3 as FPGA tool for the execution.

TABLE I

Design Parameters	**This work**
Process (μM)	0.18
Supply Voltage(V)	1.5
Maximum Frequency (GHz)	5
Power	0.060(μW)

CONCLUSION

In this publication, we presented our work on employing an advanced segmentation algorithm to distinguish between healthy and unhealthy cotton fields. In this research, K-means clustering applications have been developed for the classification and clustering of plant leaf diseases. The goal of the suggested approach is often to identify the illness. As a result, two plant diseases—leaf spot and leaf miner—were used to evaluate the suggested method. These characteristics are crucial for the color and shape of the leaf spots and provide vital details about how they are represented visually. We can easily extract the characteristics of the sick leaf from the picture by utilizing the segmentation approach. A novel method for first identifying the edges, which is The suggested system outperforms the current methods.Different neural network topologies may be used for categorization in future research. We might expand this project to categorize the symptoms of diseases affecting fruits, vegetables, commercial crops, etc. We can work toward a better application, such as creating a website where anybody can submit a picture and discover the complete details of the ailment. what they do with their harvests and farms. What are the benefits and drawbacks of this illness, and how should it be managed

REFERENCES

[1] [1]Klas E. G. Magnusson*, IEEE Student Member, Joakim Jaldén, Senior Member, IEEE, Penney M. Gilbert, and Helen M. Blau, "Global Linking of Cell Tracks Using the Viterbi Algorithm," IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 34, NO. 4, APRIL 2015 [2]K. S. Arunlal1 and Dr. S. A. Hariprasad2, International Journal of Advanced Information Technology (IJAIT), Vol. 2, No. 1, February 2012.

[2] [3]Desai Vihangi Hiren, "Automated blood cell segmentation using fuzzy based system," IEEE Transactions on Medical Imaging, November 22, 2017.

[3] [4] "Automated Cell Segmentation for Quantitative Phase Microscopy" by Nathan O. Loewke, Sunil Pai, Christine Cordeiro, Dylan Black, Bonnie L. King, Christopher H. Contag, Bertha Chen, Thomas M. Baer, and Olav Solgaard, IEEE Transactions on Medical Imaging, November 22, 2017.

[4] [5] Haiyong Zheng, Nan Wang, Zhibin Yu, Zhaorui Gu, and Bing Zheng, "Robust and automatic cell detection and segmentation from microscopic images of non-setae phytoplankton species," IET Image Processing, Volume 11, Issue 11, 11 2017.

[5] [6]D. H. Rapoport, T. Becker, A. M. Mamlouk, S. Schicktanz, and C. Kruse, "A novel validation algorithm allows for automated cell tracking and the extraction of biologically meaningful parameters," PLoS One, vol. 6, no. 11, p. e27315, 2011.

[6] [7]B. Neumann, "Cell division genes are revealed by phenotypic profiling of the human genome by time-lapse microscopy," Nature, vol. 464, no. 7289, pp. 721–727, 2010.

[7] [8]S. Huh, S. Eom, R. Bise, Z. Yin, and T. Kanade, "Mitosis detection for stem cell tracking in phase-contrast microscopy images," in IEEE Int. Symp. Biomed. Imag. From Nano to Macro, 2011, pp. 2121–2127.

[8] [9] Cell, vol. 44, no. 6, pp. 817–829, 1986; H. M. Ellis and H. R. Horvitz, "Genetic control of programmed cell death in the nematode C. elegans."

[9] [10] Automatic cell tracking applied to investigation of cell movement in wound healing experiment, R. Bise, T. Kanade, Z. Yin, and S.-I. Huh, Proc. IEEE Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., 2011, pp. 6174–6179.

[10] [11]D. H. Theriault, M. L. Walker, J. Y. Wong, and M. Betke, "Cell morphology classification and clutter mitigation in phase-contrast microscopy images using machine learning," Mach. Vis. Appl., vol.23, no. 4, pp. 659–673, 2012.

[11] [12]X. Chen, X. Zhou, and S. T. Wong, "Automated segmentation, classification, and tracking of cancer cell nuclei in time-lapse microscopy," IEEE Trans. Biomed. Eng., vol. 53, no. 4, pp. 762–766, April 2006.

[12] [13]F. Li, X. Zhou, J. Ma, and S. Wong, "Quantitative cancer cell cycle analysis using integer programming for multiple nuclei tracking," IEEE Trans. Med. Imag., vol. 29, no. 1, Jan. 2010, pp. 96–105.

[13] [14]J. E. Sulston, E. Schierenberg, J. G. White, and J. Thomson, "The nematode Caenorhabditiselegan's embryonic cell lineage," Dev. Biol., vol. 100, no. 1, pp. 64–119, 1983.

[14] [15] P. J. Keller, A. D. Schmidt, J. Wittbrodt, and E. H. Stelzer, "Scanned light sheet microscopy reconstruction of zebrafish early embryonic development," Science, vol. 322, no. 5904, pp. 1065–1069, 2008.

[15] [16] Continuous single-cell imaging of blood production from hemogenic endothelium, H. M. Eilken, S.-I. Nishikawa, and T. Schroeder, Nature, vol. 457, no. 7231, pp. 896–900, 2009.

[16] [17] Substrate elasticity controls skeletal muscle stem cell self-renewal in culture (P. M. Gilbert et al., Science, vol. 329, no. 5995, pp. 1078–1081, 2010).

[17] [18]R. Bise, K. Li, S. Eom, and T. Kanade, "Reliably tracking partially overlapping neural stem cells in DIC microscopy image sequences," MICCAI Workshop OPTMHisE, 2009, pp. 67–77.

[18] [19] Akhilesh Arora and Tayeba Qazi, "Computer Vision Based Tracking Of Biological Cells-A Review," International Conference of Advance Research and Innovation (ICARI-2014). [20]D. Lisin, M. Mattar, M. Blaschko, E. Learned-Miller, M. Benfield, "Combining local and global image features for object class recognition" Computer Vision and Pattern detection-Workshops, 2005; ISBN 978-93-5156-328-0.

[19] [21]B. Adsule, J. Bhattad, "Leaves Classification Using SVM And NN For Disease Detection" International Journal of Innovative Research in Computer and Communication Engineering, vol. 3, no. 6, pp. 5488-5495, 2015.

[20] [22] "Plant Disease Detection Using Leaf Pattern: A Review" by S. Vishnu and A. Ranjithram, International Journal of Innovative Science Engineering & Technology, vol. 2, no. 6, June 2015.

[21] [23] "Disease Detection of Cotton crop using Image Processing Technique: A Survey" by D. Naik and A. Vyavahare, International Journal for Research in Applied Science & Engineering Technology (IJRASET), vol. 3, no. VI, 2015.

[22] [24] "Svm-Based Classifier System For Recognition Of Cotton Leaf Diseases" by P. Rothe and R. Kshirsagar, International Journal of Emerging Technologies In Computational And Applied Sciences (Ijetcas), pp. 427-432, 2014

[23] [25] "Classification of Cotton Leaf Spot Diseases Using Image Processing Edge Detection Techniques" by P. Revathi and M. Hemalatha, Emerging Trends in Science Engineering and Technology (INCOSET) 2012 International Conference, pp. 169-173, 2012.

[26] S. Patil, R. Zambre, "Classification Of Cotton Leaf Spot Disease Using Support Vector Machine" International Journal of Engineering Research, vol. 3, no. 4, pp. 1511-1514, 2014.

[24] [27] V. Chaudhari and C. Y. Patil, "Disease Detection Of Cotton Leaves Using Advanced Image Processing," International Journal of Advanced Computer Research, vol. 4, no. 2, pp. 653, 2014.

[25] [28] S. Arivazhagan, R. NewlinShebiah, S. Ananthi, S. Varthini, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features," Commission Internationale du Genie Rural (CIGR) journal, vol. 15, no. 1, pp. 211-217, 2013.

[26] [29]Shi Na, Liu Xumin, and Guan Yong, "Research on k-means Clustering Algorithm: An Improved k-means Clustering Algorithm," Third International Symposium on Intelligent Information Technology and Security Informatics, IEEE, April 2-4, 2010.

[27] [30] "The improved research on k-means clustering algorithm in initial values," Liu Guoli, Wang Tingting, Yu Limei, Li Yanping, and Gao Jinqiao, Proceedings 2013 International Conference on Mechatronic Sciences, Electric Engineering, and Computer (MEC), December 20–22, 2013.

[28] [31] Lin Zhu, Fu-Lai Chung, and Shitong Wang, "Generalized Fuzzy C-Means Clustering Algorithm With Improved Fuzzy Partitions," IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), Volume: 39, Issue: 3, June 2009.