Image recognition (Soil feature extraction) using Metaheuristic techniques and Artificial neural network to find optimal output

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Abstract: Metaheuristics are a branch of stochastic optimization, which is a method for finding the best answer to a problem. If conventional optimisation strategies—like gradient ascent—are unsuccessful, researchers will typically resort to metaheuristic approaches. If an algorithm is trained to use a metaheuristic approach, it will be able to recognise a good solution when it sees one, even if the algorithm does not know what makes a solution excellent. When the issue space is broad or complicated, these methods shine because they can efficiently test a wide variety of options.

Several methods, such as data mining, AI, and machine learning, may be used to make estimates of the bio-ecological quality of soil. Using criteria including texture and segmentation, these methods may examine photographs of soil sections to determine the level of soil fertility.

Factors like air and soil temperature are used to determine the optimal soil type for a certain crop. Finding the best answer to this problem may be done with the help of population-based metaheuristic algorithms like evolutionary algorithms, swarm intelligence algorithms, physics-based algorithms, and bio-inspired algorithms.

When applied to difficult or massive situations, metaheuristic approaches can improve the efficiency and precision of soil analysis and crop selection.

Keywords: Stochastic optimization, Metaheuristics, tabu search

Introduction: Image processing is done in several steps: image capture, in which the image is pulled from the source based on the hardware; image enhancement, which involves reducing noise and adjusting contrast and brightness; and image repair, in which the image is brought back to a level that is close to the original. The next step in image processing is wavelets and multiresolution processing, which deals with figuring out the time-frequency information of a picture. For a picture to take up less room and use less bandwidth, it is compressed. A very important part of processing images is figuring out where the edges of the picture are. Then, the picture is shown in a way that depends on different things, such as how the boundary is shown or how the area is shown with a focus on internal attributes. During image segmentation, the picture is split into parts that don't meet and have the same visual features. Almost all computer vision systems use segmentation, at least during the pre-processing stage, and segmentation is used in many real-world applications, such as medical imaging, object detection, traffic control systems, and video surveillance. When you think about how hard, time-consuming, arbitrary, and error-prone hand segmentation can be, it becomes clear how important it is to find ways to automate correct segmentation. Segmentation is mostly based on different methods that deal with image intensity, edges, regions, and shapes, among other things. There are several ways to pull features from a picture of soil. These features are used to figure out the soil's properties, which include its color, texture, and ability to hold water. Another property is the soil's texture, such as sand, silt, or clay. The size, amount, and connections between pores are all affected by the makeup and structure of the soil. Clay dirt can hold more than other types. The amount of salt or organic matter in the soil affects its chemical properties. Images of the dirt are used to figure out these qualities and find the best result. There are many ways to solve a problem, and metaheuristics are a set of general-purpose random techniques made to solve hard planning problems. These algorithms, which guide a search process through the solution space, are usually non-deterministic and approximate. They are general-purpose algorithms, as opposed to methods made specifically for certain types of optimisation tasks. They don't need to know anything about the problem's structure beyond the objective function or a sample of it (training set) when the optimisation process is based only on empirical observations. Metaheuristics stand out because they are reliable and can use the information they gather about a search space that hasn't been looked at yet to steer a future search towards useful subspaces.

Mythology

Process of digital images

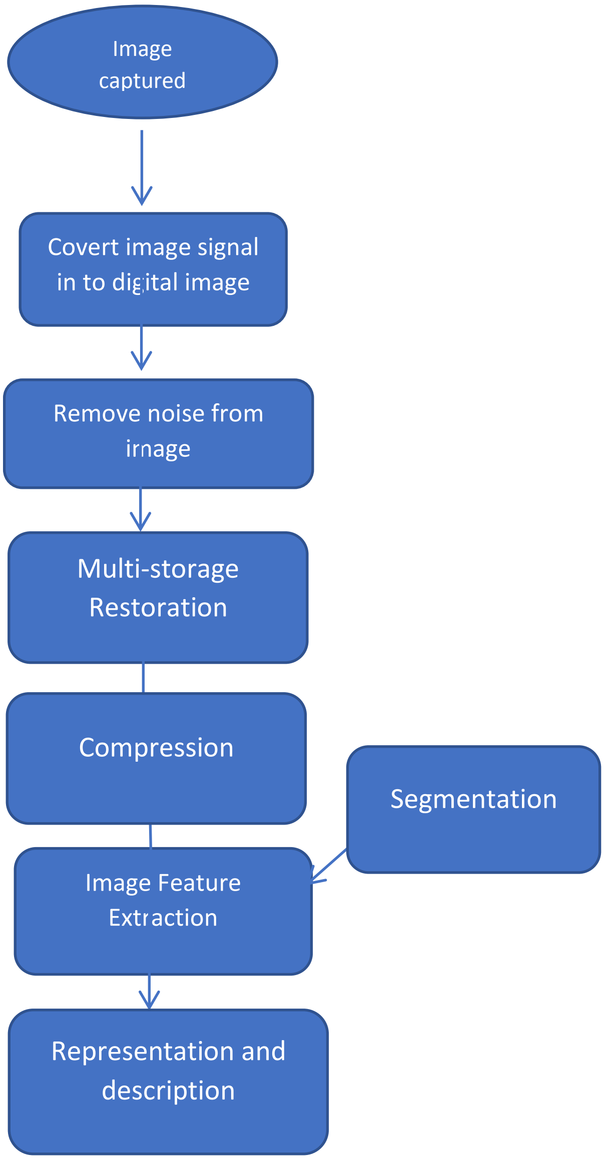
General digital image processing leas to create, process, communicate, and display digital images. It deals with following steps:

1) Conversion of image through sensor into digital images.

2) Removal of noise to improves the quality of picture

3) Extract the feature from the image and chose optimal image or image information and use in the different fields

4) In addition to this display crucial features found in an image.



Segmentation and Feature Extraction from image

In a computer system, an image is represented by a number. Imread(Image) is an example of a method in Matlab, and imshow is another.(Image)

Some numbers make up a picture, and the intensity of the colours red, blue, and green are shown in a 3-D grid. Even if a picture only has one color, it is still saved on three different colour levels. To do more calculations, you have to change the picture to grayscale, because grayscale images take up only a third of the room that RGB or coloured images do. Also, grayscale pictures are not as complicated as coloured images, so methods for processing images are clear.

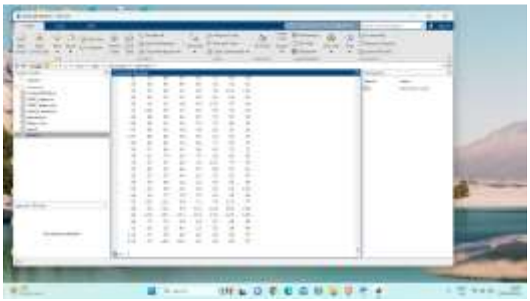


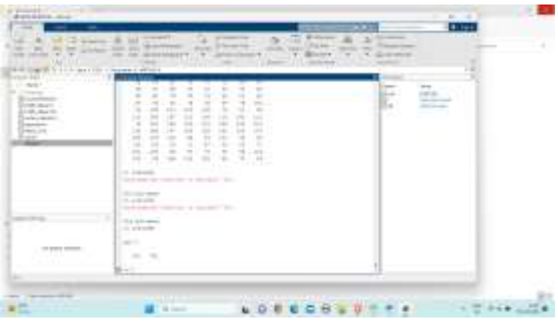
Image (a)

In this conversion some information is lost.

When

>> size(k)

ans = 350   750   3



Image(b)

After conversion of colored image to gray using rgbtogray() the size of image reduced.

Normalizing the brightness can be a crucial preprocessing step when evaluating a collection of photos, especially when trying to spot some pattern in black-and-white. Moreover in the preprocessing we can adjust the contrast of the image or reduce the size of image.

After image acquisition and pre-processing of image segmentation is next in the process.

In segmentation by thresholding the intensity values of a grayscale image, you can turn it into a binary black-and-white image. The cutoff value is assigned as 0, and those over it are given the number 1.

In the sample that follows, a grayscale image was divided up using a threshold of 1/4 the highest intensity that could be used, or 255.

Image(c)

Segmentation of image is shown here, BW=img>255/2

The CSMcCulloch algorithm, which incorporates McCulloch's approach for levy flight generation in the Cuckoo Search (CS) algorithm, is a computationally efficient picture segmentation system. Yang and Deb created the meta-heuristic optimisation algorithm CS by modelling the alluring reproduction strategy of specific cuckoo species (2009). Using Otsu's approach, Kapur entropy, and Tsallis entropy as objective functions, the CSMcCulloch algorithm is assessed for segmenting gray/color images. Experimental findings show that the suggested strategy for segmenting digital images performs well (particularly satellite images).

Image (d)

Image segmentation is crucial step in image processing, after this post-processing image is done.

Image segmentation is done with various metaheuristic methods to get optimal result.

In the above example, you can see how the CS metaheuristic method is used to segment a picture.Using some preprocessing and postprocessing methods on a picture are two ways to improve its quality. Image segmentation can't be avoided because people have different attention spans, different levels of detail awareness, and different types of things that catch their attention. One of the hardest parts of handling colour images is figuring out how to use all of this information. When pixel colours are cast onto three components, colour information is spread out in many different places.

Noise reduction is the next step in image processing. You can make a digital camera lens more sensitive to light to improve the brightness of a picture taken in low light. A lot of digital cameras, including those on smartphones, automatically raise the ISO when there isn't enough light. The picture gets grainy because the sensitivity is turned up, which makes the camera pick up more noise. (shown on the left).

We can get to the important parts of an image by getting rid of some of its parts.

Since artefacts change the row sum, a busy background makes it harder to classify. You can fix this by isolating the background and then taking it out of the picture.

Isolating the background could mean getting rid of the text, since the background of a picture is everything that isn't text. One way to get rid of a part of a picture is to use morphological methods. Image is made up of different kinds of pixels. For example, we give an image a number. The part with the highest number value is called expand, and the part with the lowest number value is called decline. It's called "opening of an image" when we do erode first and then enlargement afterward. If you do compression, then erode is called closing of a picture. When an image is closed, the darker parts stand out, while when an image is opened, the lighter parts stand out. The picture below shows how an image can be eroded and stretched.

Feature extraction and image segmentation is apply on multiple images that are store in matlab using datastore(). In addition to this feature extraction is done on multiple images.

1) Local Feature Extraction:

Local features in a picture include patterns or distinctive structures like points, edges, or small image patches. Typically, they are connected to an area of an image that is different from its immediate surrounds in terms of texture, colour, or intensity. It doesn't matter what the feature truly represents; what matters is that it stands out from its surroundings. Local features are of various types

1) Repeatable detections: When given two photos of the same scene, the detector typically identifies the same features in both photographs. The features can withstand noise and shifting lighting conditions.

2) Distinctive: There are enough differences in the area surrounding the feature centre to provide valid comparisons between the features.

3) Localizable: The feature has been given a specific location. Its location is unaffected by variations in viewing circumstances.

Feature extraction is done in several ways

You can manually or automatically pull out features:

For manual feature extraction, you need to find and describe the characteristics that are important to a certain case, as well as use a method to separate those characteristics. If you know a lot about the situation or topic, it can be easier to figure out which traits might be helpful. Through years of study, engineers and scientists have come up with ways to pull out features from pictures, signals, and text. The mean of a signal's range is an example of a trait that is easy to understand.

Automated feature extraction gets rid of the need for human help by using specific algorithms or deep neural networks to automatically pull out features from data or pictures. Using this method, you can move quickly from raw to

Metaheuristics for extracting and separating parts of a picture

In place of the more common crossing and mutation operators, this metaheuristic uses competition and teamwork as ways to evolve. Keep in mind that other well-known evolutionary metaheuristics, like ant colony planning, also show teamwork and competition in a similar way.

Optimisation methods were made so that hard problems could be solved when there was little time and few resources. The fact that all real-world processes are always unclear makes it much harder to find the best solution. Many agents work together to find the best answers to a problem. Their system tends to get better with each run while still following rules that have already been set. The resulting population will have some new traits that help the system self-organize and find the best answer in the search space.

Using an unstructured method in the HSV space, we can find the edges in colour images and divide them into groups. This method uses both the Firefly (FA) and Artificial Bee Colony (ABC) metaheuristic methods in two separate steps. First, we did a pixel-based segmentation on each tone channel using the FA method and the Gaussian Mixture Model. The number of clusters is instantly counted by the FA algorithm. This is done by looking at the histogram peaks of each single-band picture. The found peaks are used to figure out the starting means for the GMM's parameter estimate. Using Bayes' rule, you can use the GMM's posterior probabilities to group images into groups. After processing each visual channel, we put the pieces back together to make the final multichannel picture.

Metaheuristic Method of FeatureExtraction, Segementation and optimization technique in image processing

Image segmentation is a key step in image processing that involves breaking an image into useful parts. It connects lower-level tasks like identifying, recognizing, and classifying objects with higher-level tasks like analysing and understanding images.

Stochastic Method: The term "stochastic optimisation" or "stochastic search" is used to describe any kind of optimisation problem that uses randomness, either in the goal function or in the optimisation method.

For figuring out what a picture means, it's important to know how it was made, how the surface is oriented, how bright it is, where the gradients are, and how reflective it is. Even if it is a texture picture or a structure picture, texture is a big part of how pictures are made when digital image processing is used.

Image processing, which is also called "image models and transforms," is the study of how pictures can be represented in a way that is both predictable and unpredictable. Also, image data reduction and improving the quality of a picture by filtering and getting rid of any flaws are called image enhancement and image repair, respectively.

Image processing and analysis can be done on two levels, called low-level and high-level. The low-level stage works on picture representation, classification, segmentation, object recognition, compression, edge detection, and texture analysis. The high-level stage, on the other hand, is an explanation of what the low-level stage found. In the low-level part of models, you need to know how to make pictures and recognise objects regardless of the type of images being looked at.

In general, methods in picture processing that are based on statistical and mathematical models are important.

Most of the time, the basic methods for processing pictures are:

Capturing, displaying, describing, pre-processing, enhancing, filtering, edge detection, image repair, classification, segmentation, morphological analysis, compression, and identifying objects are all big groups.

To do these basic picture processing tasks, there are many scientific and statistical methods that can be used.

Particle Swarm Optimization (PSO)

The stochastic optimisation method known as Particle Swarm Optimization (PSO) resembles evolutionary algorithms in certain ways but differs in a significant way. It is based on animal swarming and flocking behaviour rather than evolution per se. PSO has no selection of any type, unlike other population-based approaches that resample populations to create new ones.

As a substitute, PSO keeps a single static population, whose members are tweaked in reaction to fresh information about the universe. In essence, the technique is a type of guided mutation.

Segmentation using PSO

The techniques are frequently referred to as "heuristic search" because they use a rough rule-of-thumb procedure that may or may not work to discover the optima rather than a precise procedure because the algorithms frequently use randomness.

Several stochastic algorithms are based on biological or natural processes, and as a higher-order technique that sets the parameters for a particular search of the objective function, they are sometimes referred to as "meta-heuristics." These optimisation methods are sometimes known as "black box" algorithms.

With a various source of randomness being utilised by the algorithm, different starting points for the search, and different decisions being made during the search, any single run of the method will be different due to the stochastic nature of the procedure.

To guarantee the same set of random numbers is supplied for each iteration of the process, the pseudorandom number generator that is utilised as the source of randomness might be seeded. Although it is fragile since it goes against the algorithm's natural randomness, this is ideal for brief demonstrations and lessons.

Instead, several iterations of a particular method might be used to account for the procedure's randomness.

The concept of several iterations of the algorithm can be applied in two crucial circumstances: contrasting algorithms and assessing the outcome

The relative value of the outcome, the quantity of function evaluations, or some combination or derivation of these factors may be used to compare algorithms. Any given run's outcome will depend on the algorithm's choice of randomness, and by itself, it is impossible to effectively gauge the algorithm's capabilities. Instead, it is best to employ a recurrent evaluation technique. It is necessary to repeatedly test each stochastic optimisation algorithm using a different randomness source in order to compare them, as well as to summarise the probability distribution of the best outcomes obtained, such as the mean and standard deviation of the objective values.

Conclusion:

In order to prepare an image for post processing techniques including texture-based analysis, feature extraction, selection, and classification, one technique is called image segmentation. For extracting feature of soil from an image mainlyn rely on effective picture segmentation algorithms. In this study, an attempt is made to automatically segment different parts of the image of soil which is done by combining stochastic modelling with heuristic-based image segmentation. To find the best intensity thresholds, the Particle Swarm Optimization (PSO) algorithm is first applied. Labeling priors for the Markov random field are generated from PSO.

References:

1)Automatic recognition of asphalt pavement cracks using metaheuristic optimized edge detection algorithms and convolution neural network Author Nhat-Duc Hoang a, Quoc-Lam Nguyen b, Van-Duc Tran c, Volume 94, October 2018, Pages 203-213

2) Published: 27 November 2022
A Systematic Review on Metaheuristic Optimization Techniques for Feature Selections in Disease Diagnosis: Open Issues and Challenges

- Sukhpreet Kaur,
- Yogesh Kumar,
- Apeksha Koul &
- Sushil Kumar Kamboj

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3) Research Article Image Processing-Based Pitting Corrosion Detection Using Metaheuristic Optimized Multilevel Image Thresholding and Machine-Learning Approaches Nhat-Duc Hoang 1,2 1 Institute of Research and Development, Duy Tan University, Da Nang 550000, Vietnam 2 Faculty of Civil Engineering, Duy Tan University, Da Nang 550000, Vietnam Correspondence should be addressed to Nhat-Duc Hoang; hoangnhatduc@dtu.edu.vn Received 30 December 2019; Revised 24 February 2020; Accepted 13 April 2020; Published 5 May 2020 Guest Editor: Dr. Dilbag Sing

3) A survey on image segmentation using metaheuristic-based deformable models: state of the art and critical analysis

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Gonzalez, R.C.; Wood, R.E. Digital Image Processing, 3rd ed.; Prentice Hall: Hoboken, NJ, USA, 2007. [Google Scholar]

Russ, J.C.; Neal, F.B. The Image Processing Handbook, 7th ed.; CRC Press: Boca Raton, FL, USA, 2015. [Google Scholar]

Skarbek, W.; Koschan, A. Colour Image Segmentation: A Survey; Technical Report 94–32; Techical University of Berlin: Berlin, Germany, 1994. [Google Scholar]

Lucchese, L.; Mitra, S.K. Colour Image Segmentation: A State of the Art Survey; PINSA: Lee's Summit, MO, USA, 2001; Volume 67, pp. 207–221. [Google Scholar]

Fernandez-Maloigne, C. Advanced Color Image Processing and Analysis; Springer: Berlin/Heidelberg, Germany, 2012. [Google Scholar]

Vantaram, S.R.; Saber, E. Survey of contemporary trends in color image segmentation. J. Electron. Imaging 2012, 21, 4. [Google Scholar] [CrossRef]

Gracia-Lamont, F.; Cervantes, J.; Lopez, A.; Rodriguez, A. Segmentation of images by color features: A survey. Neurocomputing 2018, 292, 1–27. [Google Scholar] [CrossRef]

Ridler, T.W.; Calvard, S. Picture thresholding using an iterative selection method. IEEE Trans. Syst. Man Cybern. 1978, 8, 630–632. [Google Scholar]

Chen, Y.B.; Chen, O.T. Image Segmentation Method Using Thresholds Automatically Determined from Picture Contents. EURASIP J. Image Video Process. 2009, 2009, 140492. [Google Scholar] [CrossRef][Green Version]

Kanungo, T.; Mount, D.M.; Netanyahu, N.S.; Piatko, C.D.; Silverman, R.; Wu, A.Y. An efficient k-means clustering algorithm: Analysis and implementation. IEEE Trans. Pattern Anal. Mach. Intell. 2002, 24, 881–892. [Google Scholar] [CrossRef]

Chen, J.; Pappas, T.N.; Mojsilovic, A.; Rogowitz, A. Adaptive perceptual color-texture image segmentation. IEEE Tran. Image Proc. 2008, 17, 1524–1536. [Google Scholar] [CrossRef]

Frigui, H.; Krishnapuram, R. A Robust Competitive Clustering Algorithm with Applications. Comput. Vision J. IEEE Trans. Pattern Anal. Mach. Intell. 1999, 21, 450–465. [Google Scholar]

Gu, C.; Lim, J.J.; Arbelaez, P.; Malik, J. Recognition using regions. In Proceedings of the 2009 IEEE Conference on Computer Vision and Pattern Recognition, Miami, FL, USA, 20–25 June 2009. [Google Scholar]

Gould, S.; Fulton, R.; Koller, D. Decomposing a scene into geometric and semantically consistent regions In Proceedings of the 2009 IEEE 12th International Conference on Computer Vision, Kyoto, Japan, 29 September–2 October 2009.

Ren, X.; Malik, J. Learning a classification model for segmentation. Int. Conf. of Comput. Vis. 2003, 2, 10–17. [Google Scholar]

Healey, G. Using color for geometry insensitive segmentation. Opt. Soc. Am. 1989, 22, 920–937. [Google Scholar] [CrossRef]

Xin, J.H.; Shen, H.L. Accurate color synthesis of three-dimensional objects in an image. Opt. Soc. Am. 2004, 21, 5. [Google Scholar] [CrossRef][Green Version]

Chaves-Gonzalez, J.M.; Vega-Rodrıguez, M.A.; Gomez-Pulido, J.A.; Sanchez-Perez, J.M. Detecting skin in face recognition systems: A color spaces study. Digit. Signal Process. 2009, 20, 806–823. [Google Scholar] [CrossRef]

Jurio, A.; Pagola, M.; Galar, M.; Lopez, C.; Paterna, D. A comparison study of different color spaces in clustering based image segmentation. In Communications on Computer and Information Science; Springer: Berlin/Heidelberg, Germany, 2010. [Google Scholar]

Koschan, A.; Abidi, M. Detection and classification of edges in color images: A review of vector valued techniques. IEEE Signal Process. Mag. 2005, 22, 64–73. [Google Scholar] [CrossRef]

Ruiz-Ruiz, G.; Gomez-Gil, J.; Navas-Gracia, L.M. Testing different color space based on hue for the environmentally adaptive segmentation algorithm (ESA). Comput. Electron. Agric. 2009, 68, 88–96. [Google Scholar] [CrossRef]

Alata, O.; Quintard, L. Is there a best color space for color image characterization or representation based on multivariate Gaussian Mixture Model? Comput. Vis. Image Under-Standing 2009, 113, 867–877. [Google Scholar] [CrossRef]

Yang, X.S. Nature-Inspired Metaheuristic Algorithms; Luniver Press: Beckington, UK, 2008. [Google Scholar]

Parpinelli, R.S.; Lopes, H.S. New inspirations in swarm intelligence: A survey. Int. J. Bio-Inspired Comput. 2011, 3, 1–16. [Google Scholar] [CrossRef]

Pham, D.T.; Ghanbarzadeh, A.; Koc, E.; Otri, S.; Rahim, S.; Zaidi, M. The Bees Algorithm-A Novel Tool for Complex Optimisation Problems. In Intelligent Production Machines and Systems, 2nd I*PROMS Virtual International Conference, 3–14 July 2006; Elsevier: Amsterdam, The Netherlands, 2006; pp. 454–459. [Google Scholar]

Kennedy, J.; Eberhart, R.; Shi, Y. Swarm Intelligence; Academic Press: Cambridge, MA, USA, 2001. [Google Scholar]

Blum, C.; Roli, A. Metaheuristics in combinatorial optimization: Overview and conceptual comparison. ACM Comput. Surv. 2003, 35, 268–308. [Google Scholar] [CrossRef]

Rothlauf, F. Design of Modern Heuristics Principles and Application; Springer: Berlin/Heidelberg, Germany, 2011. [Google Scholar]

Senthilnath, J.; Vipul, D.; Omkar, S.N.; Mani, V. Clustering using levy flight cuckoo search. In Proceedings of the 7th International Conference on Bio-Inspired Computing: Theories and Applications, Advances in Intelligent Systems and Computing, Beijing, China, 2–4 November 2018; Lecture Notes in Computer Science (LNCS). Springer: Delhi, India, 2012; pp. 65–75. [Google Scholar]

Senthilnath, J.; Omkar, S.N.; Mani, V. Clustering using firefly algorithm: Performance study. Swarm Evol. Comput. Elsevier 2011, 1, 164–171. [Google Scholar] [CrossRef]

Giuliani, D. Colour Image Segmentation based on Principal Component Analysis with application of Firefly Algorithm and Gaussian Mixture Model. Int. J. Image Process. 2018, 12, 4. [Google Scholar]

Giuliani, D. A Grayscale Segmentation Approach using the Firefly Algorithm and the Gaussian Mixture Model. Int. J. Swarm Intell. Res. 2017, 9, 1. [Google Scholar] [CrossRef]

Lindsay, B.G. Mixture Models: Theory, Geometry and Applications. In NSF-CBMS Regional Conference Series in Probability and Statistics; Institute of Mathematical Statistics: Hayward, CA, USA, 1995. [Google Scholar]

McLachlan, G.J.; Basford, K.E. Mixture Models: Inference and Applications to Clustering; Marcel Dekker: New York, NY, USA, 1988. [Google Scholar]

Chapron, M. A new Chromatic Edge Detector Used for Color Image Segmentation. In Proceedings of the IEEE International Conference on Pattern Recognition, Hague, The Netherlands, 30 August–3 September 1992; pp. 311–314. [Google Scholar]

Halkidi, M.; Batistakis, Y.; Vazirgiannis, M. On Clustering Validation Techniques. J. Intell. Inf. Syst. 2001, 17, 107–145. [Google Scholar] [CrossRef]

Saitta, S.; Raphael, B.; Smith, I.F.C. A comprehensive validity index for clustering. Intell. Data Anal. 2008, 12, 529–548. [Google Scholar] [CrossRef][Green Version]

Bolshakova, N.; Azuaje, F. Cluster validation techniques for genome expression data. Signal Process. 2003, 83, 825–833. [Google Scholar] [CrossRef][Green Version]

Celebi, M.E. Improving the performance of K-means for color quantization. Image Vis. Comput. 2011, 29, 260–271. [Google Scholar] [CrossRef][Green Version]

https://in.mathworks.com/products/matlab.html