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A Survey of Diverse Segmentation Methods in Image Processing

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***Abstract*—The importance of image-processing techniques has increased across a wide range of applications as a result of advancements in computer technology. An important stage in the processing of images is segmenting of images. The process of breaking a picture into groups that each have their own distinct characteristics and similar characteristics, such as intensity, texture, class, culture and colour is known as segmentation. Image segmentation has been done with many different algorithms and methods. In this article, study reviews various image segmentation technologies. This paper covered many segmentation methods, including Threshold, Edge Detection, Region-based, Neural Network Image Segmentation and Clustering in any economy to increase the quality of life. This study is helpful in deciding how to best apply image segmentation techniques, as well as in enhancing their precision and effectiveness, in order to achieve the main goal of developing new algorithms.**

Keywords — Segmentation, Image Processing, Neural Network, Edge Detection, Thresholding.

I. INTODUCTION

An image is a depiction of anything visually, and it is full of meaningful information. One useful application of digital image technology is the ability to analyse an image and extract relevant data without negatively impacting the original. The enhancement of images is a necessary and significant step in order to satisfy this criteria [1]. As long as the image has been filtered to remove unwanted elements, it can be used for anything [2]. The method of segmenting an image is the initial in learning about image processing. In reality, segmentation frequently only shows interest in a subset of the image's components that have similar traits. One of the crucial components in computer vision, image processing, and image recognition is image segmentation. It divides an input image into a number of similar categories to find the area of interest. As a prerequisite to feature extraction and recognition, image segmentation is crucial.

II. IMAG E SEG M E N TAT I O N

Image segmentation is one of the most common techniques and analyses used in digital image processing to divide an image into numerous parts, usually relying on the pixels in image [3] as shown in Fig.1. The procedure of segmenting an image involves dividing the foreground from the background or grouping areas of pixels that have a common shape or colour. In order to locate and name the pixels in image of a 3D volume which indicate tumour in the lungs of patient or other organs for instance, is one of the most frequent applications of image segmentation in medical imaging. Image segmentation also has a number of medical and technological uses, including as noise reduction, locating objects in satellite images, object identification, and recognition, systems for video monitoring, automatic traffic control, etc.[4-5].

The two fundamental characteristics of intensity values 'similarity and discontinuity' are the foundation of the majority of image segmentation algorithms [3]. The first technique involves segmenting the image into groups according to sharp changes in intensity, like edges. The second method bases the partitioning of images on some pre-established parameters.

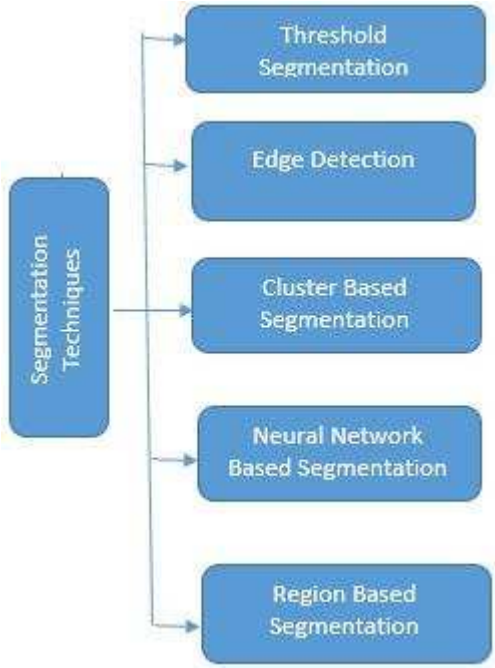

Fig. 1. Classification of Segmentation Techniques.

A. Threshold Based Segmentation

The thresholding method is the one that is used most frequently in segmenting an image. The process of image segmentation known as thresholding involves selecting the appropriate threshold value to split an image's pixels into distinct areas and differentiate between foreground and background components. If the intensity of any pixel (x, y) is greater than or equal to the threshold value, f(x, y) T, then that pixel belongs to an object; otherwise, it belongs to the background. There are three types of thresholding methods depending on the threshold value chosen:

• Global Thresholding

The foreground and background objects' intensity sharing is significantly distinct, global thresholding is employed so that both items can be easily distinguished using just one threshold value. The value of threshold T in this sort of thresholding is determined by the pixel's characteristic and the image's grey level value. Entropy- based thresholding, Otsu method, and other widely used global thresholding techniques.

• Local Thresholding

This method transforms a colour image into a binary image. This approach separates images into various sub- regions before selecting different thresholds T's for each sub-region separately. Simple statistical thresholding and 2-D entropy-based thresholding are some of frequently used local threshold approaches.

• Adaptive Thresholding

Using this method, the threshold value of every pixel is determined; if the value is lower than a predetermined thresholds, the pixel is categorized as background, otherwise it is classified as foreground. Using the pixel intensities of different image objects, this technique is used to separate image objects from the background [6]. This technique's fundamental flaw is that it requires a lot of computer power and is rarely applied in real-world situations.

The local thresholding based on FGPA proposed to solve the uneven illumination and reflection problem by adopting the mean value of neighbourhood blocks and Gaussian weighted sum design idea in the local neighbourhood [7]. An algorithm for more precise and faster segmentation of the target curve, known as quasi- bimodal threshold segmentation (QBTS), which converts the multimodal histogram into a quasi-bimodal histogram proposed by Ruan et al [8].

Histogram dependent technique, P-tile method, OSTU thresholding, Mean method, Edge maximisation technique, and visual approach are some of the several thresholding methods that have been developed by various researchers. On identify the optimum segmented image, the Pile Technique, Mean Technique, EMT, and HDT technique on satellite images was used [9]. Among the aforementioned thresholding strategies, Edge Maximization Technique and Histogram Dependent Technique are the most effective. The researchers proposed a modified Otsu-based Image Segmentation Algorithm to improve the efficiency of the Otsu technique [10].The standard deviation was used to calculate the appropriate threshold value. In comparison with previous techniques, the outcomes show that the cost of computation is lower and that it is more noise-resistant.

According to Kaiping Wei [11-12], doing image segmentation using the present methodologies takes a lot of time and processing resources. The issue is significant for real- time applications. They suggested a brand-new 2-d Otsu algorithm (TOPSO) and Particle Swarm Optimization (PSO)- based threshold-based segmentation technique. To find the best threshold for the segmentation process, TOPSO algorithm used PSO approach. On Matlab 7.0, they put the suggested hybrid technique into practise. The TOPSO algorithm is 25 times faster than the conventional Otsu algorithm, according to the results. For real-time applications, it works well.

B. Edge Detection based segmentation

Edge detection is the fundamental stage of the image segmentation process applied to identify the edges of objects in images. The process of obtaining edge detection involves locating abrupt changes or discontinuities in the brightness of the image. In most cases, it entails organising discontinuity points into curved line segments or edges. Gradient and Gray histogram techniques are used for edge identification in im- age segmentation[13].The edge detection approach employs a number of operators, including the Laplacian of Guassian (LoG) [14], Sobel, Prewitt, Canny Edge detector, and the Classical edge detectors [15].Edge identification based on fuzzy C means clustering was proposed on MRI images[16]. Balanced Contrast Enhancement Technique (BCET) was used to enhance quality of images of medical field by making more immune to noise. As a next step, the images are then segmented utilizing the Fuzzy C means clustering method. The Canny Edge Detection method is then applied to the image in order to locate the image's borders. Their technique provides improved outcomes in order to accurately maintain more edge information.

Markov Random Fields have been employed by Wesolkowsk [17] for region and edge-based hybrid colour image segmentation. An edge detection technique is first used to carry out the line process. In order to identify edges, a vector angle measure is employed as a distance metric among individual pixels. The fundamental issue with their method is that it is a pixel neighbour model and hence bears from the identical problems as the region growth method. The MRF model is examined using a parameter estimation method.

Fast Laplacian of Gaussian Edge Detection for Quantum Images was proposed [18]. The discrete LoG mask was located using a Gaussian operator. Then, they used the zero crossing points to identify the edges and the LoG mask to filter the quantum image before examining the time complexity. A modified Canny Edge identification technique for ultrasound pictures was put forth [19]. Due to the noise sensitivity of ultrasound pictures, a modified median filter is used before the data is processed by a canny edge detector to improve

the accuracy with which the borders of internal organs are identified. A new edge detection method was proposed that uses a variety of filters, including Median, STD, Gobar, Weiner, Geometric and Harmonic filters, among others, to find sharp and precise edges [20].

With the help of region growth and edge detection technologies, Yu Xiaohan [21] proposed a novel approach to image segmentation. Their hybrid approach enables the segmentation process avoid mistakes when the two strategies are applied separately. While second order derivative is utilised for detection of edges, region growth is employed to locate the image's edge pixels. On 3D MRI image data, experiments are performed. Following edge detection, smoothing is done using the Gaussian approach. Their method is superior, according to the results, to preserve more edge information.

C. Cluster Based Segmentation

Clustering is effective method in segmentation of images. The approaches that divide a picture into groups of pixels with similar properties are known as clustering-based techniques. The process of grouping data components into groups, hence that they are more similar to one another than to other items in the identical cluster is known as data clustering. Clustering can be divided into two categories.

• Hard Clustering

A straightforward clustering technique, hard clustering separates the image into a collection of clusters from which each pixel can only possibly originate from one of those clusters. These techniques make use of membership functions, which have values of either 1 or 0, meaning that a pixel can either belong to a specific cluster or not. One k-means clustering based method called HCM is an instance of a hard clustering-based method. This method begins by computing the centres, after which each pixel is given its closest centre. It places a strong emphasis on both lowering inter-cluster equality and enhancing intra- cluster similarity.

• Soft Clustering

Since perfect division is impossible in real life because of the presence of noise, soft clustering offers a more realistic form of clustering. Soft clustering approaches are therefore most effective for segmentation of images where the partitioning is flexible. Fuzzy c means clustering is an instance of this kind of method. One pixel can belong to many clusters when using this technique, which divides pixels into clusters based on partial membership. The de- gree of belonging is defined by membership values. This method is more adaptable than alternative approaches.

Numerous clustering algorithms exist, including fuzzy c- means (FCM), k means, enhanced fuzzy c-mean algorithm (IFCM) and adaptive k means. The algorithm K-Means clustering is example of an unsupervised classification method that can be utilised to separate the desired area from the surrounding background. The data is divided into K-clusters. A segmentation technique relies on the K-means algorithm was proposed for images [22]. They employed a grey gradient maximum entropy technique for feature extraction and a K-mean algorithm for image classification. In order to effectively reduce the impact of noisy data on the K-Means method and increase the accuracy of the clustering results suggested an improved K-means Clustering Algorithm [22]. For the purpose of segmenting images Adaptive K-means Algorithm was proposed, a straight-forward method that produces reliable segmentation values [23]. The use of fuzzy set theory in applications of medical field is described [24].They put forth Markov random field (MRF), a brand-new approach that produces image clusters completely automatically and is less noise-sensitive. A new method for detection of edges in MRI images was presented [25].They employed the Fuzzy C-Means (FCM) clustering method for segmentation of images, and they utilized the Semi Translation Invariant Contour Let Transform (STICT) to enhance the original MRI images quality. The Canny edge detection technique is then utilised to detect the fine edges. The results of the experiment indicate that it produces excellent results than alternative approaches.

An improved segmentation technique has been put forth by Ruoyu Du et al. [26] that uses a sigma filter to alter the surrounding pixels of the targets. The suggested technique performs better than the original FCM, according to visual and quantitative evaluation. A mean shift-based FCM for the extraction of skin lesions has been presented by Huiyu Zhou et al. [27]. They have suggested a fuzzy c-means objective function with a mean field term that is based on mean shift and incorporates it into the conventional FCM goal function. Their algorithm can effectively extract the borders of skin lesions, according to experimental findings.

D. Neural Network Based Image Segmentation

Neurons, the nodes that make up neural networks, are connected to one another. Each neuron uses one input data point, often one image pixel, and an activation function, a straightforward calculation, to produce a result. The output of a network of neurons is influenced by their respective numerical weights. The outcome is fed into more neural layers until the neural network provides a prediction for every input or pixel at the end of the procedure. The authors told that with the least amount of pre-processing, conventional neural networks (CNN) can segment images and extract characteristics from pixel images [28]. A single pixel in an image is represented by a single neuron in an ANN. Using training samples, a neural network is trained to produce an image, and after finding connections between neurons (pixels), the segmented new images are created from the trained image [29]. Two ANN model was suggested by authors for the early identification of breast cancer that are firstly directly applying classifier to ROI image data and secondly figuring out what's going on behalf of the features extracted from the image signals that have already been processed [30]. The authors used a new FFANN technique to improve cardiac image segmentation. This technique makes it possible to clearly define the texture boundaries and detect edges. The outcomes of the experiment demonstrate that

FFANN has a more effective learning capacity and requires less time to segment images than other techniques [31].

For the RGB and HSV cluster space, Xuejie Zhang [32] suggested a novel Fast learning Artificial Neural Network (FLANN) based colour image segmentation algorithm. To balance out the distribution of colours, noise is first removed using a 3*3 averaging filter. The second step is transforming the pixels into RGBSV format using HSV conversions. Fast learning Artificial Neural Network (FLANN) clustering is used to generate a clustering result from an image. The next step is to separate pixels of the same colour. Each image segment is given a segment number. Effects of neighbourhood size and tolerance are seen. Results showed that the suggested algorithm produced flawless colour segments for the image.

SENet is an example of CNN channel attention method. Additionally, spatial information compression is achieved via the use of global average pooling to obtain feature information between channels. Then, additional nonlinear connections are obtained between channels by employing two fully connected layers. These are able to hold on to useful information while suppressing information that is irrelevant [33]. Deep neural network based image semantic segmentation with hierarchical feature fusion solves the problem of feature extraction issues. Through the use of a convolutional structure, this algorithm is able to fully extract the feature information that is hidden in both the shallow low-level features and the deep semantic features at the pixel level and the image level, respectively [34].

E. Region Based Image Segmentation

Segmentation on region based is more noise resistant and comparatively straightforward than other techniques [35]. Using a set of predetermined criteria, divide an image into areas that are similar in region-based approaches. Region growth, region splitting, and region merging are the three fundamental components of region-based segmentation [36]. A region-based sequential technique called ”region growth” scans nearby pixels and adds them to larger areas based on pre-defined ”stop conditions” and” growing criteria”. The procedure of breaking an image into a number of distinct and unified sections is referred to as region splitting. After each split, a region merging mechanism is utilised to compare the adjacent regions and, if necessary, unite them. Using the soft KNN algorithm, the researchers developed a technique for region- based picture segmentation. To find the area of the image that was ambiguous, they combined the k-nearest neighbour approach with soft categorization techniques. They gathered the images from social networks for the experiments. This strategy outperforms the conventional k-nearest neighbour approach significantly [37].

In an effort to enhance the normalised cut image segmentation approach, Civahir Cigla [38] suggested a novel graph theoretic colour image segmentation technique. They utilised an image with an undirected weighted graph, in which the nodes stand in for the areas and the weights between them indicate how closely related the regions' intensities are. The issue of over segmentation, where more regions are formed for the image, has been resolved by their updated normalised cut method. The outcomes are in contrast with the NCIS method. The outcomes demonstrate how the suggested strategy enhances the NCIS algorithm.

An unsupervised segmentation technique for images utilising level set techniques and texture statistics was put out by Karoui [39, 40]. They assert that their approach is unique from other approaches since it does not depend on independent variables or limit itself to first order grey features. The weights of every feature are changed during the feature selection stage of the implementation to achieve segmentation. In the implementation phase, the number of distributions is determined by the filter response histogram, and the energy of each band's image wavelet is determined by the haar wavelet [41]. The level sets are initialised again using PDE. Results indicated that a zebra image had been correctly segmented.

III. CONCLUSION

Image segmentation has a bright future and focuses on current research in a variety of areas, including recognition and detection of objects, images of aerial view and medical. After a thorough examination of the various approaches to image segmentation. It has been noted that a hybrid approach to image segmentation typically combines two or more methods. A number of variables, including pixel colour, texture, intensity, similarity between images, image content, and problem domain, affect how well an image segmentation algorithm performs. A single approach cannot be taken into account for all types of images. Any technique can be effective for a specific kind of image. Machine learning methods can also be used to improve segmentation. In the future, we plan to use a CNN model to locate the target area, and then apply traditional segmentation techniques to further improve our results. This paper provides a literature review of several research approaches and several research issues in the field of image segmentation.

REFERENCES

[1] M. Yasmin, S. Masood, and M. Raza, “BrainImage Enhancement-A Survey Brain Image Enhancement - A Survey,” https://www.researchgate.net/publication/236898965, no. May 2014, 2012.

[2] S. Raut, M. Raghuvanshi, R. Dharaskar, and A. Raut, “Image Segmentation – A State-Of-Art Survey for Prediction,” Int. Conf. Adv. Comput. Control Image, pp. 420–424, 2009, doi: 10.1109/ICACC.2009.78.

[3] S. L. Eddins, R. E.woods, and C. G. Rafae, “Gonzalezbook.pdf.” 2009.

[4] M.Yasmin, S. Mohsin, and M. Raza, “BrainImage Analysis: A Survey Brain Image Analysis: A Survey,” https://www.researchgate.net/publication/236898963, no. May 2014, doi: 10.5829/idosi.wasj.2012.19.10.3347.

[5] M. Sharif, M. Y. Javed, and S. Mohsin, “Face Recognition Based on Facial

Features," : https://www.researchgate.net/publication/236953573, no. May, 2014.

[6] E. R. Davies, Computer Machine Vision Theory, Algorithms, Practicalities. 2012.

[7] S. Gao, Y. Wang, Z. Chen, F. Zhou, R. Wang, and N. Guo, "Design and Implementation of Local Threshold Segmentation Based on FPGA," J. Electr. Comput. Eng., vol. 2022, 2022, doi: 10.1155/2022/6532852.

[8] X. Ruan, H. Deng, Q. Xu, Y. Liu, and J. He, "Threshold Segmentation and Length Measurement Algorithms for Irregular Curves in Complex Backgrounds," Sensors, vol. 22, no. 15, 2022, doi: 10.3390/s22155761.

[9] S. S. Al-amri, N. V Kalyankar, and S. D. Khamitkar, "Image Segmen- tation by Using Thershod Techniques," J. Comput., vol. 2, no. 5, pp.83–86, 2010.

[10] M. C. Unajan, B. D. Gerardo, and R. P. Medina, "A Modified Otsu-based Image Segmentation Algorithm (OBISA)",Proc. Int. MultiConference Eng. Comput. Sci., vol. 0958, no. 1, pp. 13-16, 2019.

[11] K. Wei, T. Zhang, S. Xianjun, and J. Liu, "An improved threshold selection algorithm based on particle swarm optimization for image segmentation," Proc. - Third Int. Conf. Nat. Comput. ICNC 2007, vol. 5, no. 2, pp. 591–594, 2007, doi: 10.1109/ICNC.2007.226.

[12] W. Wang and J. Gang, Proceedings of 2018 International Conference on Information Systems and Computer Aided Education, ICISCAE 2018," Proc. 2018 Int. Conf. Inf. Syst. Comput. Aided Educ. ICISCAE 2018, pp. 64–70, 2019.

[13] S. Lakshmi and V. Sankaranarayanan, "A study of Edge Detection Techniques for Segmentation Computing Approaches", Comput. Aided Soft Comput. Tech. Imaging Biomed. Appl., pp. 35-41, 2010.

[14] M. Sharif, S. Mohsin, M. Y. Javed, and M. A. Ali, "Single Image Face Recognition Using Laplacian of Gaussian and Discrete Cosine Transforms" Int. Arab J. Inf. Technol. vol. 9, pp. 562-570, 2012.

[15] B. Sumengen and B. S. Manjunath, "Multi-Scale Edge Detec- Tion And Image Segmentation", Proc. Eur. Signal Process. Conf., 2005.

[16] A. Zotin, K. Simonov, and M. Kurako, "Edge detection in MRI brain tumor images based on fuzzy C-means clustering", 22nd Int. Conf. Knowledge-Based Intell. Inf. Eng. Syst., pp. 1261-1270, 2018.

[17] S. Wesolkowski and P. Fieguth, "A Markov random fields model for hybrid edge- and region-based color image segmentation," Can. Conf. Electr. Comput. Eng., vol. 2, pp. 945–949, 2002, doi: 10.1109/ccece.2002.1013070.

[18] S. Yuan, E. Venegas, Z. Chaoping, W. Yan, X. Mao, and Y. Luo, "Fast Laplacian of Gaussian Edge Detection Algorithm for Quantum Image" EEE Int. Conf. Ubiquitous Comput. Commun. Data Sci. Comput. Intell. Smart Comput. Netw. Serv., pp. 798-802, 2019,

[19] M. Nikolic, E. Tuba, and M. Tuba, "Edge Detection in Medical Ultrasound Images Using Adjusted Canny Edge Detection Algorithm" IEEE, pp. 1-4, 2016.

[20] N. Yadav and V. Sindhu, "Image Segmentation of Color Image using Threshold Based Edge Detection Algorithm in MatLab" p. 2, 2017.

[21] X. Yu and J. Yla-Jaaski, "A new algorithm for image segmentation based on region growing and edge detection," Proc. - IEEE Int. Symp. Circuits Syst., vol. 1, pp. 516–519, 1991, doi: 10.1109/iscas.1991.176386.

[22] J. Zhu and H. Wang, "An improved K-means Clustering Algorithm", IEEE, pp. 10-12, 2010.

[23] X. Zheng, Q. Lei, R. Yao, Y. Gong, and Q. Yin, "Image segmentation based on adaptive K -means algorithm", EURASIP J. Image Video Process., pp. 1-10, 2018.

[24] N. A. Mohamed, N. Ahmed, and A. Farag, "Modified Fuzzy C-Mean in Medical Image Segmentation" IEEE, pp. 3429-3432, 1999.

[25] Nguyen M. Hien, N. T. Binh, and N. Q. Viet, "Edge detection based on Fuzzy C Means in medical image processing system Edge Detection based on Fuzzy C Means in Medical Image" Int. Conf. Syst. Sci. Eng. Edge, no. January, pp. 12-15, 2017,

[26] R. Du and H. J. Lee, "A Modified-FCM Segmentation Algorithm for Brain MR Images," Int. Conf. Converg. Hybrid Inf. Technol., pp. 5–7, 2009.

[27] H. Zhou and G. Schaefer, "Anisotropic mean shift based fuzzy c-means segmentation of skin lesions," pp. 438–443, 2008.

[28] L. S. M and V. K. Govindan, "Convolutional Neural Network Based Segmentation" Springer-Verlag Berlin Heidelb., pp. 190-197, 2011.

[29] B. J. Van Der Zwaag, H. Groningen, and L. Spaanenburg, "Analysis of Neural Networks for Edge Detection": https://www.researchgate.net/publication/228817626, no. May 2014, 2020.

[30] M. Mehdy, P. Ng, E. Shair, N.Saleh, and C. Gomes, "Artificial Neural Networks in Image Processing for Early Detection of Breast Cancer" Comput. Math. Methods Med., vol. 2017, pp. 1-16, 2017.

[31] P. M. Shakeel, S. Baskar, and R. Sampath, "Echo cardiography image segmentation using feed forward artificial neural network (FFANN) with fuzzy multi-scale edge detection (FMED)" Mustafa Musa Jaber" Int. J. Signal Imaging Syst. Eng., vol. 11, no. 5, pp. 270-278, 2019.

[32] X. Zhang and A. L. P. Tay, "Fast Learning Artificial Neural Network (FLANN) based color image segmentation in R-G-B-S-V cluster space,"IEEE Int. Conf. Neural Networks - Conf. Proc., pp. 563–568, 2007, doi: 10.1109/IJCNN.2007.4371018.

[33] G. Wang, L. Cheng, J. Lin, Y. Dai, and T. Zhang, "Fine-grained classification based on multi-scale pyramid convolution networks," PLoS One, vol. 16, no. 7 July, pp. 1–13, 2021, doi: 10.1371/journal.pone.0254054.

[34] D. Yang, Y. Du, H. Yao, and L. Bao, "Image semantic segmentation with hierarchical feature fusion based on deep neural network," Conn. Sci., vol. 34, no. 1, pp. 1772–1784, 2022, doi: 10.1080/09540091.2022.2082384.

[35] W. Kang, Q. Yang, and R. Liang, "The Comparative Research on Image Segmentation Algorithms" First Int. Work. Educ. Technol. Comput. Sci., pp. 703-707, 2009,

[36] S. Angelina, L. P. Suresh, and S. Veni, "Image Segmentation Based On Genetic Algorithm for Region Growth and Region Merging", Int. Conf. Comput. Electron. Electr. Technol. [ICCEET], pp. 970-974, 2012.

[37] S. Wazarkar, B. Keshavamurthy, and A. Hussain, "Region-based Segmentation of Social Images Using Soft KNN Algorithm ScienceDirect Region-based Segmentation of Social Images Using Soft KNN Algorithm" https//www.researchgate.net/publication/322350580 Reg., no. January, 2018,

[38] C. C¸ ig˘ la and A. Alatan, "Region-based image segmentation via graph cuts," Proc. - Int. Conf. Image Process. ICIP, pp. 2272–2275, 2008, doi: 10.1109/ICIP.2008.4712244.

[39] I. Karoui, R. Fablet, J. Boucher, and J. Augustin, "Region-based image segmentation using texture statistics and level-set methods," ICASSP, IEEE Int. Conf. Acoust. Speech Signal Process. - Proc., vol. 2, pp. 693–696, 2006, doi: 10.1109/icassp.2006.1660437.

[40] Bose, K., Shubham, K., Tiwari, V. and Patel, K.S., 2022." Insect Image Semantic Segmentation and Identification Using UNET and DeepLab V3+". In ICT Infrastructure and Computing: Proceedings of ICT4SD 2022 (pp. 703-711). Singapore: Springer Nature Singapore.

[41] Choudhary, M., Tiwari, V. and Jain, S., "Person re-identification using deep siamese network with multi-layer similarity constraints". Multimedia Tools and Applications, pp.1-17, 2021, Springer