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Image Segmentation Based on Modified Tsallis Entropy

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Abstract

Thresholding is a way to extract the features of an object from its background. Various methods are in existence for obtaining the threshold value. An effective method, the Tsallis entropy model, is used to calculate the threshold value based on which the image is segmented. To get better feature extraction, the non-extensive parameter ‘q’ is used to distinguish the long-range correlation. The value of this parameter is varied and is found to give good results when q equals ‘0.8’. In this paper, an enhancement to the above method is proposed which results in a significant increase in the object clarity after segmentation.

Keywords: Tsallis entropy, segmentation, optimal threshold, correlation, Infrared image

1 Introduction

Segmentation refers to the process of splitting an image into subparts. The extent of splitting or the way in which the apportioning is done is based solely on the application of the segmentation or the problem to be solved by the segmentation procedure. The process of segmentation uses certain mathematical algorithms and procedures to segment an image and remove any unwanted or trivial parts of the input digital image. Segmentation is used in several areas. It is used in fast segmentation of bone in CT-Scan images [11], weather analysis by segmenting satellite images, motion detection cameras, face recognition systems, etc. Another application of segmentation is seen in Infrared(IR) images where the threshold can be obtained easily and efficiently [3].

Thresholding is the simplest way to segment a digital image. A certain intensity level is calculated and all the intensity values above and below this level are replaced with white or black respectively. Then, these values are used to transform the image into a binary image depending on the intensity at each pixel. There are many models used to determine the threshold value. Some models use the histogram shape and some others use the entropy of the foreground and the background of the image. Here the Tsallis entropy model is implemented. Changes are made to the attributes of the Tsallis entropy to get a better feature extraction from the images.

2 Materials and Methods

Traditionally 1D histogram was used for entropy segmentations, which is now replaced by 2D histograms since the latter is better in reflecting spatial information with comparatively less noise. Hence maximum fuzzy entropy can be used to obtain the threshold value for segmenting a 2D histogram [4]. Class variance sum is used to calculate the threshold value in general thresholding methods. This fails to give good results if the object has low gray level changes while the background has high gray level changes or vice-versa, which may lead to some discrepancies. So, if the discrepancies are taken into account the output yielded is better [6].

The logic behind the approach of thresholding proposed by Beauchemin [2] is to binarize an image so that it represents the original image as accurately as possible. The new image generated should be the best approximate of the edges and other sharp features present in the input image. There are many ways of determining the threshold values. Each one may suit different type of images like IR images, radiographic images, NDT result images, etc. The purpose of thresholding is to extract features from a digital image and eliminate the useless objects in the image. Images are conventionally thresholded into bi-level images. There are many procedures and algorithms for effective bi-level thresholding. But, these procedures when used for multilevel thresholding become computationally very complex and not feasible. To address this issue, new methods like swarm-intelligence-based global optimization algorithms, cuckoo search and wind driven optimization have been found to yield better results for multilevel thresholding [1].

Conventionally only gray-level histogram were used to calculate the optimal threshold value. Considering the gradient magnitude along with the gray level has given better results as it was simultaneously able to explicitly capture gray level occurrence probability and the spatial distribution properties [10]. One of the applications of image segmentation is processing of documents and manuscripts of historical importance and digitizing them so that the storage and transmission of these important data becomes easy. A successful method for the above process is by using an algorithm which implements the Tsallis entropy model to calculate the optimal threshold value [8].

The Tsallis entropy uses non-extensive parameter to find multilevel threshold values due to which, it is still one of the efficient methods to find the multilevel threshold values. Combining Tsallis entropy with Golden Ratio Particle Swarm Optimization (GRPSO) to obtain objective values, is found to be more efficient than using genetic algorithm, Particle Swarm Optimization (PSO) and Bacterial Foraging (BF) algorithm [7].

3 Methodology

Formally Boltzmann-Gibbs entropy was used to segment images based on threshold values. Tsallis entropy, a more generalized version of the above is used which provided better results as it had similarities with Boltzmann-Gibbs entropy as well as Shannon entropy [9]. To describe Tsallis Entropy briefly, it uses non extensive parameter value ‘q’ to find the threshold value of an image. The general formula of Tsallis entropy is,

$$S = -k \sum_{i=1}^{W} p_i \ln p_i,$$

Later, due to much internal interactions the formula is modified as,

$$S_q = \frac{1 - \sum_{i=1}^{W} p_i^q}{q-1}$$

where ‘q’ is a parameter of non-extensivity.

An implementation of Tsallis entropy can be seen in Albuquerque thresholding method where the probability distribution of pixel intensities is substituted in above formula to obtain H_q^A and H_q^B. The threshold values are obtained from the sum of H_q^A and H_q^B. The maximum threshold value obtained is the optimal threshold value [5]. Although the Albuquerque method was successful, it was effective with global long-range correlations but did not prove as effective in the case of local long-range correlation. Hence it was not able to efficiently segment IR images and the output images from Non-Destructive Testing (NDT). To overcome this issue, certain modifications were introduced to the initial method. The new equations are

$$H_q^A(t) = \frac{1 - \sum_{i=1}^{t} (\frac{P_i}{P_A})^q}{q-1}$$

$$H_q^B(t) = \frac{1 - \sum_{i=t+1}^{n} (\frac{P_i}{P_B})^q}{q-1}$$

The H^A and H^B values for all the local regions are calculated and each time, the minimum value of the two is considered as a candidate for optimal threshold value. The maximum of the candidate values is used as the optimum threshold value. This is used to segment the images. After observing multiple test cases, it can be concluded that the 'q' value that yielded the best results was 0.8 [5]. Using the earlier method, better threshold values were obtained by varying the q value. The new proposal here is, in local correlation if the probability value in the entropy is multiplied by a constant, say C, segmented image has enhanced details.

$$H_q^A(t) = -\sum_{i=1}^{t} C * \{(p_i/P_A)\, ln(p_i/P_A)\}$$

$$H_q^B(t) = \frac{1 - \sum_{i=t+1}^{n} C \; * \{(\frac{P_i}{P_B})^q\}}{q-1}$$

where C value is generally 75 for regular, medical images and 550 for IR images.

Since the local long range correlation is used, multiplying the probability value by this constant value (C) increases the dynamic range. The optimum value for 'C' is obtained after conducting many experiments on different images. This 'C' value can be increased to some extent to attain even better details. This extent or peak value varies for different images based on their pixel intensities. Up to this peak value the background details are suppressed efficiently, thereby giving better view of the objects. Crossing this peak leads to deterioration of object details.

4 Experimental Results

The modified Tsallis entropy is applied for different categories of images like normal, IR and medical radiographic images.

Table 1: Normal Vs improved threshold for standard images

Images	Normal Threshold	Improved Threshold
Lena	41	77
Barbera	56	85
Baboon	54	90

Table 2: Normal Vs improved threshold for Infrared images

Images	Normal Threshold	Improved Threshold
IR1	36	174
IR2	35	172

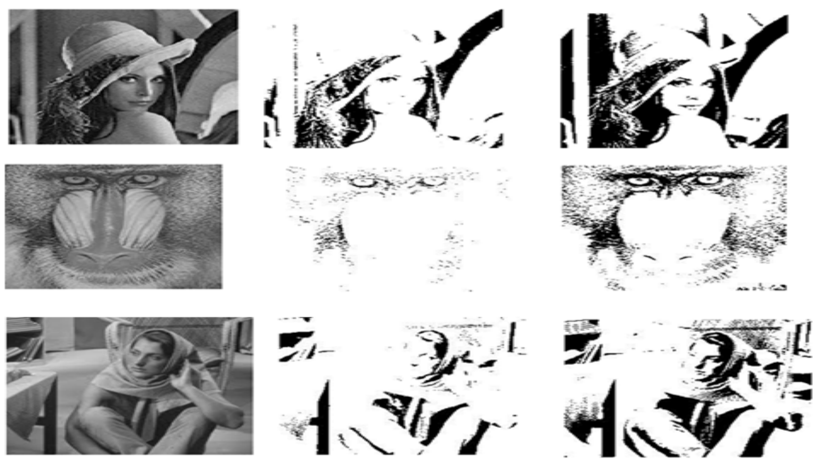

Fig. 1. Normal Images, Tsallis entropy based segmentation and modified Tsallis entropy based segmentation

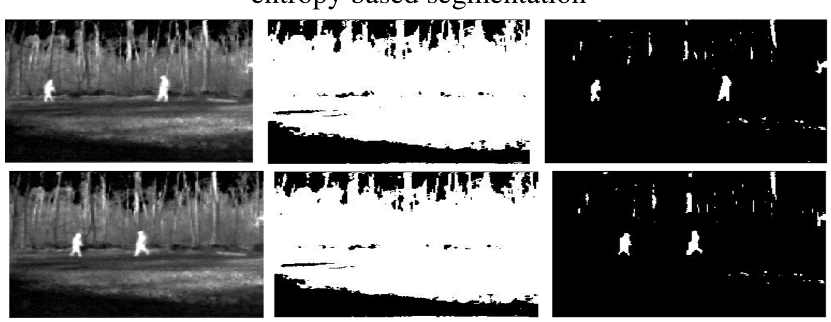

Fig. 2. Infrared Images, Tsallis entropy based segmentation and modified Tsallis entropy based segmentation

Fig. 3. Sample medical radiographic image, Results of Tsallis entropy based segmentation and Results of Modified Tsallis entropy based segmentation

The Fig. 1. given above shows various images and their segmented versions, whereas, the second column represents images segmented based on threshold value obtained by Tsallis entropy using long range correlation. The third column shows images segmented with Tsallis entropy along with the factor ‘C’. The corresponding threshold values are shown in Table 1. Similarly Fig. 2. and Table 2 gives details of image before and after implementing the new criteria for IR images. Significant improvement in image segmentation can be seen clearly from the figures. Images in Fig. 3. shows the initial medical radiographic image, Tsallis entropy based image segmentation and modified Tsallis entropy based segmentation respectively. The modified Tsallis entropy gives better image segmentation than the Tsallis entropy based image segmentation. The quality of the image segmentation is a subjective parameter.

5 Conclusions

The Tsallis entropy model is one of the best methods to find the optimal threshold value based on which an image can be segmented. This is because, a non-extensive parameter which makes use of local-long range correlation is used rather than global long-range correlations. Furthermore, it can be observed that if the probability values are multiplied by a constant factor (C) the segmentation is more efficient than the above suggested method. Upon experimenting with many images, the optimum C value for regular images, medical radiographic and IR images are found to be 75 and 550 respectively. The outputs yielded show the object details distinctly from its background. This can be evidently seen in the test cases and results using various standard images and IR images shown above.

References

[1] Ashish Kumar Bhandari, Vineet Kumar Singh, Anil Kumar, Girish Kumar Singh, Cuckoo search algorithm and wind driven optimization based study of satellite image segmentation for multilevel thresholding using Kapur’sentropy, Expert Systems with Applications, **41** (2014), 3538–3560.

[2] Beauchemin, M., Image thresholding based on semivariance, Pattern Recognition Letters, **34** (2013), 456-462.

[3] Feng, D., Wenkang, S., Liangzhou, C., Yong, D., and Zhenfu, Z, Infrared image segmentation with 2-D maximum entropy method based on particle swarm optimization (PSO), Pattern Recognition Letters, **26** (2005), 597-603.

[4] Lan, J., and Zeng, Y., Multi-threshold image segmentation using maximum fuzzy entropy based on a new 2D histogram, Optik, **124** (2013), 3756– 3760.

[5] Lin, Q., and Ou, C., Tsallis entropy and the long-range correlation in image thresholding, Signal Processing, **92** (2012), 2931–2939.

[6] Li, Z., Liu, C., Liu, G., Cheng, Y., Yang, X., and Zhao, C., A novel statistical image thresholding method, International Journal of Electronic Communication (AEU), **64** (2010), 1137–1147.

[7] Manikantan, K., Arun, B.V., and Yaradoni, D.K.S, Optimal multilevel thresholds based on Tsallis entropy method using golden ratio particle swarm optimization for improved image segmentation, Procedia Engineering, **30** (2012), 364-371.

[8] Mello, C.A.B., Schuler, L.A., Thresholding images of historical documents using a Tsallis-entropy based algorithm, Journal of software, 3 (2008), 29-36.

[9] Portes de Albuquerque, M., Esquef, I.A., Gesualdi Mello, A.R., Image thresholding using Tsallis entropy, Pattern Recognition Letters, **25** (2004), 1059–1065.

[10] Xiao, Y., Cao, Z., and Yuan, J, Entropic image thresholding based on GLGM histogram, Pattern Recognition Letters, **40** (2014), 47-55.

[11] Zhang, J., Yan, C.-H., Chui, C.-K., and Ong, S.-H., Fast segmentation of bone in CT images using 3D adaptive thresholding, Computers in biology and medicine, **29** (2010), 231-236.

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