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Segmentation of Objects by Using Thresholding Technique

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Abstract: It is essential to segment the scattered and distributed objects in the field of image inpainting and image restoration methods and many other fields. This paper presents a novel object segmentation technique. The objects in the image are segmented by using a multiple-color thresholding technique. In the segmentation process, some misclassifications have occurred. Those are mitigated in the post-processing stage by using some of the morphological operations. The performance of the proposed technique is compared with existing techniques. The results show that the proposed technique gives an optimal performance of the existing techniques both in terms of visually and quantitatively.
Keywords: Segmentation, Morphological operations, Connected component analysis, Dilation.

Introduction

Image segmentation divides the image into a number of meaningful segments. It is the fundamental step in many fields those are medical imaging techniques [1, 2], image retrieval [3, 4], change detection [5, 6, 7], object recognition [8, 9, 10, 11, 12] and video surveillance [13, 14]. In object segmentation technique particular object is extracted from the image. It divides the image into two regions foreground and background. Various methods are proposed in the literature to solve this problem [15-21].All these methods require user assistance.

The oldest and simple object segmentation technique is Magic Wand and Lasso tool [22]. This is used by the many image editing tools, but the accuracy depends completely on user assistance. Intelligent scissors [23] uses object boundaries to segment the objects more accurately. This method requires few seed points on object boundary and it uses 'live-wire' boundary detection [24] to find the optimal control between the provided points. Some of the contour based object segmentation methods are proposed in [25-27]. Some of the methods like [28, 29, 30] require users to draw the boundary edges in order to segment the object, then the segmented result is refined by the matting tools [31]. Corel knocout2 [32] uses object trimap to describe the three regions. Those are the foreground, background and unknown regions. The pencil tool is used to mark the object boundary. In the three regions are the unknown region is computed by estimating the alpha value between the pencil color to the foreground and background.

Due to the superior performance Graph-based segmentation [33] is used widely in the last decade. In graph cut segmentation technique the image is considered as a weighted undirected graph and the segmentation is solved by finding a global minimum of the energy function defined over the graph. In [34] an extensive user effort is required to obtain pleasing results. A review of well-known graph based image segmentation techniques can be found in [35]. In Lazy Snapping [36] user draws lines on the foreground and background. It uses graph cut technique [33] to segment the object. It shows adequate results, however, the user is fatigued in terms of post-processing boundary editing which is quite similar to the seeding step in intelligent scissors method.

In Grab Cut based segmentation [34] the target object bounded by the rectangle box; inside the box is considered as the foreground and outside the region is considered as background. The segmentation result obtained after applying the Grab cut is considered as initial segmentation. The fine segmentation is achieved by matting [33] technique in the initial segmented result. Some of the well-known graph based segmentation methods are [35, 38–42]. Grow cut [43] technique considers the labeling problem as bi-directional in order to solve. All the techniques discussed so far can able to segment a single object accurately. But these techniques are not effective in segmenting the scattered and distributed objects.

The techniques in [21, 43, 44] is able to segment the object which may be coherent, distributed and scattered. It requires the user marked points on the target object. When the scattered object has meshed then it is difficult to mark the points in the target object. The proposed object segmentation technique is also used to segment the coherent, distributed and scattered objects even when the object is like mesh like structure. In the proposed technique, the threshold values are used to segment the object.

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Proposed method

The proposed method is used to segment the scattered and distributed objects from digital images with little user assistance. For obtaining the initial segmentation multiple-color thresholding is used. The result obtained after thresholding contains some blobs which are mitigated by using the morphological techniques.

In the initial segmentation process, the original input image is converted into the YCbCr color space. A histogram is obtained for the Y, Cb, Cr channels.This technique requires two thresholds for each channel: one is the minimum threshold value and other is the maximum threshold value. Selection of the threshold values is the key in the segmentation process. If we select the wrong threshold value it leads to undesired segmentation. The threshold values are selected based on intensity variations present in the histograms. The following eqn.1 [45] is used for segmentation.

$$\Omega(x,y) = \begin{cases} 1, & \text{if } t_{min} \le f(x,y) \le t_{max} \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Where t_{min} is the minimum threshold value and $t_{max}$is the maximum threshold value. The result obtained after applying the segmentation is considered as the initial segmented result. The initial segmented result may include background objects. This is due to the color similarity between the foreground and a background object. One can observe in Fig. 1b is the initial segmentation result of Fig.1a which contains some blobs these are encircled with red color. These are eliminated or at least mitigated in the refinement process.

The misclassifications occurred in the initial segmentation process are two types. One of them is called as false positives and other is called as false negatives. When the non-object pixel is classified as object pixel it is considered as false positives. Normally these are small in size and these are eliminated using the connected component analysis [21]. In the connected component analysis the object is divided into a number of connected groups. The size of each group is calculated and which is having less γ vale those are eliminated. The object pixels which are classified as non-object pixels are called as false negatives. These are normally appearing around the boundary of the object. This can be included by using the dilation operation.The final segmented resultafter applying the refinement process is shown in Fig.1c

(a) (b) (c)

Fig.1 (a) Original input image (b) Initial segmented result (c) Final segmented result

Results and Discussion

The proposed segmentation technique is assessed by the dataset used in [43] in the evaluation process. The data set contains the different kinds of objects, such as fence occluded images whether the fence may be regular or irregular, images with multiple distributed objects with the same type e.g., flowers and sheep and single coherent object e.g., flower, bear, and wall. Quantitative and Qualitative evaluation is performed with state-of-the-art segmentation techniques.

In order to show the performance of the proposed technique different types of images is considered as examples. Which are shown in Fig.2 among these the first image i.e. Fig2a &Fig.2b contains the scattered regular fence which is segmented from the image which is shown in Fig.2g & Fig.2h. In Fig.2b the fence is very thin in this case also the proposed technique is able to get the fence. According to the [21, 34, 38 & 43] user has to mark few points on the target object in order to segment the fence which is difficult in this case. Whereas Fig.2c & Fig. 2e are contained the Coherent object the segmented results of these are shown in Fig.2i& Fig2k. The performance of the proposed technique is tested for the segmentation of the aerial image contains the river the input image and out is shown in Fig.2j respectively. Fig.2f contains the fence occluded by the picket of flowers in this case the segmentation object is occluded with the foreground object still the technique achieved the promising results which is shown in Fig.2l.

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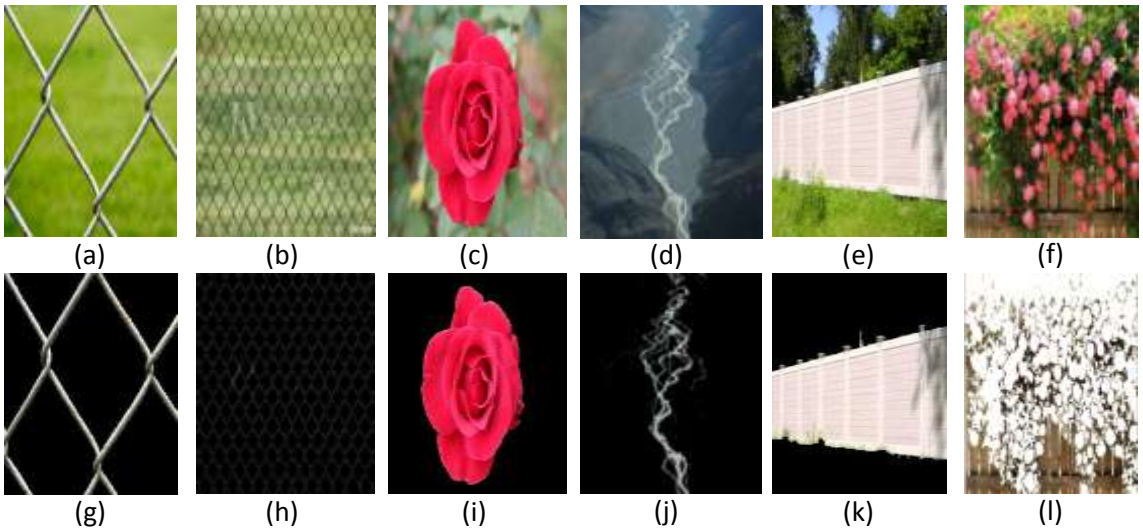
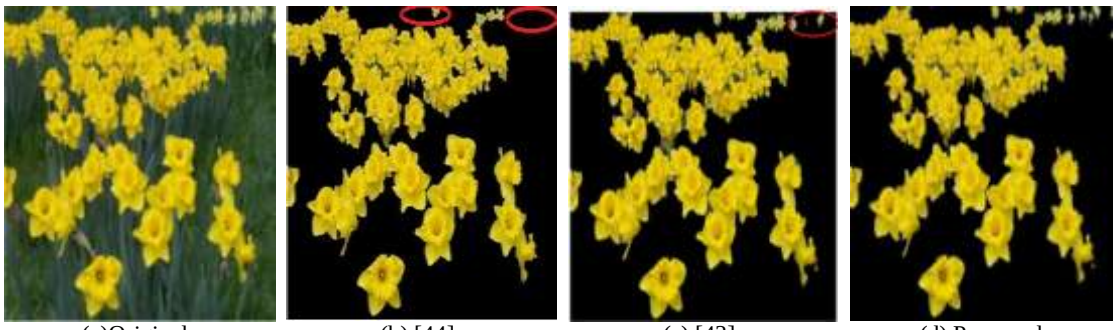


Fig.2 Segmentation results of various objects. Top row (a-f): Input images (g-l): Bottom row segmentation results obtained by the proposed approach.

Qualitative analysis and Comparison

The visual results of the proposed technique are compared with the well know object segmentation techniques: De-fencing method [21], Grab Cut [34], Grow cut [38], Dost [43], Semi-automatic segmentation technique [44]. In order to evaluate results quantitatively ground truth image is required the set of images which are considered in Dost [43] are considered for evaluation of the proposed technique.

Fig.3a contains the bed of yellow flowers image is the original input image. The input image contains a similar type object i.e. the yellow flower is distributed in the entire image. Fig.3b contains the segmentation result obtained by the semi-automatic segmentation technique [44] some flowers which are in the input image is not segmented by this approach those are marked by the red circles. The result of the Dost [43] is shown in Fig.3c which is close to the expected outcome however few flowers are missed in the output those are highlighted by the red circles. The segmentation result obtained by the proposed approach is shown in Fig.3d. This is very accurate to the expected result.



(a)Original (b) [44] (c) [43] (d) Proposed

Fig.3 Visual comparison of the proposed method with the [43, 44] for 'Bed of Flowers' image (a) Input image (b) Result of [44] (c) Result of [43] (d) Result of the proposed approach.

In each Fig shown in the following, the input test image is presented in (a) and ground truth of the test image is shown in (b) The segmentation result obtained by the de-fencing technique [21], Grab cut [34], Grow cut [38], Dost [43] are shown (c, d, e, & f) respectively, the result obtained by the proposed approach is shown in (g). The inaccurate segmentation results are highlighted by using circles.

The visual comparison of the Sparrow image is presented in Fig.4. The de-fencing method [21] and Dost [43] are close to the ground truth. The misclassifications in the segmentation result are encircled. Whereas in the Grab Cut [34] and Grow Cut [38] large part of the background portion is noted in the segmentation result. The segmentation result obtained by the proposed method does not exhibit such flaws.

In Fig. 5 visual comparison of the 'sheep' image is shown. It is having two distributed objects of similar type in the image. The segmentation result obtained by the de-fencing method [21] missed one of the sheep in the image. The result obtained by the Grab cut [34] contains some blobs. The result obtained by Grow cut [38] contains a large portion of the background object. Whereas the Dost [43] result is very close to the ground truth, but a very small portion of the background objects is noticed near the legs of both sheep and the result obtained by the proposed approach is almost free of such errors.

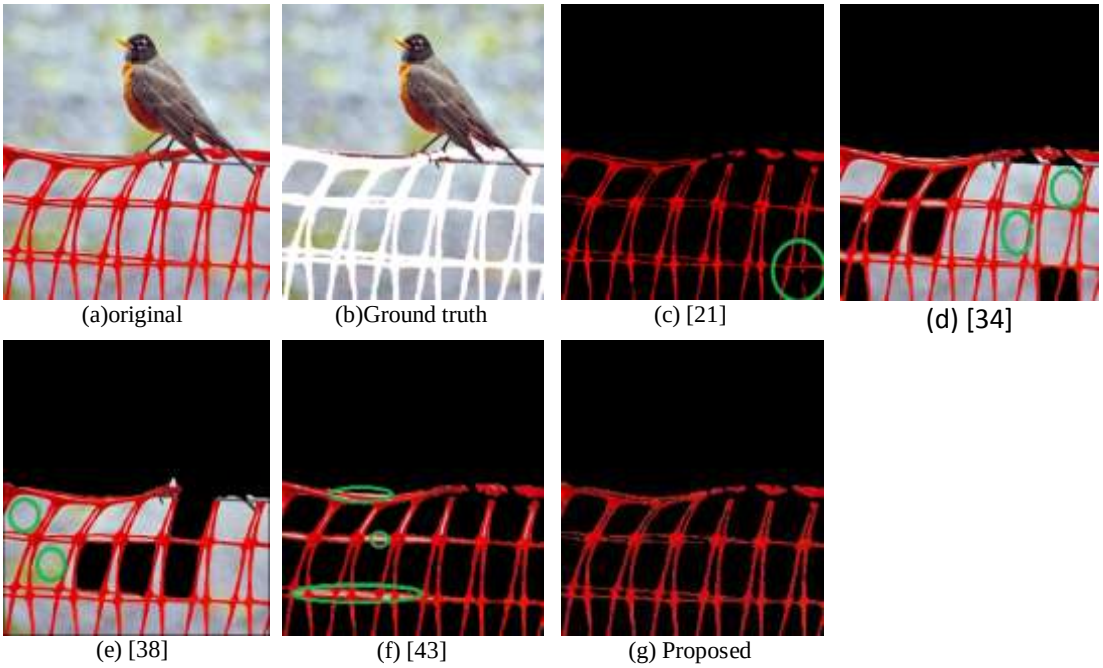


Fig.4 Visual comparison of the proposed method with the [21,34,38,43] for 'sparrow' image (a) Input image (b) Ground truth (c) Result of [21] (d) Result of [34] (e) Result of [38] (f) Result of [43] (g) Result of proposed approach.

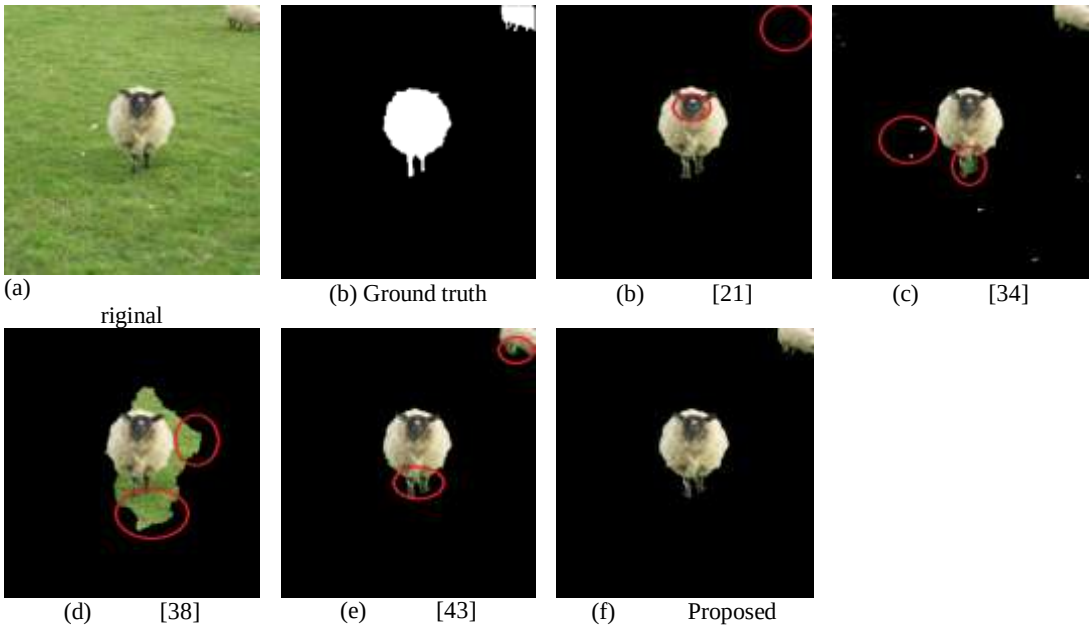


Fig.5 Visual comparison of the proposed method with the [21,34,38,43] for 'sheep' image (a) Input image (b) Ground truth (c) Result of [21] (d) Result of [34] (e) Result of [38] (f) Result of [43] (g) Result of proposed approach.

The visual quality of the 'snapdragon' is shown in Fig.6. The result obtained by the de-fencing method [21] and Dost [43] are almost similar very few parts from the background are noticed. The result obtained by the Grab cut [34] and Grow cut [38] are contains a large portion from the background. The result obtained by the proposed approach also contains a few portions from the background which is less compared to other results.

The visual quality of the 'Bear' is shown in Fig.7. The result obtained by the de-fencing method [21] the Grab cut [34] and Grow cut [38], and Dost [43] contains a few parts from the background object. Whereas the result obtained by the proposed approach does not contain such flaws.

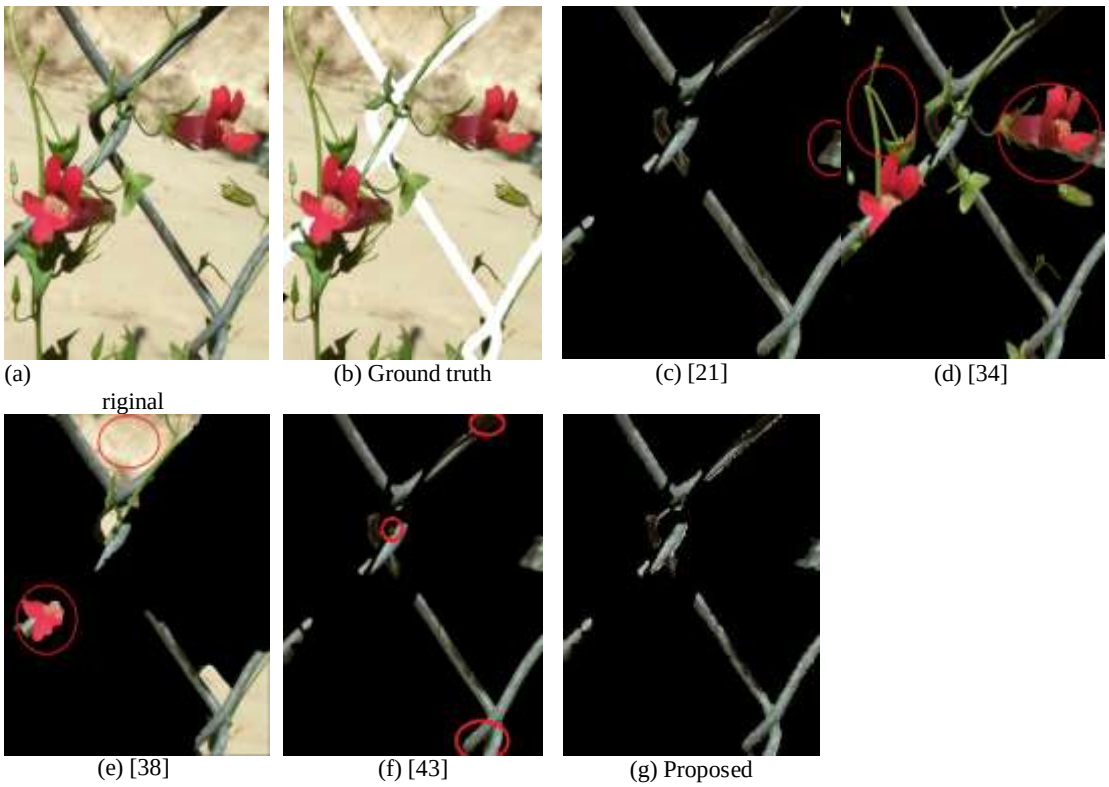


Fig.6 Visual comparison of the proposed method with the [21,34,38 & 43] for 'snapdragon' image (a) Input image (b) Ground truth (c) Result of [21] (d) Result of [34] (e) Result of [38] (f) Result of [43] (g) Result of proposed approach.

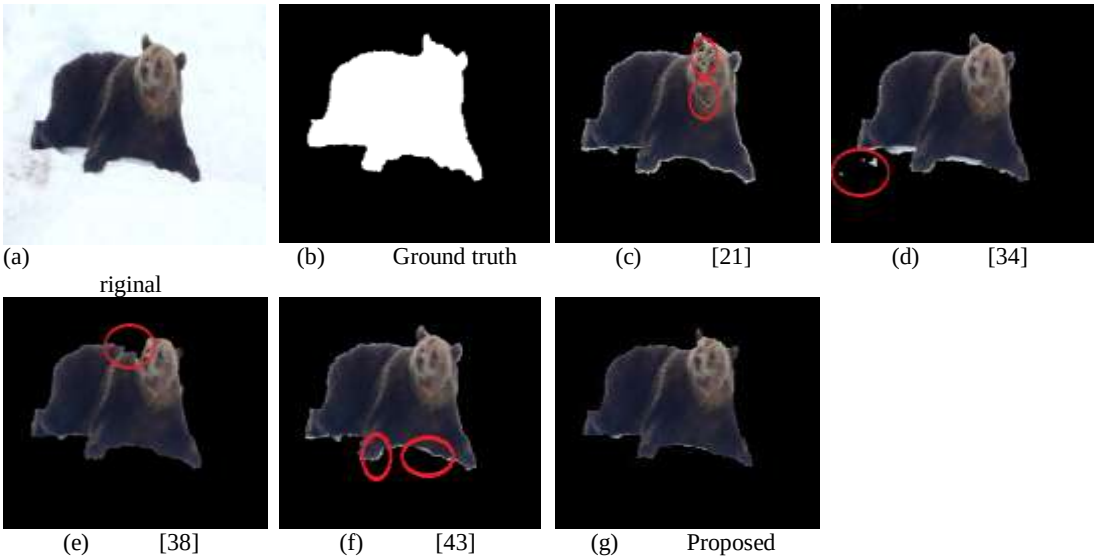


Fig.7 Visual comparison of the proposed method with the [21,34,38 & 43] for 'bear' image (a) Input image (b) Ground truth (c) Result of [21] (d) Result of [34] (e) Result of [38] (f) Result of [43] (g) Result of proposed approach.

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Quantitative analysis and comparison

In order to evaluate the performance of the proposed method the set of images and ground truth of the images used in Dost [43] are used. Statistical parameters: Accuracy, precession, recall and F1 score in eqn.2 &eqn.3. are used for the evaluation of the segmentation results. Accuracy is computed to find the closeness of the measured value to the actual value. Precision is used to find the repeatability of the measured value.

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \; ; \;\; \text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{FN} + \text{TN} + \text{FP}} \tag{2}$$

The recall is the average of correctly identified positives to the total positives. It is also called a true positive rate. F1 score is the weighted average of the recall and precision. It is considered both false positives and false negatives it is useful when these values are unbalanced.

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}; \; \text{F1 score} = \frac{2 \times \text{precision} \times \text{recall}}{\text{precision} + \text{recall}} \tag{3}$$

The eight images are considered for the evaluation of the segmentation method proposed in this paper. The comparative parameters are presented in Table 1 and Table 2. Best results are highlighted in both tables. Table 1 contains the objective evaluation of accuracy and precession. For the sparrow, snapdragon, park and bear images the proposed method given better results in terms of accuracy. The average accuracy of the [21, 34, 38 & 43] is 0.95, 0.84, 0.9 & 0.98 respectively. The accuracy achieved by the proposed method is 0.97 which is less than the method presented in [43]. Garb cut [34] produced the least average accuracy among all the methods used in the comparison. Apart from the park and rose image the proposed method outperforms in terms of precision. The average precession of the [21, 34, 38 & 43] is 0.91, 0.64, 0.64 & 0.94 respectively. The average precession of the proposed method is 0.99 which is better than the compared methods. Grab cut and Grow cut [34, 38] produced the poorest average in terms of the precision

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Table 1 The objective evaluation of theproposed method is compared with the [21, 34, 38 & 43] methods in terms of accuracy and precision

Exp	Accuracy					Precision				
	[21]	[34]	[38]	[43]	Proposed	[21]	[34]	[38]	[43]	Proposed
Chimpanzee	0.96	0.32	0.80	**0.98**	0.97	0.96	0.14	0.37	0.91	**0.99**
Sparrow	0.95	0.97	0.71	0.96	**0.98**	0.98	0.50	0.42	0.90	**0.98**
Sheep	0.93	**0.99**	0.92	0.98	0.97	0.85	0.94	0.45	0.88	**0.99**
Snapdragon	0.97	0.86	0.84	**0.99**	**0.99**	0.88	0.39	0.32	0.97	**0.99**
Park	0.95	0.57	0.88	**0.99**	**0.99**	0.98	0.24	0.63	**0.99**	0.98
Rose	0.95	**1.00**	0.99	0.99	0.99	0.85	**1.00**	0.99	0.92	0.99
Wall	0.96	**0.98**	**0.98**	**0.98**	0.91	0.85	0.97	0.96	0.97	**0.99**
Bear	0.96	**0.99**	**0.99**	**0.99**	**0.99**	0.95	0.95	**0.99**	0.97	**0.99**
Average	0.95	0.84	0.89	**0.98**	0.97	0.91	0.64	0.64	0.94	**0.99**

In Table 2 Recall and F1 score, evaluation results are presented. For the sparrow, sheep and Snapdragon images the proposed method marginally better results than other methods used for the comparison. The average Recall achieved for the [21, 34 & 38] is 0.92, 0.95& 0.8. The average recall achieved for the Dost [43] and the proposed method is same which is 0.97. The proposed method produced the best results in terms of F1 score for all the images considered in the evaluation process. The average F1 score achieved for [21, 34, 38 & 43] is 0.91, 0.72, 0.69 & 0.95. For the proposed method the average F1 score is 0.98. Grow cut [38] produced the least average F1 score among the methods used for the comparison. The visual and objective results show the effectiveness of the proposed segmentation method for the scattered, distributed and coherent objectives.

Table 2 The objective evaluation of theproposed method is compared with the [21, 34, 38 & 43] methods in terms of recall and F1 score

Exp	Recall					F1 score				
	[21]	[34]	[38]	[43]	Proposed	[21]	[34]	[38]	[43]	Proposed
Chimpanzee	0.88	0.75	0.69	**0.96**	0.89	0.92	0.24	0.49	0.93	**0.95**
Sparrow	0.76	0.93	0.93	0.93	**0.97**	0.86	0.65	0.58	0.91	**0.98**
Sheep	0.88	0.98	0.83	0.91	**0.99**	0.86	0.96	0.59	0.89	**0.99**
Snapdragon	0.96	0.95	0.67	0.96	**0.97**	0.92	0.55	0.43	0.96	**0.98**
Park	0.97	0.98	0.36	**1.00**	0.99	0.97	0.39	0.46	**0.99**	**0.99**
Rose	0.96	0.99	0.96	**1.00**	0.99	0.90	**0.99**	0.98	0.96	**0.99**
Wall	0.96	0.98	0.99	**1.00**	0.98	0.90	**0.99**	0.98	0.98	**0.99**
Bear	0.96	**1.00**	0.95	0.99	0.99	0.95	0.97	0.97	0.98	**0.99**
Average	0.92	0.95	0.80	**0.97**	**0.97**	0.91	0.72	0.69	0.95	**0.98**

Conclusion

In this paper, thresholding based segmentation technique is presented to segment the scattered, coherent and distributed objects from the image. The initial segmented result obtained by the segmentation technique contains some blobs and disconnected portions in the edges of the segmented object. The blobs in the segmented result are eliminated by using the connected component analysis. The disconnected portions are included by using the dilation operation. The results obtained by the proposed approach shows the effectiveness of the proposed approach both in terms of subjectively and objectively.

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