# The Color Dissimilarity based Method among Other Segmentation Methods: A Comparison

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Abstract: The segmentation process plays a very important role in the process of detecting and recognizing objects in an image. Although many segmentation methods have been developed, there is no method that can give good results and is generally accepted. This study aims to find a better segmentation method in finding patterns or ground-truths of objects in an image, so that these objects can be easily recognized. Based on the results shown by all the methods being compared, several methods were not successful in showing the pattern of objects contained in the sample image. The segmentation method based on color dissimilarity, which is a method that emulates the way humans recognize an object based on visible color differences, shows the best results compared to other methods. This method is a very suitable method to be used in the process of detecting and recognizing objects in an image.

## 1 INTRODUCTION

Our interest in an image actually lies in certain parts. This part usually has unique and special properties. In image processing, this part is commonly referred to as the target or foreground. The other part is called the background. It takes an extraction process to separate these parts so that they can be analyzed and identified. This is where image segmentation comes into play. Based on the features it has, whether in the form of gray pixels, colors or other textures, the segmentation process is carried out. The goal is to find these targets (Jun, 2010).

In image processing, object identification can be done after going through a number of process stages. This series of processes consists of noise removal, segmentation, feature extraction and classification. Of all the stages of this process, the segmentation process is the most important and most determining the success of the object identification process (P. Agrawal et al., 2010). The process of segmenting an image is a process of partitioning an image into several parts. The process of image partitioning is carried out based on the similarity of existing characteristics in the image, such as similarity in color, intensity, texture, shape and others, so that it can be used to find and identify objects and boundaries in an image (Kumar et al., 2014). This segmentation process will change the image representation in such a way that it becomes easy to analyze (Dass et al., 2012).

Image segmentation is the first step in image analysis. The image segmentation process divides the image into a collection of pixels which are connected into a single unit. The resulting set of pixels is a region, which is determined on the basis of visual properties extracted from the local features of the image (Ivanovici et al., 2013). The segmentation process will divide the image into several segments in such a way that it can find objects and image boundaries. Image segmentation is used to identify objects and backgrounds in the image (Saini & Arora, 2014). Image segmentation is the process of assigning a label to each pixel in an image such that pixels with

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the same label share certain visual properties (Jayagar & Jeyakumari, 2015). The segmentation technique mainly converts complex images into simple images.

There are many factors that influence the results of the image segmentation process. Apart from the problem domain, the pixel color factor, color intensity, texture, similarity and image content will determine the outcome of this segmentation process. The number of these factors, of course, is not all capable of being considered or handled by every existing segmentation method. So it is very natural that there is no segmentation method that applies to all types of images (M. W. Khan, 2014). This is due to the variety of existing image features (Vidhya et al., 2016). Each image segmentation technique has its own advantages and disadvantages. Some of the existing techniques were developed with a specific purpose, so that they will be more suitable and perform better when applied to these applications. Therefore, the performance measure is more determined by the application (Faiza Babakano, 2015).

Various approaches have been proposed in image segmentation, both related to certain aspects and improvements from previously known methods. These efforts are practically unceasing to optimize and refine existing techniques in order to obtain more perfect results (Phonsa & Manu, 2019). Although various segmentation techniques have been developed with more promising results, they are still a challenge and continue to be developed in an effort to find better techniques (Fahad & Morris, 2006). Because there is no universal segmentation technique, in order to streamline the segmentation process, these various techniques often have to be combined in their application (Zaitoun & Aqel, 2015). The selection of this segmentation technique and the level of segmentation carried out are determined based on the type of image and the characteristics of the problems being faced related to this image (B. Kaur & Kaur, 2015). A good segmentation technique is a segmentation technique that is able to maintain image features in an efficient and short computation time (D. Rasi, 2016). The existing images are of course very diverse, both in terms of color, intensity, texture, features and so on, which are used as a basis for segmentation. It becomes very natural that a segmentation technique cannot be applied in general. By considering the various advantages of each existing technique, it is necessary to consider an alternative combination of these existing techniques (Song & Yan, 2017).

Some image segmentation techniques in principle work based on the gray level of an image. But in fact, this technique works even better when applied to color images. This is possible because the colors in an image have a lot of information and are clear (Shakti, 2013). Knowledge of pixel color is the basis for developing the segmentation method (K. & S., 2014). The existence of pixels in an image greatly affects the image segmentation process. Although the segmentation process can be carried out on the basis of the features of the image, the results will not be good if it ignores the existence of pixels and the relationship between these pixels. This is due to the existence of pixels that often overlap between regions in an image (Karmakar & Dooley, 2002). The segmentation process which is based on a certain combination of color intensity and texture gives better segmentation results (Taneja et al., 2015).

There are 3 (three) factors that can be considered as assessing whether a segmentation method is good or not. The three factors are precision (reliability), accuracy (validity), and efficiency (viability). The difficulty is that each of these factors affects one another. Improvement in one factor will impact on other factors (Udupa et al., 2006). There are some general guidelines that can be applied in choosing a segmentation technique. If the benchmark is pixel clusters, then area-based segmentation techniques are most appropriate. If based on pixel classification, without considering the cluster connection, then the clustering segmentation technique is better (Hosseinzadeh & Khoshvaght, 2015). To get good results and apply to various applications and images is certainly not easy. Continuous research is needed to develop better segmentation techniques. One alternative that needs to be considered is to involve user interaction (Chandel et al., 2012).

In this research, we will compare various well-known and widely used segmentation techniques. The aim is to get to know and at the same time know the advantages and disadvantages of each of these segmentation techniques. By understanding the characteristics of each of these segmentation techniques, it will be easier to choose the appropriate technique for the segmentation problem at hand.

# 2 IMAGE SEGMENTATION TECHNIQUES

As previously mentioned, there are various techniques and algorithms that have been applied in image segmentation. These various techniques and algorithms are then grouped with various approaches as well. The groupings include:

a. contextual technique and non-contextual technique.

The segmentation technique is grouped on the basis of its treatment of the features possessed by the image. The contextual technique fully considers the relationship between image features, whereas the non-contextual technique completely ignores (Sekar & Ilanchezhian, 2015);

b. based on discontinuity dan based on similarity.

The segmentation technique is grouped based on how to partition the image based on the intensity of the gray level of the image. In the based on discontinuity technique, image partitioning is carried out when there is a sudden change, whereas in the based on similarity technique, image correction is carried out on the basis of the similarity of the gray level of the image (Matta, 2014; Narkhede, 2013; Sonawane & Dhawale, 2015);

c. structural, stochastic and hybrid techniques.

In structural techniques, image sorting is carried out based on the structural information of the image part, while in stochastic techniques it is carried out based on the discrete pixel value of the image (D. Kaur & Kaur, 2014). Hybrid technique is a segmentation technique that combines both techniques, namely using discrete pixels and structural information together (Inderpal & Dinesh, 2014).

Regardless of how they are grouped, each of these techniques has a different way from one another, which will be described in the following section.

## 2.1 Threshold Method

This method performs image segmentation based on a certain threshold value, which is usually predetermined. By specifying an appropriate threshold value, a gray image can be converted to a binary image. In general, the conversion of a gray image to a binary image is carried out by referring to a threshold value (T). Furthermore, for all gray level values of the image that are equal to or less than T, they are classified as black (0), while otherwise classified as white (1). Because this method works on the basis of a gray image, the color image will be converted to a gray image first. This threshold resulting image can be defined as (Yan et al., 2005):

$$g(x,y) = \begin{cases} 1 \text{ if } f(x,y) > T \\ 0 \text{ if } f(x,y) \leq T \end{cases} \quad (1)$$

Referring to the properties of an image, this method is then applied with several variants, namely global, local and adaptive. The global threshold variant is applied to a segmentation process based on the gray level values. The segmentation process, which refers to the gray level values and local properties of the image, applies the local threshold variant. Whereas for the segmentation process based on the gray level value, the environment and pixel coordinate properties of the image will apply an adaptive threshold variant (Al-Amri & Kalyankar, 2010).

This method partitions the image using a threshold value. Image segmentation is done by comparing the threshold value with all image pixels. Each image pixel is then given an object label or image background (Vidhya et al., 2016) (Kang et al., 2009). This method has the advantage of simple calculations and fast operation. Excellent performance is produced when the image has contrasting objects and backgrounds. Poor results will be obtained when the images do not have sufficient gray scale differences (Yuheng & Hao, 2017). The key to the success and weakness of this method is the accuracy in selecting / determining the threshold value (Sivakumar & Meenakshi, 2016).

## 2.2 Edge based Method

This method performs the segmentation process by finding the pixels that are the boundaries of the objects contained in an image. This boundary is a closed area and the number of closed areas is equal to the number of objects in the image (Rani & Sharma, 2012). Previously, the image is converted to gray image first, and edge detection is done with the help of the operator (Ansari et al., 2017). This method partitions an image based on a significant change in image intensity. An edge is a set of pixels that are related to one another, and at the same time it is the boundary of two regions that have different gray values. Therefore, these pixels are commonly referred to as edge points. This edge point can be determined based on the approximate intensity gradient of the pixels (Senthilkumaran & Rajesh, 2009).

There are various edge detectors applied to this edge-based segmentation method (Pardhi & Wanjale, 2016; Yogamangalam & Karthikeyan, 2013). This is intended to simplify image analysis. Detector functions to reduce data processing, but on the other hand, structural information related to object boundaries can still be maintained (Canny, 1986). Different techniques are used to perform edge detection and among them the gradient-based method and the gray histogram are the most commonly used techniques for edge detection (W. Khan, 2013). In the gray histogram method, segmentation is based on separating the foreground from the background by selecting a threshold value. Whereas in a gradient based method, segmentation is based on sudden changes between the intensity of two regions (Zhengdong, 2015).

There are several variations of this method based on the type of operator used, namely the Robert, Sobel, Prewitt, Canny and Laplace operators (Saluja et al., 2013). Sobel operator is used for edge detection in two directions (horizontal. Vertical) (Maurya et al., 2020). This operator is used to calculate the gradient estimate of the image enrichment function. Similar to the Sobel operator, the Prewitt operator detects edges based on the difference in pixel intensity in the image.

## 2.3 Region based Method

The concept of this method is actually very close to human perception, that is, features are extracted based on certain aspects such as ratio, circularity, invariance and so on from color, shape and texture (S et al., 2014). This area-based segmentation technique works with the concept of homogeneity. The image will be divided into areas where there are connected pixels, which have similar characteristics, which are different from other regions (Kaganami & Beiji, 2009). By relating the different regions in this image to the object and its background, this method is very suitable for object detection and recognition (Lalaoui & Mohamadi, 2013). This method performs sorting of areas on certain criteria which include color, intensity or object. In order to obtain a wider area, taking into account the characteristics of existing pixels, an area-based segmentation method was developed, namely region growing and region splitting and merging (Sivakumar & Meenakshi, 2016).

In the region growing method, the formation of a homogeneous region begins with a pixel at a certain position. Then this area is expanded by adding adjacent pixels that have the same property, namely the predetermined homogeneity criteria. The similarity rate of pixels in a certain region will be greater than the similarity rate in other regions (Qiong, 2015). Properties that can be used as criteria include grayscale level, texture, color or shape. Then this criterion will determine whether a pixel next to it can join in the region or not (Szénási, 2014). The advantage of this method is its ability to separate areas with certain characteristics and is able to show boundaries well. Unfortunately, the high computation costs, uneven grayscale and noise are not handled properly, so the results are not perfect (Yuheng & Hao, 2017).

In the technique of separation and merging of regions, an image is divided into four quadrants with certain criteria to distinguish its homogeneity. Sorting is done repeatedly with the same criteria, until sorting is no longer possible. The sorting results are then recombined to get the desired results (Kaganami & Beiji, 2009; Kang et al., 2009).

## 2.4 Clustering based Method

This method refers to the process of grouping the same or similar data into a particular group or cluster. In the image segmentation process, this method classifies the image based on the pixels in it. This method differentiates and classifies pixels according to certain requirements and rules. Pixels are classified according to similarity using a mathematical algorithm (Wang & Yang, 2010). Pixels with the same characteristics are grouped into a cluster. As a result, the image will be divided into a number of clusters with different pixel coherence for each cluster (Chandhok et al., 2012).

The grouping of pixels into clusters is based on the principle of maximizing the similarity of pixels in a cluster and maximizing the differences between clusters. The process is carried out repeatedly by paying attention to the characteristics of each cluster formed (Jain et al., 1999).

Clustering techniques can be classified into two categories, namely hard clustering and soft clustering. In hard clustering, it emphasizes that there are differences or clear boundaries between one cluster and another. A pixel belongs to one cluster only. In soft clustering, pixel grouping is based on several similarity criteria. Similar pixels will merge into the same cluster. The similarity criteria used can be distance, connectivity or intensity (Sravani & Deepa, 2013).

One of the most popular and widely used clustering methods is K-Means clustering (Acharya et al., 2013). A very simple and fast clustering algorithm, which aims to group data into K clusters (Luo et al., 2003). Grouping is carried out on the basis of the proximity of the grouped elements to the center of the cluster. The distance calculation is done on the various properties which form the basis of grouping (Bhatia, 2004). In color image segmentation, besides using RGB space, the K-Means algorithm can also be applied to the HIS space, so that the hue and intensity components can be fully considered (Zhang & Wang, 2000).

In the K-Means method, the number of clusters has been determined, with the center of the cluster being initially determined randomly. Pixels are then grouped into a cluster based on their proximity. The average for each cluster is then calculated, then proceed with regrouping based on the proximity of the pixel value to the average value on the cluster. This process is repeated until there are no significant changes or in a certain number of repetitions (Thilagamani & Shanthi, 2011).

## 2.5 Watershed based Method

This method includes methods that take advantage of the similarity category in an area, using mathematical morphological approaches and real-life analysis, such as areas affected by floods (Saini & Arora, 2014). Image is considered as a surface gradient topography (Tang, 2010) with the image pixels having the highest gradient will be the boundary of an area, such as a watershed, with continuous boundaries, without gaps (Seerha & Kaur, 2013). Therefore, to understand the working concept of this method, imagine a watershed. An image is analogous to a watershed whose direction follows the color intensity gradient in the image. The segmentation process begins by determining the part of the image that has a minimum intensity, and serves as the base point for watersheds (Bleau & Leon, 2000). When it rains, the watershed will be flooded, forming a puddle area. To prevent standing water from mixing with puddles in other areas, a dam or water barrier is built (Vartak & Mankar, 2013).

The Watershed method in principle succeeds in utilizing the concept of the concept and property discontinuity of an image. By applying grayscale mathematical morphology, this method is able to distinguish well an object in the foreground from its background in an image (Rahman & Islam, 2013). Its weakness is the complexity of the calculation, sensitivity to blur and often results in excessive image segmentation (Jayapriya & Hemalatha, 2019).

## 2.6 PDE based Method

The basic idea of this PDE (Partial Differential Equations) based method is to convert a certain curve, surface or image into a partial differential equation (PDE) with certain initial conditions and limitations. The segmentation results are obtained from the solution of this equation (Wei & Chan, 2016). In this method, image segmentation is carried out by utilizing active contours on an image. The active contour in the form of a curve in an image is defined explicitly by using a multidimensional function. Several PDE methods used for image segmentation are the Snakes, Level-Set, and Mumford Shah method (Xin-Jiang et al., 2009).

To overcome the weaknesses of the Snakes model, an adaptive PDE model has been developed, namely the fuzzy PDE contour model, which applies the Fuzzy C-Means classification to the PDE geometric contours when segmenting images. The aim is to find the boundary of the segmentation area of an image (Bueno et al., 2004).

The problem of changing the object topology in the image is resolved naturally by developing a level set function (Sliž & Mikulka, 2016). In the Level-Set method, the curve or surface of an image is represented as a set of zero levels of a higher dimensional surface. This method turns out to provide a more accurate numerical implementation. Thus, this method is also able to better handle topological problems (Xin-Jiang et al., 2009). The Level-Set method is quite simple and adaptable for calculating and analyzing the interface changes of an image, either two or three dimensions (Zhou et al., 2010).

The PDE method is proven to be able to overcome the geometric complexity of an image. The image generated from the segmentation process using the PDE method can increase the texture contrast of the image (Sofou & Maragos, 2008). With this capability, the PDE method is believed to be able to produce a better segmentation process than other methods (Shahzad et al., 2008).

Apart from segmentation purposes, the PDE method is also suitable for denoising and enhancing image coherence (Yoruk & Akgul, 2004). The application of a nonlinear isotropic diffusion filter to the PDE method will allow the edge enhancement of an image. The algorithm used is additive operator splitting (AOS), which allows the application of filters recursively and separately. To produce good denoising, the PDE method applies the non-convex variational image recovery method. In this case an AOS scheme is used in the decomposition of the Gaussian pyramid (Weickert, 2001).

## 2.7 ANN based Method

This method is actually inspired by the human nervous system model, by simulating the learning process carried out by the human brain. This neural network or neuron is a parallel system that works with guidance and has the ability to learn, just like humans (Amanpreet Kaur & Kaur, 2015). In implementation, this artificial neural network system is trained with a number of training samples, as if the system is involved in the learning process (S. Agrawal & Xaxa, 2014). The system receives input, processes and provides output based on a familiar concept or pattern (Amritpal Kaur & Kaur, 2014).

In its development, currently various neural network models have been developed with a variety of learning algorithms, exploration methods and various analysis methods as well (Tianhao & Tianzhen, 2005). In the image segmentation process, various approaches are used with different levels of success. In general, there are two categories of network methods namely supervised and unsupervised methods. In the supervised method, it takes the presence of an expert to supervise and simultaneously carry out the learning process in the system. Whereas in the unsupervised method, the practical system works automatically. Even if expert involvement exists, it is minimal and intended to improve system performance (Amza, 2012).

This ANN paradigm has been widely used in image processing techniques, including in image segmentation. One of the ANN methods that is considered feasible for image segmentation is the PCNN (Pulse-Coupled Neural Network) model (Carata & Neagoe, 2016). A model inspired by the cat visual system by simply modeling the cortical neurons in the visual area of the cat brain (Cheng et al., 2008), is believed to be able to produce good segmentation results, even though the input image is in poor condition. Each pixel of the image is represented by a neuron. The initial conditions of these pixels and their environment will determine the state of the neurons. These neurons will form a network of temporal pulses, which are presented in a two-dimensional array of laterally connected layers of neurons and pulses. This neural network is then used as the basis for image processing applications (Kuntimad & Ranganath, 1999) (Harris et al., 2015). Image segmentation is performed based on temporal correlation which depends on lateral modulation and bridging waves to synchronize pixels in the same area (Zhan et al., 2017). Related to the problem of setting PCNN parameters in the image segmentation process, it can be overcome by applying artificial intelligence techniques, for example by applying algorithms based on particle swarm optimization (PSO), genetic algorithms (GA) and differential evolution (DE) (Hernández & Gómez, 2016).

### 2.8 Color Dissimilarity based Method

This segmentation method works following the concept of human work identifying objects. An object can be recognized by humans, because the eye's ability to distinguish the color of the object. Each color has its own different R, G and B values, with a value range of 0 - 255. That is, conceptually, there are millions (256x256x256) of color types available. However, not all of these colors can be recognized / distinguished by humans. Apart from the lighting factor, the color similarity factor is also difficult to identify. A new color can be distinguished when the value of R, G or B, singly, in pairs or all three, differs from a certain value (Karma, 2020).

By comparing two adjacent pixels in an image, the segmentation process is carried out with the concept:

$$( k_1 \cup k_2 \cup k_3 ) \rightarrow f(x,y,i) = 255 \quad (2)$$

where:

$k_1 = (\Delta R_{12} \cup \Delta R_{13} \cup \Delta G_{12} \cup \Delta G_{13} \cup \Delta B_{12} \cup \Delta B_{13}) \geq 9$

$k_2 = ((\Delta R_{12} \cap \Delta G_{12}) \cup (\Delta R_{12} \cap \Delta B_{12}) \cup (\Delta G_{12} \cap \Delta B_{12}) \cup (\Delta R_{13} \cap \Delta B_{13}) \cup (\Delta R_{13} \cap \Delta B_{13}) \cup (\Delta G_{13} \cap \Delta B_{12})) \geq 7$

$k_3 = ((\Delta R_{12} \cap \Delta G_{12} \cap \Delta B_{12}) \cup (\Delta R_{13} \cap \Delta G_{13} \cap \Delta B_{13})) \geq 6$

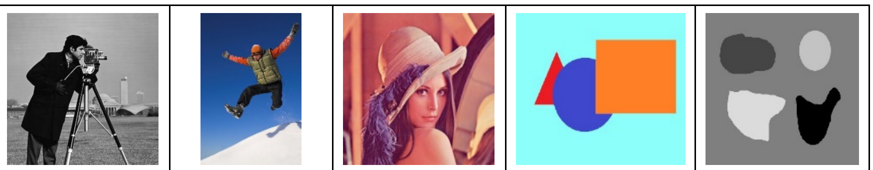
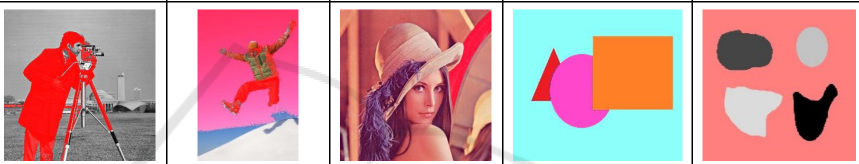
The results obtained are then converted into black and white images, and to clarify and reinforce the results, it ends with a morphological process (Karma et al., 2020).

## 3 RESULTS AND DISCUSSION

Comparisons of the various segmentation methods discussed earlier are carried out on the basis of the results they provide. The main criteria for comparison is the extent to which the results given by each method are able to lead us to the detection of objects in the image. The extent to which each method is able to produce a pattern that is the ground-truth of the object contained in an image. Image segmentation process is a process that plays an important role in the detection and recognition of objects. Therefore, a segmentation process is declared good, if the process is able to provide results that facilitate the process of detecting and recognizing the object.

Testing is carried out using the MATLAB program code from each method on 5 (five) existing samples. In this study, comparisons were made of the results of the segmentation of the proposed Color Dissimilarity method with other methods, such as Thresholding (Bhosale, 2015), Edge (Rajan, 2016), Region Growing (Kroon, 2008), K-Means Clustering (Analyst, 2018), Watershed (MathWorks, n.d.), Fuzzy C-Mean (Li et al., 2011) and Pulse Coupled Neural Network (Hernández & Gómez, 2016). Sample images and results from the segmentation process of each method are presented in Table 1.

Table 1: Sample image and results of each method.

| | |
|---|---|
| Sample image |  |
| Thresholding |  |
| Edge |  |
| Region growing |  |
| KMeansClustering |  |
| Watershed |  |
| Fuzzy C-Mean |  |
| Pulse Coupled Neural Network |  |
| Color dissimilarity (Proposed Method) |  |

This study only uses 5 (five) samples, with sample characteristics that are expected to represent the characteristics of the image in general. The characteristics of the image used are colored or gray images, images that have objects with different background colors or close to the object's color, and images that have several objects attached or separated. This study wants to find out which segmentation method is able to provide better segmentation results, in terms of our ease in detecting objects in the image.

As previously stated, in general, there is no perfect segmentation method that is capable of providing consistent and always good results. Based on the results of tests carried out on the five existing samples, a number of methods seemed unsuitable for use in the process of detection and object recognition, as desired. This is due to the inability of this method to produce a pattern or ground-truth of the object in the image. However, it must be admitted that there are relatively good results for certain samples.

When examined from the results given, the Watershed method shows the most undesirable results, because it is practically unable to produce patterns from existing objects. The K-Means Clustering method is relatively the same as the Watershed method, except in sample number 2, this method is able to show patterns of existing objects. Fuzzy C-Mean and Pulse Coupled Neural Network methods give practically the same results, with unclear and inconsistent patterns, as in the results from sample number 5. The same thing happens to the Thresholding method. There is an object pattern in sample number 4, but it is wrong in sample number 5. The Region Growing method does not appear to produce a pattern from existing objects, except to change the coloring of the original image. The Edge method is able to produce clear borders based on color differences in the image. These borders provide a detailed pattern and tend to be complex and difficult to spot. The relatively good pattern is actually produced by the color dissimilarity method. Of the five existing samples, three samples were able to show their object patterns clearly. Meanwhile, the other two, number 1 and 3, formed a pattern, but it did not clearly show the pattern of the object.

## 4 CONCLUSIONS

This research also shows that there is no perfect and generally applicable segmentation method. However, the Color Dissimilarity method turned out to be able to produce a pattern or ground-truth of the objects contained in the segmented image. This means that this method is very fixed when applied in the process of detecting and recognizing objects in an image.

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