On Comparison of Different Image Segmentation Techniques

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Abstract: Nowadays, image processing is mostly denoted to the processing of digital images. Image processing has two branches: improving images and machine vision. Improving images are the methods that use blurring and increase contrast to improve the visual quality of images and ensure that they are displayed correctly in the destination environment (such as a printer or monitor), while machine vision deals with methods that can be used to mean and understand the content of images to be used in robotics. Image segmentation is one of the greatest significant steps on digital image processing. Image segmentation is separation of picture pixels into separate zones that are identical or as closely correlated as possible in terms of brightness, texture, or color. Image segmentation has lots of applications in many image processing tasks, such as image therapy, machine vision, image compression, object detection. This paper, will provide comprehensive review about different image segmentation techniques. We will compare each of the existing methods with each other and will investigate the positive potentials and drawbacks of each of these methods.

Keywords: Image processing, Image enhancement, Image segmentation, Object detection.

1. Introduction

In the field of image processing, there is a topic called segmentation, which we will address in this article. In digital images, the term image segmentation is the division of picture into groups of pixel based on certain criteria. In fact, the purpose of computer image segmentation is to segment that picture to the corresponding component portions or items. Overall, self-governing splitting up are the greatest challenging jobs in digital image processing.

Cancer has been known as a deadly disease for many years. Even in the new age, despite the great advances in technology, it can be a very deadly disease if we do not detect it in the early stages. So scientists are looking for ways to identify cancer cells in a patient, as it could protect millions of lives. The shape of cancer cells has important role at defining harshness of cancer. To identify cancer cells, it will not be very useful for recognizing the items in picture. Here, if we only identify the Bounding Boxes, we cannot identify the shape of the cells. Image segmentation techniques are very effective here in identifying the targeted cells. They help us to achieve results that are more meaningful and achieve our goal of identifying cancer cells.

Image segmentation is done in different ways that can be normally alienated into the two groups: classical as well as morphological. In classical and traditional methods, changes in light intensity are used to extract the edges and local characteristics of the objects in the target image. Another type of classical algorithms are methods based on statistical algorithms in which segmentation is based on the distribution of pixels and finding the appropriate threshold. Because images often contain noise, clutter, obstruction, light exposure, and the etc., these methods are unusable for many applications. The new methods, that are used recently, use classification (clustering), for image segmentation and classification. These algorithms are like Fuzzy C-means and K-means clustering algorithms, neural network algorithms such as simple competitive training, Bayesian simple training tree and so on. Although these methods have good diagnostic accuracy, they are highly dependent on the initialization value (in K-means the initialization value of the cluster centers and in neural networks the training rate) and the algorithm must be applied to the image over and over again to achieve the optimal answer. Finding the optimal centers of image clusters is a difficult non-polynomial problem. On the other hand, in the most methods, pixel clustering is done based on features such as color or brightness and no spatial or neighborhood information of the pixels is used, which makes these methods inefficient in segmenting noisy images. Also, based on the principle that neighboring pixels in the image are correlated with each other, and given that most pixel clustering algorithms segment the image pixels without considering the similarity between neighboring pixels, the image is so-called over-segmented (it is divided into many areas).

Image segmentation by using clustering neighborhood pixel information, has been considered by researchers in recent years. Let us go through some revision of the works done before.

In [1] the author introduced local light intensity information by modifying the impartial function of FCM method for image segmentation. Consequently, the pixels were tagged under the influence of their local neighborhood. In [2, 3] two new versions of the FCM algorithm are introduced that compute the neighborhood statement before fuzzy clustering. And then, the improved FCM algorithm was defined to accelerate image segmentation, in which a linear weighted total image was computed using the primarily picture, and at that time FCM clustering method was applied for newly created image histogram [4, 5].

The FGFCM algorithm is proposed in [6]. The performance of this method was based on creating a new image using a similarity criterion that combined spatial information and local information of light intensity. Then, an evolutionary approach to unsupervised image segmentation was proposed that aimed to cluster pixels based on information about light intensity and pixel neighborhood relationships, using a genetic algorithm [7,8]. The idea of using non-local pixel information, which was based on non-local mean filtering, was proposed in [9] to cluster noisy image pixels.

Result of image segmentation method will be the set of pieces or areas in the image that the image will be created by putting all these areas together. In addition, the outcome of the image segmentation process could be set of "outlines" take out as of digital picture. All pixels at specific area or part of the image (resulting from the image segmentation or image segmentation process), depending on some of the calculated features or characteristics of the image, such as "color", "intensity" or "textures" are similar to each other. On the other hand, according to the same characteristics or features calculated from the image, the "adjacent" areas or pieces will be significantly different from this particular piece or area. If image segmentation methods are used to process a set of digital images (usually in the field of medical imaging), contours obtained from image segmentation can be used, of course, using "interpolation" algorithms such as "moving cubes" (marching cubes) to implement 3D Reconstruction applications.

2. Applications of image segmentation

The applied tenders of image segmentation are the followings: Content-based Image Reclamation applications, machine vision, Medical Imaging, comprising the production of concentrated 3D pictures using images from Computed Tomography Scanning (CT-Scan) or Magnetic Resonance Imaging (MRI) images, identification of the location of tumors and other pathologies in the body, measuring the volume of living tissues in the body, Face Detection, Brake Light Detection, Satellite Images. In addition to the mentioned applications, different general-purpose methods are advanced to the implement image segmentation applications. For such applications to be beneficial, they should be shared by "Domain Specific Knowledge" so that they can be used effectively to solve image segmentation problems in specific domains as figure below.

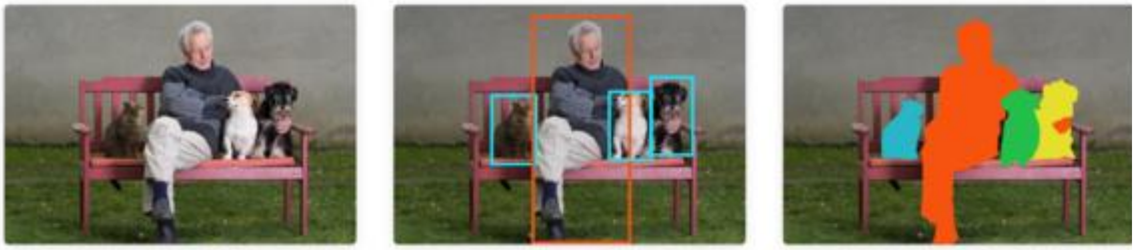


Fig. 1: Application of image segmentation in detecting different parts and individuals in an image.

3. Different algorithms for image segmentation

As it is mentioned earlier, the method of separating digital picture to more than a few segments or regions is named image segmentation. Determination of Image Segmentation techniques are to abridge or change main display of a picture to a display, which facilitates image analysis and, most importantly, provides far more meaningful information to the computer image processing system or vision. Image Segmentation Algorithms are:

- Supervised Algorithms:
  - "Thresholding" image segmentation using "prior knowledge" or "human input"
  - Random Walk image segmentation method
  - Image segmentation by active contour method

- Unsupervised Algorithms
  - "Thresholding" image segmentation using "prior knowledge" or "human input"
  - Image segmentation by simple linear iterative clustering (SLIC)

- Felzenszwalb image segmentation

In supervised algorithms, in order to properly segment the images into areas containing objects, there is a need for prior knowledge (in the form of human input) to guide the algorithm.

However, in unsupervised algorithms, no prior knowledge is required to ensure optimal system performance. Unsupervised image segmentation methods attempt to automatically divide images into sets of meaningful regions. However, depending on the used algorithm, it may be possible for users to change specific settings of the algorithm to attain anticipated consequences. For example, in this paper we consider comprehensively one of the image segmentation techniques and discuss about different aspects of this algorithm completely.

4. Thresholding method for image segmentation

One simple way to separate objects from a background (segment the image into a background and objects in it), is to select pixels whose "intensity values" are more or less than a "threshold". Using such a technique can be very useful for segmenting the image into the background and its objects (separating objects from the background). An image called “page” embedded in the scikit-image library is used to show how the thresholding method works in digital image segmentation. First, the functions and libraries necessary to implement the image segmentation system are imported by Thresholding method as below;

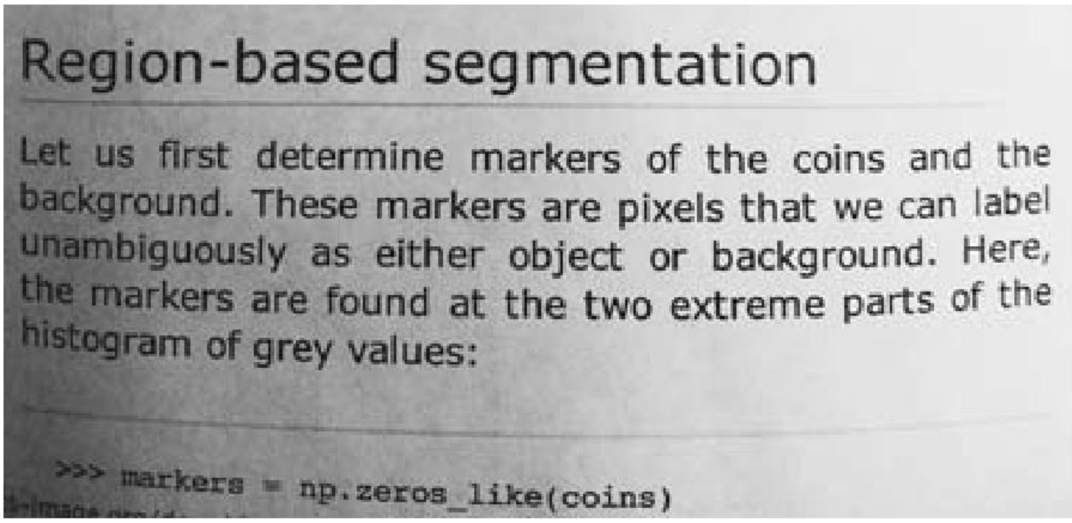
```
import numpy as np
import matplotlib.pyplot as plt
import skimage.data as data
import skimage.segmentation as seg
import skimage.filters as filters
import skimage.draw as draw
import skimage.color as color
```

Then, by using the following code, a simple function is running to display the coded images:

```
def image_show(image, nrows=1, ncols=1, cmap='gray'):
    fig, ax = plt.subplots(nrows=nrows, ncols=ncols, figsize=(14, 14))
    ax.imshow(image, cmap='gray')
    ax.axis('off')
    return fig, ax
```

Using the following commands, the page image is displayed as follows;

```
text = data.page()
image_show(text)
```



Region-based segmentation

Let us first determine markers of the coins and the background. These markers are pixels that we can label unambiguously as either object or background. Here, the markers are found at the two extreme parts of the histogram of grey values:

>>> markers = np.zeros_like(coins)

Fig. 2: The target image that will be displayed on the monitor.

As you can see in the image above, the uploaded image is a bit dark. However, it is possible to select the appropriate value (meaning, intensity value) as the threshold, thereby achieving a reasonable segmentation of the uploaded image; without the need of more advanced image segmentation methods. The concept of "histogram" is used to select the appropriate intensity value as the threshold. A histogram is a chart, which illustrates amount of pixels in a picture at unlike values of concentration (Intensity Values). Simply, a histogram is a graph in which the horizontal axis shows all the values of the pixel intensity in the image, while the vertical axis shows the frequency of these values. In the Fig.3, we can see the histogram graph of the input "page" image.

```
fig, ax = plt.subplots(1, 1)
ax.hist(text.ravel(), bins=32, range=[0, 256])
ax.set_xlim(0, 256);
```

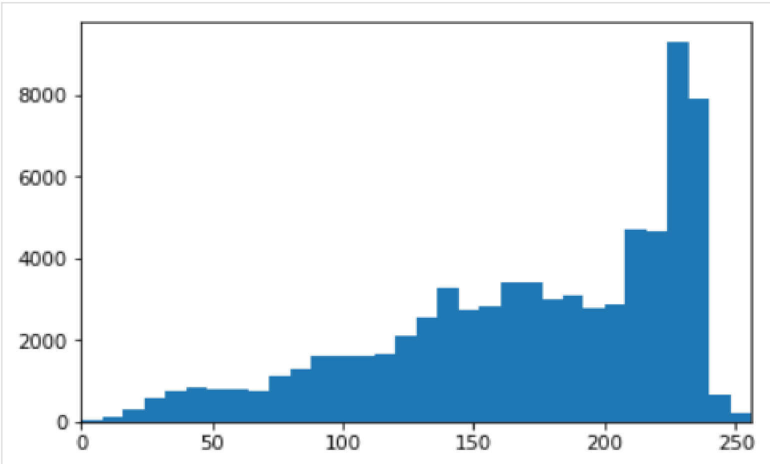


Fig. 3: The histogram diagram of the input "page" image

In this example, the histogram corresponds to an 8-bit image is shown, so there will be 256 possible values on the horizontal axis to display the pixel intensity values in the image. As it can be seen in the image above, a large amount of pixels in picture are almost bright (pixels with a magnitude of zero represent the black color in the image and concentration values of 255, white pixels in display picture). Bright pixels at the image were likely for representing the white background of image. In an ideal histogram-based segmentation method, the pixel intensity values in the image are "bi-modal"; In other words, the pixel intensities in an image will focus around two different intensities. This allows users to select a middle value (the middle value is the value that sits right in the middle of the two intensities around which most of the image pixels are centered) as the threshold, areas, or parts of the image will easily separate. In histogram-based segmentation methods, the system can easily separate these areas if the two areas in the image show different color intensities.

5. Conclusion

Image segmentation techniques are also known by other names such as image division. Image segmentation is one of the most important subfields of "image processing" and "computer vision", that today are becoming one of the standard processes of image processing and manipulation in many software, libraries and programming modules. The quality of the results of the following sections depends on the quality of the segmentation steps. There are two different ways to split images. One of them uses the uniformity of intensity values within the components of the image. Another uses the method of finding boundaries between components thus using non-uniformity in the image. In this paper we have discussed about different image segmentation methods and implement one of these methods completely and shown the outcomes of it.

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