WATERSHED TRANSFORMATION : REDUCING THE OVER-SEGMENTATION PROBLEM BY APPLYING A NOISE REDUCER AND A REGION MERGER

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ABSTRACT

Image segmentation is used to identify homogeneous regions in an image, it has been a subject of research for the last three decades. It is usually the first, and most difficult task for any image understanding system. Image segmentation is usually associated with pattern recognition problems and is considered the first phase of such a process. Consequently, the success of the pattern recognition process is dependent on the quality of this initial stage.

Here we examine image segmentation. We describe the watershed transformation algorithm and our variation of it. We provide results for our implementation and compare then to previously published results from traditional implementations of the watershed transformation. Finally, we believe that these results substantiate the case that our modifications to the watershed provide much improved segmentation results.

Keywords: image segmentation, watershed transformation, region merging.

1. INTRODUCTION

The main goal of segmentation is to divide an image into parts that have a strong correlation with objects of areas from the real world scene. Thereby we isolate objects of interest from the rest of the scene.

Here image segmentation is used to analyze an image. We attempt to group pixels into regions. These regions may be later associated with informational labels, but the segmentation process simply gives each region a generic label (region 1, region 2, etc.).

These regions can represent objects, parts of an object, or background. For instance, an OCR system doesn't try to process the whole image at once, it segments the image into characters and then uses a pattern recognition mechanism to determine each character.

Because of the different natures of algorithms used in image segmentation, they are expected to give somewhat different results and consequently different information. It also depends on what the step following segmentation has to achieve. For instance, if we take an image containing an orange, the brain would prefer to see the orange segmented as only one circle.

But if the step after segmentation is a matching technique to determine the disparity of the object, we may prefer to have more details on the segmented orange. Here we employ a matching technique to determine the quality of the segmentation process [Vanderstockt00].

2. THE WATERSHED TRANSFORMATION

The Watershed Transformation was introduced by Christian Lantuejoul and Serge Beucher in 1979 [Beucher79]. The watershed transformation principle is quite easy to understand as it equates to the physical flooding/rising of water. Relief flooding simulations may be used to segment an image. This has been exploited for a long time in mathematical morphology and has lead to the notion of the watershed transform. It is a powerful tool for image segmentation.

The problem with the transformation is it often leads to an over-segmentation of the image. To overcome this a major enhancement was performed by Fernand Meyer and Serge Beucher in 1982 with the marker-controlled watershed [Beucher91].

The marker is defined manually and represents the catchment basin, this is where the water starts flooding. Using this enhancement, it is possible to merge several regions automatically and to concentrate the segmentation on the objects of interest.

3. OUR VARIATION OF THE WATERSHED TRANSFORMATION

The watershed transformation is used for contour detection as the result of the transformation provides the watersheds which are the lines defining the contours of the regions.

Our approach is based on the same fundamentals with the principle difference that it is region-based and not edge-based as is the traditional watershed transformation. Instead of flooding water from the minima, we plant a seed. Each seed has its own colour, this will in turn become its label at the end of the process (the label of the region).

We define the minima and plant a seed in each minimum. Simultaneously the seed grows to fill the area up to the minima as long as the topography allows it. This is similar to the work presented by Vincent-Soille DVSB algorithm [Vincent-Soille91].

The next step is the same as that used in the watershed technique where the water floods the minima and continues rising. In our case, the seeds all grow together.

Once a seed touches another growing seed, we do not mark this point as is done in the watershed because we are not interested in the contour of the region. Instead, we apply the rule that a seed cannot grow where another seed already grew. At the end of the process, we end up with the regions in different colours where the colours are their identifiers (or labels). This technique is based on a combination of the watershed transformation and region growing that is used in graphism to fill a polygon.

4. RESULTS

After applying our algorithm to several images we noticed problems with some images resulting in over segmentation. On further investigation noise was identified as the source of the problem.

As we apply an edge detector filter to the image in pre-processing, any noise that exists is magnified leading to over-segmentation. To eliminate this we applied a pre-processing mask. Any pixel that does not have at least two surrounding pixels the same colour has its colour changed to that of the majority of surrounding pixels.

In figure 1, is a set of images where we have added noise of random colour. The 'noise reducer' mask is very efficient until 40% noise is added. After this percentage the borders loose their definition. For instance the "L" is split into two regions. At 60% some regions are not detected at all (e.g. the letter "W").

In our opinion, the segmentation results are good for an acceptable level of noise (less than 40%).

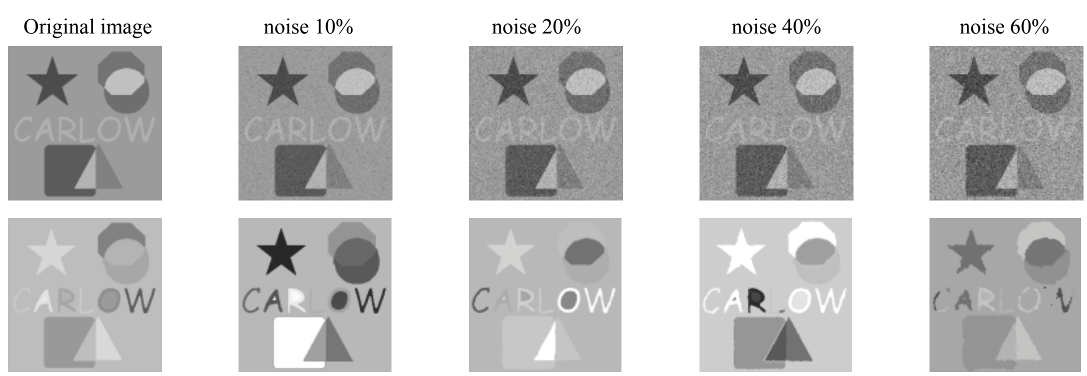

Figure 1: Result after applying the noise reducer on noise added images, followed by the watershed transformation

In figure 2b, it is difficult to see the difference with the original image (Figure 2a). However, if we concentrate on the white line on the left of the image, we see it is starting to break up.

In Figure 2c, we see the results of Serge Beucher algorithm that uses the mosaic effect [Beucher91].

In our opinion, the mosaic effect is too strong as it modifies the contours of some regions. In our implementation and segmentation generally, we want to maintain as close as possible the shape of each region. If we allow the regions to change then the matching step becomes more difficult and unpredictable.

We note that it is difficult to see any improvement between figures 2a and 2b on applying the noise reducer. However, after applying the watershed transformation to these the differences become apparent.

Figures 2d and 2e show this comparison. In figure 2d the minimum is modified facilitating road detection to enable comparison with Serge Beucher results [Beucher91].

In this sequence of images the main interest is the segmentation of the road from its surroundings to facilitate autonomous vehicles. In figures 2e and 2f the road is well segmented. However, we believe that our implementation provides a better result (figure 2e) for input to the next stage of vehicle control. Beucher’s algorithm results (figure 2f) in an over segmented image that may complicate any further processing.

Figure 2a: Original Image of the road

Figure 2b: Our noise reducer result

Figure 2c: Serge Beucher's Mosaic Effect

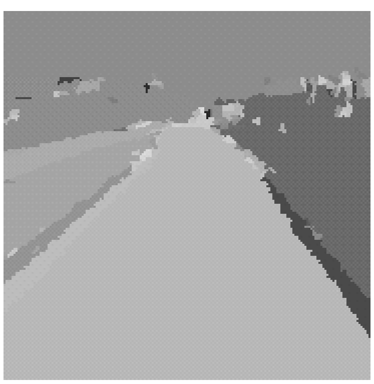

Figure 2d: Result without the noise reducer

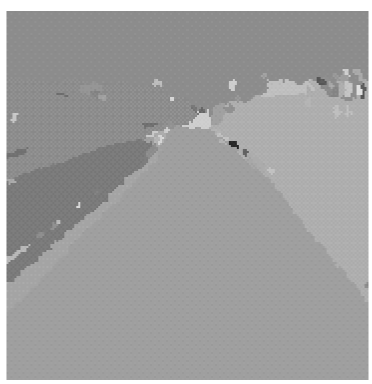

Figure 2e: Result with the noise reducer

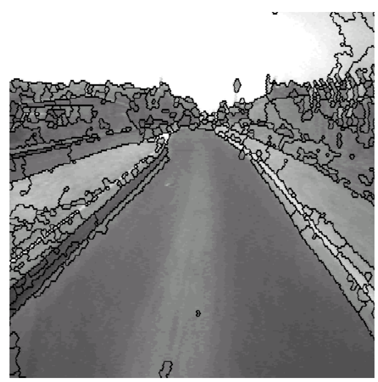

Figure 2f: Serge Beucher's result

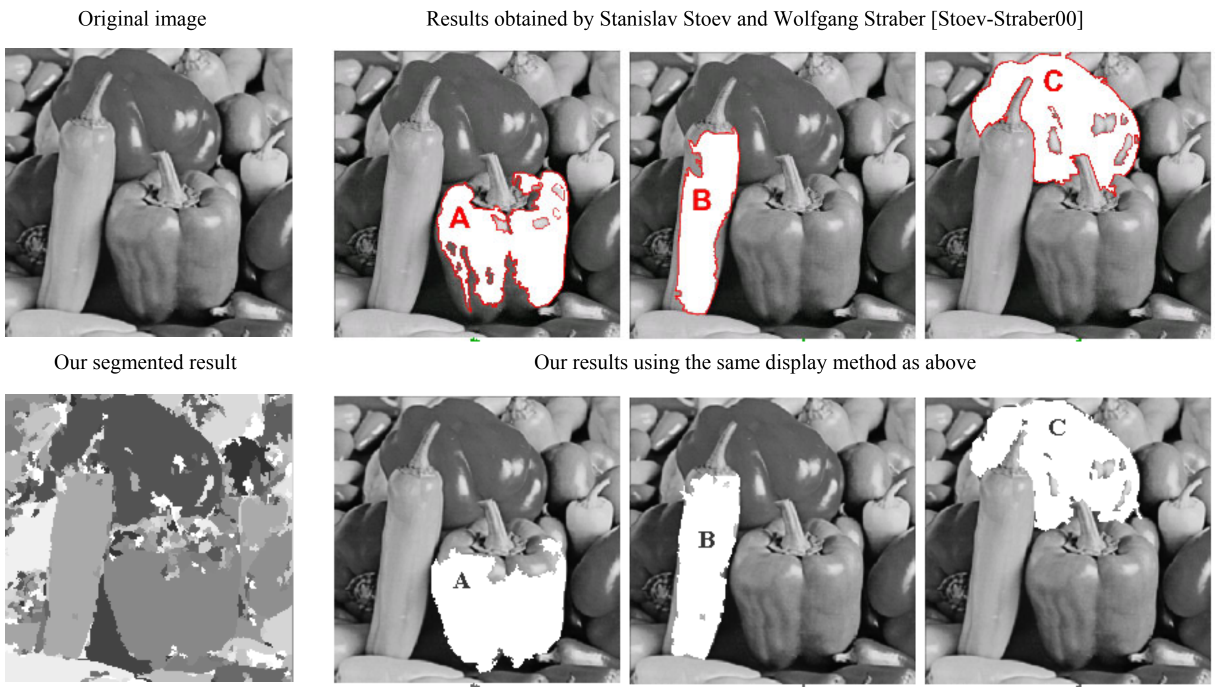

Figure 3 : Comparaison of Stanislav Stoev and Wolfgang Straber's results against our results

Stanislav Stoev and Wolfgang Staber have worked on a similar region merging approach [Stoev-Straber00]. Their technique was based on basin-merging criteria. They used four different criteria.

The comparison of their results and our results can be illustrated in figure 3. The region A is very different in the two results, B seems to give a better result in our approach and C is very similar in both.

5. CONCLUSION

We conclude that our variation on the watershed transformation simplifies any further image processing.

Our region merger algorithm ensures that images are not over segmented unlike the mosaic effect. The noise reducer has two uses, to reduce the noise and to curtail over segmentation without greatly modifying the region's shape.

The possibility of changing the minima can reduce the over-segmentation and allow concentration on the most significant part of the image.

The main disadvantage to the watershed algorithm is that it usually results in an over-segmented image. It is our opinion that we have partially overcome this problem.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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