Kunst aufräumen a la Ursus Wehrli
Content-Based Selection of Methods for Image Segmentation

Projektleiterin
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Abstract
Many different methods for image segmentation have been developed. Each of them usually has its advantages for one single class of images only. An unsolved problem in the field of image segmentation, however, consists in the fact that there does not exist a single approach which can be applied to several classes of images with the same success. As an idea for a solution of this problem we propose an autonomous selection of a segmentation method by a neural network depending on the specific content of the image to be segmented.
The neural network is trained with statistical image measures of classical modern paintings and is able afterwards to select the most appropriate of four standard methods for image segmentation for unknown test images. We evaluate our approach in the field of edutainment by an automatization of Ursus Wehrli's idea of „Cleaning up artworks".

1 Introduction
Many different methods for image segmentation have been developed. Each of them usually has its advantages for one single class of images only. An unsolved problem in the field of image segmentation, however, consists in the fact that there does not exist a single approach which can be applied to several classes of images with the same success. As an idea for a solution of this problem we propose an autonomous selection of a segmentation method by a neural network depending on the specific content of the image to be segmented.
In section 2 we introduce our approach, in section 3 we describe the data we used to train and test the neural network, and in section 4 we present the results.
Finally, we introduce an edutainment interface in section 5 which utilizes the proposed selection of segmentation methods depending on the image content.

2 Our Approach
We considered four of the most widely-used methods for image segmentation. They are summarized in subsection 2.1. Our intent was the training of a neural network to be capable of selecting those of these methods which is the best choice in terms of a proper segmentation of the image at hand.
To generate ground truth data for the training of the neural network we determined the best method of segmentation for each training image by visual inspection of segmentation results.
The selection of the most appropriate method by the neural network is carried out on the basis of the image content. To quantify the image content we consult the values of seven statistical image measures for each image. They are described in subsection 2.2. The neural network is described in subsection 2.3.

2.1 Considered Methods for Image Segmentation
The four methods of image segmentation we consider for our approach are as follows:

- THRES: Simple Global Thresholding
- RGROW: Region Growing Using Color
- COLOR: Advanced K-Means-Clustering Using Color
- SNAKE: Snakes Using Gradient Vector Flow

2.2 Used Statistical Image Measures
The decision of the neural network about the most appropriate method of segmentation is based on the values of seven statistical image measures of first and second order, which characterize the content of the image at hand.
For the choice of these measures we leaned on the approved standard image. They are as follows:

Entropy
Standard deviation of the H, S, and V component of the image (i.e., 3 values)
Standard deviation of the gradient
Contrast (horizontal and vertical, thus 2 values)
Correlation (horizontal and vertical, thus 2 values)
Energy (horizontal and vertical, thus 2 values)
Homogeneity (horizontal and vertical, thus 2 values)

This results in a vector with 13 values to characterize the content of an image.

2.3 Neural Network
We have compared several different feedforward neural networks. Here we will report on the one which performed best. It has 120 neurons in a single layer. We employ classical backpropagation. The input per training image consists in the 13-vector of the image measures, and the output consists in the four-vector which encodes the appropriateness of the four methods of segmentation for this training image. One training step consisted of 100 repetitions for each of 21 training images. After 14 steps the network performed without error on the training images. The ground truth data to train the network is described in section 3.1

3 Training- and Testdata

For the evaluation of the developed technique images are appropriate which can be segmented easily based on only a few outstanding features such as color. Such images can be found frequently in classical modern painting. Thus, we chose classical modern paintings for training as well as for testing the neural network.

3.1 Trainingdata

As training images we chose 21 classical modern paintings, 10 of them are depicted in figure 1. To generate ground truth data for the training of the neural network we applied all four methods of segmentation to each of the 21 training images and assessed the best method via visual inspection. We also determined the best and second bestmethod for the 10 test images by visual inspection to evaluate the results described in section 4. Figure 2 shows examples for three paintings.

3.2 Testdata

To test the trained neural network we chose 10 classical modern paintings different from the training images.

4 Results

We rated the methods chosen by the neural network for each test image. The rating is „Perfect“ if the best method was chosen compared to the ground truth, „Good“ if the second best method was chosen, and „Poor“ if any other method was chosen. Summarizing, in 60% (i.e., 6 out of 10 test images) we obtain a „Perfect“ choice by the neural network. If we are satisfied with the second best method we obtain in 90% a „Good“ result, and in 10% a „Poor“ choice. To assess these results one may consider the probabilities of choosing 6 times „Perfect“, 9 times „Good“, and 1 time „Poor“, which would correspond to a random choice of a segmentation method. These probabilities are 1.6%, 0.9%, and 0.9%, respectively.

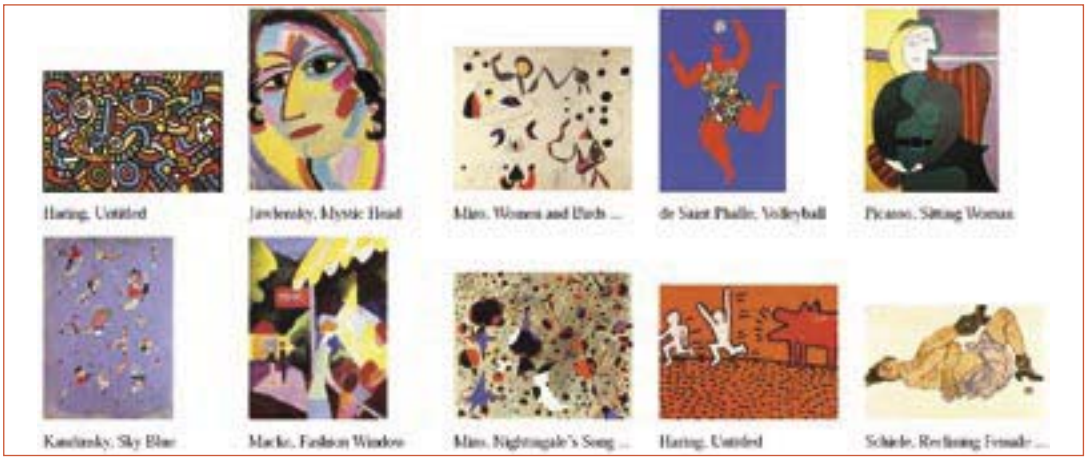

Figure 1. Training images

Figure 2. Ground truth. Each segment is labeled by an own color. By visual inspection we assessed the segmentations of all four methods. First two images: segmentation results of best method RGROW and worst method THRES for Jawlensky's painting (original in figure 1). Last two images: segmentation result of best method RGROW and worst method THRES for Macke's painting (original in figure 1). To comprehend our ratings, please compare the segmentations with the original paintings.

5 Application

The Swiss comedian and artist Ursus Wehrli has attended to the problem of image segmentation in his performances and books on „cleaning up artworks“. He used scissors and glue to segment famous artworks and reorder the segments according to, e.g., color and form (figure 3).

This idea was motivation and framework for us to develop an interface which allows for the automatic clean up of artworks in the Wehrli fashion. This interface applies the content-based selection of methods for image segmentation proposed above, and thus is a first application and test case of this approach. Figure 3 faces the versions cleaned up by Wehrli and those cleaned up by our approach for two representative sample artworks. For the large majority of tested sample images our results look rather similar to those of Wehrli, which means that our approach is capable of selecting the proper segmentation method depending on the image content. Many more examples and the details of reordering the identified segments are shown and described in M. Petke's diploma thesis.

References

- Gabriele Peters and Matthias Petke, Content-Based Selection of Methods for Image Segmentation, 10th International Conference on Signal and Image Processing (SIP 2008), 2008.

- Matthias Petke, Kunst aufräumen a la Ursus Wehrli – Bildinhaltsgesteuerte Auswahl von Segmentierungsalgorithmen, diploma thesis, Technical University Dortmund, 2007.

Figure 3. Two artworks cleaned up by Ursus Wehrli and by our approach. For both images the best method was RGROW, and the neural network was able to select it for segmentation. After segmentation the segments are arranged as shown in the last column.