Title	複数の動的輪郭モデルの競合による領域抽出に関する研究
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Citation	
Issue Date	1999-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1294
Rights	
Description	Supervisor:阿部 亨，情報科学研究科，修士

Region Extraction by Competition of Multiple Active Contour Models

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February 15, 1999

Keywords: Region Extraction, Active Contour Model, Mixture Models, Fisher's Discriminant.

1 Introduction

Accurate extraction of object region is an important subject of image recognition. Active contour model (Snakes) is a region extraction method with the following advantages: (1) Closed region is extracted stably. (2) Features of the object region can be put in extracting process. For these reasons active contour model has been researched widely.

Most of existing methods with active contour model are capable of extracting the object region which has uniform image properties (e.g. intensity, texture, etc.). However, for the accurate extraction, these methods are not applicable to the region composed of multiple small regions or the region corrupted by noise, because the contour is deformed with the local region information along the contour.

To deal with this problem, extraction methods which use wide-ranging region information to deform the contour have been proposed. For examples, Etoh proposed a method in which an image is segmented by clustering method based on AIC and active contour model is applied to the segmented image, and Zhu introduced MDL-based growing and competition of multiple regions into the extracting process. These methods are effective for the region whose properties are not uniform. However, there are the following problems: (1) Clustering procedure on an image is required in advance. (2) It is necessary to set multiple initial contours manually. To resolve these problems, it becomes necessary to acquire the wide-ranging region information easily and to use this information for the region extracting effectively.

In this paper, we propose a novel region extraction method. In the proposed method, to acquire the wide-ranging region information, multiple active contours are set in the object and the background regions respectively, each contour is deformed by the competition between the neighboring contours, and the object region is extracted as a set of multiple contours (i.e. the extracted region consists of the inside regions of the contours). Furthermore, to assist in setting the initial contours, we propose a method for making multiple initial contours from an initial curve. In the proposed method, initial curves are set in an image by user, each curve is divided into segments at adequate loci, and each segment is used as a core for making an initial contour (a closed curve). To show the effectiveness of the proposed method, we give the experimental results of region extraction at the end of this paper.

2 Region extraction by competition of multiple active contour models

In the proposed method, to acquire the wide-ranging region information, multiple active contours are set in an image, and each contour is deformed by the competition between the adjacent contours. Each contour first expand toward the direction of spreading the inside area, when it detects crossing points with other contours, it makes a common boundary for the two contours by inserting new control points between the crossing points. For An pixel P on the boundary between region A and B, likelihood of belonging to A and B is computed from their feature distribution and feature values of P. Region competition is performed by moving the boundary to make P included in a region of higher likelihood.

To infer the distribution of feature values in each contour, we use EM Algorithm which is the maximum likelihood method via incomplete data. In this method, feature values of each contour are assumed to be subject to the normal density, and whole feature distribution is described by weighed sum of distribution functions of each region (mixture model). The distribution parameter inferred by EM algorithm is a local optimum, however it guarantees the convergence of computation.

In the case that feature values of each region is described by multi dimension, by Fisher's discriminant based on the inferred feature parameters, we decide a projection axis on which between-region feature variance is to be large and with-in region feature variance is to be small for two regions which compete each other. By computing likelihood for each region on this axis, the region to which an pixel on the boundary belongs is decided.

An object region is extracted as a set of regions by implementing these consecutive processes iteratively (e.g. computation of mixture model parameters, decision of the projection axes by Fisher's discriminant, and the expansion and the competition of each contour on the projection axes based on the likelihood ratio) until the whole contours converge.

3 Generation of the initial contours

To compute the mixture model parameters appropriate for the object extraction, It is important to set the initial contours at the location which describes the features of objects and background as accurately as possible. In the proposed method, user first draw the curves across the objects and backgrounds, and set the number of segments into which each curve is divided. And image features are acquired along the curves.

To compute the appropriate mixture model parameters, it is desirable that between-region mean is large and within-region variance is small about the feature values. For this reason, the initial curves are divided base on Otsu's discriminant criteria to maximize the separability of feature values between the segments, and then the initial contours are generated automatically from each segment. This makes it possible to set the initial contours in an easy way at the appropriate positions for computation of the parameters.

4 Experimental result of region extraction

We performed the following experiments using artificial images to verify the robustness of the proposed method against noise. (1) Comparison of the extraction precision between basic active contour model using gray level gradient for the image energy function, and the proposed method using gray level gradient and likelihood ratio for the image energy function. (2) Comparison of the extraction precision between single active contour model and multiple active contour models both of which use gray level gradient and likelihood ratio for the image energy function. As the result of these experiments, it was confirmed that by introducing the likelihood ratio and competition of the multiple contours, the proposed method surpasses basic active contour model in robustness against noise.

Regarding real images, experiments was performed on the object region which is: (1) composed of multiple regions with uniform feature values. (2) in complex shape. (3) with complex background. (4) composed of texture region. As the results of these experiments, accurate result was not acquired for regions between which the separability of the feature values is small, however the extractions of whole object region showed fine results in each case. This shows the effectiveness of the proposed method under the real environment.

5 Conclusion

In this paper, we proposed a novel region extraction method by region competition of multiple active contour models. We also proposed novel method to decide the location of the initial contours in effortless way. Through the experiments using artificial images, it was confirmed that the proposed method in which likelihood ratio and multiple region competition were introduced, was more robust than single active contour model against noise. Our method also showed fine extraction results for objects in real images with complex background and varying textures. Further works are listed as following: (1) Improvement of the algorithm aiming at more robust and precise region extraction. (2) Region extraction with prior knowledge.