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Deformable Boundary Initialization for Object Detection in Natural Images Using Multiple Scale Edges

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ABSTRACT
The deformable contour model is a popular technique to segment object in image processing. Its applications range from edge and curve detection, to shape modeling and visual tracking. However, the performance of a deformable contour to model any arbitrary shape is heavily dependent upon proper contour initialization. To alleviate this problem, we propose a multi-scale method to obtain a suitable edge map to aid the contour initialization problem. The proposed technique utilizes wavelet edge detection, multi-scale edge linking coupled with a method of classifying relevant edges. Several parameters from the scale evolution of the multiple scale edges detected by a continuous wavelet decomposition of an image is used in a clustering algorithm to classify the edges belonging to either the background or the object(s) of interest. This paper presents the approach and preliminary results which are encouraging.

General Terms
Algorithms

Keywords
deformable contour, multiple scale edges, wavelet, initial contour, object detection, segmentation.

1. INTRODUCTION
In computer vision, segmentation is a fundamental step prior to further processing and analysis operations performed on images. All segmentation approaches, regardless of the type of images they operate on, aim to segment an object of interest from the rest of the image structure. Image segmentation methods may be broadly divided into three categories: region based segmentation, contour based segmentation and morphological based segmentation [1]. This work presented in this paper focuses on the contour based segmentation approach.

Edges are recognized as important features in shape recognition. The human visual system locates an object by its outline where sharp changes in intensity profile takes place [2]. However, edge detection should not be considered as a simple operation to label the location of intensity changes: instead edge detection should involve some form of feature extraction in order to facilitate object recognition. Among many edge detection approaches that are available, the multi-scale approach to edge detection has received much attention due to its close resemblance to the human visual perception model [3]. Mallat [2][4] uses multiple scale edges to characterize different types of edges such as ramp edge, step edge, discontinuities and dirac, and shows that the edges carry enough information to reconstruct the image to a quality that a human observer can visualize. Williams [5] suggests that multiple scale edges can be tracked from a coarse to fine scale to give satisfactory and complete edge detection. An application of multiscale edges on real world application has been demonstrated by Siegel [6], who uses multiple scale information in remote visual inspection of scratches on aircraft skin.

Edge detection is an important step in the image segmentation process. One such class of segmentation approach is the deformable contour method. A few examples of the deformable contour methods include the snake deformable model [7], elastic template [8] and the Non-Uniform Rational B-spline (NURBS) [9] [10]. The snake algorithm, introduced by Kass [7] shows the ability to deform to arbitrary shape of an object. Snakes work based on energy minimization methods where controlled continuity splines are allowed to move under the influence of external image dependent forces, internal forces, and certain constraints set by the user. A later development by Bimbo [8] uses an elastic template matching based on modeling of a piecewise fourth order B-spline polynomial function, that is parameterized with respect to the arc length. In each interval of deformation, the B-spline points are updated by recalculating the B-spline formulation through a gradient descent algorithm. Ma [9] introduces NURBS to represent curve and contour. Liang [10] uses NURBS warping method to obtain an object's contour. This contour is guided by gradient vector flow (GVF) to provide an efficient convergence to the object contour. Although these deformable contour methods yield fast and accurate segmentation of the desired object in the image, however, they need a user initialized contour to start the deformation process.

There have been some reported works on deformable contour models that are insensitive to proper contour initialization. Yezzi [11] combined the curve evolution theory with the classical snake model to enable the deformable contour split and merge according to topological changes in the image. In a more recent work by

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Paragios [12], gradient vector flow geometric active contour shows the ability to handle topology changes by splitting and merging and the method is invariant to initial contour location. These approaches however suffer from high computation cost and time.

The major aim of this work is to perform image segmentation through edge detection using multi-scale edges. The segmentation result can be used as the initial contour for a more sophisticated and complete segmentation using deformable models, such as snakes or NURBS. This work solves the problem of manually initializing the starting contour as noted earlier and ensures convergence of the deformable contour to the desire object boundary.

2. OVERVIEW OF THE APPROACH

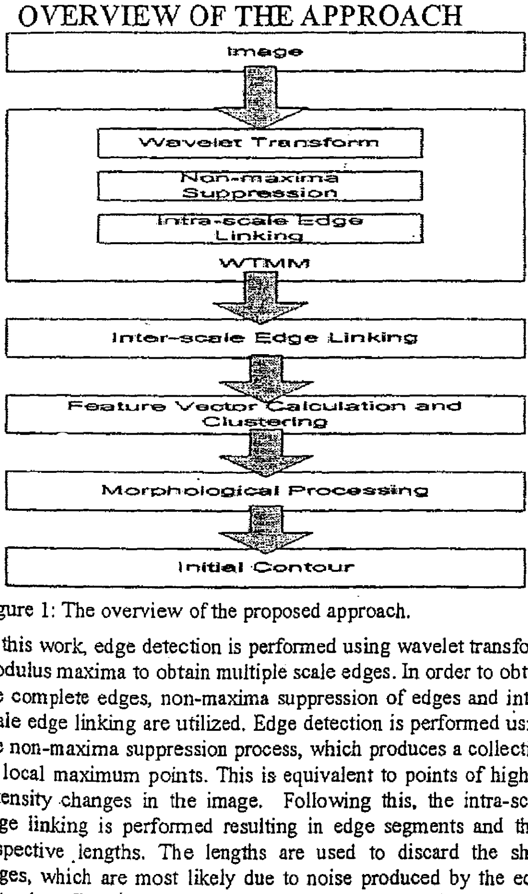

Figure 1: The overview of the proposed approach.

In this work, edge detection is performed using wavelet transform modulus maxima to obtain multiple scale edges. In order to obtain the complete edges, non-maxima suppression of edges and intra-scale edge linking are utilized. Edge detection is performed using the non-maxima suppression process, which produces a collection of local maximum points. This is equivalent to points of highest intensity changes in the image. Following this, the intra-scale edge linking is performed resulting in edge segments and their respective lengths. The lengths are used to discard the short edges, which are most likely due to noise produced by the edge detection. The remaining edges are then linked using an inter-scale edge linking algorithm. After inter-scale edge linking is complete, a feature vector is then calculated for each edge segment. These feature vectors consist of information about the edge strength, types of edges such as ramp edge or step edge and the width of the edges. These feature vectors, once computed, are clustered using an automatic clustering algorithm. Finally, using morphological processing, the clustered edges are linked to form a closed contour. The steps are summarized in Figure 1

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