Chapter 39
An Adaptive Elastic Net Method for Edge Linking of Images

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ABSTRACT

In this chapterr, the authors propose an adaptive Elastic Net method for edge linking of images. Edge linking is a fundamental computer-vision task, which is a constrained optimization problem. In the proposed method, an adaptive dynamic parameter strategy and a stochastic noise strategy are introduced into the Elastic Net, which enables the network to have superior ability for escaping from local minima and converge sooner to optimal or near-optimal solutions. Simulations confirm that the proposed method could produce more meaningful contours than the original Elastic Net in shorter time.

INTRODUCTION

Extracting features from images is a common computer-vision problem. In particular, edge point images are problematic since there is inherently very little information available (Gilson & Damper, 1997). Such images consist of binary points on a two-dimensional plane which represent the edges and corners of an object. Then a feature-extraction algorithm should infer from the points a description of the object or objects present in the image. There are many approaches for the

extraction process, and one of the approaches is to assume the existence of a single object only, then to link the edge points in a meaningful way so that to form a contour that represents the object in the image. The advantage of this approach is that it reduces the problem to that of enumerating the image points, and then ordering them into a sequence which describes a path corresponding to the contour of the object. Thus the problem of edge linking is isomorphic to the classical traveling salesman problem (Gilson & Damper, 1997). The traveling salesman problem is a typical problem

of combinatorial optimization, and is known to be NP-hard which cannot be solved optimally in polynomial time.

In the last 20 years also, neural networks have been shown to be powerful tools for solving combinatorial optimization problems, particularly NP-hard problems (Vakhutinsky & Golden, 2003). S. J. Gilson and R. I. Damper examined the suitability of four well-known unsupervised techniques including the Elastic Net (Durbin & Willshaw, 1987), active contours (Witkin & Terzopoulos, 1987), Kohonen map (Kohonen, 1982) and Burr's modified Elastic Net (Burr, 1988), which were all applied to solve the TSP, for the task of edge linking and found that of these, only the Elastic Net and Kohonen map were realistic contenders (Gilson & Damper, 1997). Furthermore, the Elastic Net's geometry corresponds well to the problem definition, and its convergence is governed by well-established physics theories leading to a sensible solution (Gilson, 1999). So the Elastic Net is a very powerful and stable edge linker (Gilson & Damper, 1997).

However, as a penalty method, the Elastic Net always suffers from a parameter tuning problem whenever applied to traveling salesman problems, of course a fundamental drawback of this type of networks (Stone, 1992; Jiahai Wang et al, 2003). Furthermore, as a gradient decent algorithm, the Elastic Net method attempts to take the best path to the nearest minimum, whether global or local. So it is always confronted with a local minimum problem (Jiahai Wang et al, 2003; Durbin et al, 1989). In addition, while it generates reasonably good solutions, running time is long. Some researchers have proposed small modifications of the Elastic Net algorithm (Burr, 1988; Stone, 1992; Boeres et al, 1992), but analysis shows that these modified algorithms achieve less (Durbin et al, 1989).

As is well known, stochastic characteristic embedded in neural network is a useful property for optimization problems, due to random fluctuations could help neural networks escape from local minima. There are a large number of neural network algorithms improved by introducing some stochastic characteristic to increase their solving ability. They are built by introducing random variations into the network, either through giving the network's neurons stochastic transfer functions, or through giving stochastic weights.

In this work, we intend to enhance the ability of the Elastic Net to escape from local minima by introducing a stochastic noise strategy. Being different with other stochastic methods, the stochastic noise strategy enables the Elastic Net to obtain random dynamic properties from the problem states perspective. And the stochastic noise strategy is an appropriate way to introduce stochastic characteristic. During the period of elastic net algorithm processing, edge points vibrate in their oscillation domains and therefore modify the neurons movement and matching relationship. With gradually decreasing the edge points' oscillations, the problem is reduced to the targeted edge linking problem. Thus the proposed algorithm is able to jump out of local minima and get convergence at a superior solution. Moreover by introducing an adaptive dynamic parameter strategy into the Elastic Net, we attempt to make the network have adaptive features so as to alleviate the problems of the Elastic Net mentioned above.

Extensive simulations were implemented on a set of artificial images devised with the aim of demonstrating the sort of features that may occur in real images. And the experimental results confirm that the proposed method effectively improves both the solution quality and convergence speed of the Elastic Net for edge linking problems.

THE ELASTIC NET METHOD FOR EDGE LINKING

Durbin and Willshaw (1987) first proposed the elastic net method in 1987 for solving traveling salesman problems. Since edge linking problem is isomorphic to the classical TSP, the Elastic Net

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