USING SYNCHRONOUS HOPFIELD NEURAL NETWORKS FOR SCANLINE-BASED STEREO MATCHING

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ABSTRACT

This paper presents a scanline-based stereo matching technique using synchronous Hopfield neural networks (SHNN). Feature points are extracted and selected using the Sobel operator and a user-defined threshold for a pair of scanned images. Then, the scanline-based stereo matching problem is formulated as an optimization task where an energy function, including dissimilarity, continuity, disparity and uniqueness mapping properties, is minimized. Finally, the incorrect matches are eliminated by applying a false target removing rule. The proposed method is verified with an experiment using several commonly used stereo images. The experimental results show that the proposed SHNN solves effectively the scanline-based stereo matching problem.

INTRODUCTION

Stereovision is a popular passive range finding technique that has been widely applied in many areas such as inspection and robotics. It employs a pair of cameras that simultaneously take images of an object from different positions. The key of perceiving depth information is to determine which point in one image corresponds to a given point (called conjugate point) in the other image (called the "correspondence problem" or "stereo matching problem"). Many different approaches have been developed to solve this difficult problem (Tate and Li 1990). In general, these approaches can be classified into two main categories: feature-based matching (FBM), and area-based matching (ABM) (Medioni and Nevatia 1994). For the ABM methods, each point of an image is matched as the center of a small window of pixels in a reference image, where either a difference or similarity measure is minimized or maximized. For the FBM methods, features such as boundaries, edges, corner points, lines, arcs, and regions are extracted and then used as a matching set to facilitate the matching process instead of an area (Grimson, 1985; Lee and Leou, 1994; Mousavi and Schalkoff, 1990; Ohta and Kanade, 1985; Ruicheck and Postaire, 1995)[3][9][12][19][21,p.9].When using points as matching features, the selection of feasible matching candidates from the enormous features becomes the first issue. In general, the FBM method derives a sparse map and leaves the rest of the area to be interpolated later. The benefits of using stereo vision are its non-scanning, economics, and flexibility.

Hopfield and Tank (1982a, 1982b, 1985)[5][6][7,p.9] developed Hopfiled nerual networks, which have been widely applied to the problems such as weighted point matching (Hertz et al. 1991)[4], path determination (Cavalieri et al., 1994)[1], analog-to-digital (A/D) conversion (Tank and Hopfield, 1986)[23], and pattern recognition (Nasrabadi and Li, 1991)[18]. Mousavi and Schalkoff (1990a)[12] used Hopfield neural networks to minimize an energy function subject to the similarity and epipolar constraints. Later, they improved the formulation by using the intra-scanline and inter-scanline constraints to enforce the energy function (Mousavi and Schalkoff, 1990b)[12]. Parvin and Medioni (1991)[22] used a Hopfield neural network for a multi-scale strategy in matching the extracted features for the correspondence of 3D objects. Wolfe also solved the correspondence problem and the pose estimation problem by Hop-field neural networks (Wolfe and Magee, 1983; Wolfe 1991)[25]. They used Hopfield networks to assign the mapping relationship that scores the highest. Hu and Siy (1993)[8] proposed a novel class of optimization problems called the "Picking Stone Problem" (PSP), which was solved under uniqueness and ordering constraints by Hopfield neural network. Nasrabadi and Li (1991) [18] developed a two-dimensional binary Hopfield neural network for object recognition, and subsequently they extended their research to the stereo features matching (Nasrabadi and Choo, 1992) [17] . Lee *et al.* (1994) applied a Hopfield neural network to the stereo correspondence for extracting the 3D structure of a scene. Similarity, smoothness and uniqueness constraints were transformed into the form of an energy function. Ruichek and Postaire (1995)[21] built an energy function mapped onto a two-dimensional Hopfield neural network for minimization. Pajare *et al*. (1997)[20] presented a relaxation approach using Hopfield neural networks to solve the global stereo matching problem. They used edges as the matching primitives and the similarity, smoothness, and uniqueness properties are adopted for matching. Tien and Chang (1999)[24] used Hopfield neural networks to solve the stereo matching problem globally, and then applied the 3D information for inspection. Mortara and Spagnuolo (2001)[13] presented a solution to the correspondence problem for polygon blending by matching the skeleton that was approximated by morphological characterization of the shape. Giaguinto *et al.* (2002) [2] used a cellular neural network (CNN), which minimized the energy function for a real-time stereo matching problem.

In this paper, the scanlined based stereo matching problem is first represented as an energy function, which is minimized by a designed synchronous Hopfield neural network (SHNN). Then, a statistical false target removing rule is proposed to screen out the incorrect match.