Parallel Image Matching Based on Local Entropy Difference Vector

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Abstract

This paper presents a novel parallel image matching algorithm based on the local entropy difference vector (LEDV). Spatial information is introduced into the definition of image entropy and a thresholding operation is employed to limit the contribution of a mismatching block to the matching result. The proposed approach confirms the robustness of the LEDV to irradiation distortion, geometric distortion, local noise interference and occlusion, coupled with the transform of image entropy definition to make it suitable for parallel processing, can lead to good matching result, which is validated by experiments on a variety of images in natural environment.

Keywords: image processing, image matching, local entropy difference vector, SIMD

1. Introduction

Image matching is an inarguably important operation in computer vision and image processing. It has been widely used in aircraft navigation, resource analysis, weather forecast and medical diagnosis [1]. Image matching algorithms proposed in the past 30 years can be classified into two types: template matching methods based on color or grey correlation and feature matching skills based on image features extracted [2]. Compared with the former, the latter usually shows advantages of being robust to geometric distortion, gray difference and noise interference. However, most of them need to extract feature points or edge of the image, and the matching results depend mainly on the quality of feature extraction. In fact, it is still a difficult work to segment or extract feature from the image of scenery in natural environment [3].

In aircraft navigation system, aerial photographs or satellite images of the areas where the aircraft is going to fly over are taken and stored in computer memory on the aircraft as reference image before the flight. While flying, the aircraft takes photographs of the areas where it arrives, namely real-time image, and matches it with the reference image to determine the position of the aircraft.

In this paper, a new definition of image entropy is presented and a parallel image matching algorithm dedicated to a SIMD array computer is proposed.

The rest of the paper is organized as follows. Section 2 defines the LEDV. Section 3 introduces the DZJ-I array computer in brief. Section 4 describes the proposed algorithm. Section 5 illustrates the experimental results. Section 6 draws conclusions.

2. Local Entropy Difference Vector

Since the concept of entropy in physics was introduced into information theory by Shannon, it has been applied in image
processing tasks, such as image segmentation, compression, retrieval, restoration, reconstruction, enhancement, correction, fusion and matching.

Let \( F = [f(x, y)]_{M \times N} \) be an image of size \( M \times N \), where \( f(x, y) \) is the gray value of pixel \((x, y)\), \( 1 \leq x \leq M \), \( 1 \leq y \leq N \), and \( f(x, y) \in G_L=\{0,1,\ldots,L-1\} \), the set of gray levels. The entropy of \( F \) is defined as

\[
H_f = -\sum_{i=1}^{M} \sum_{j=1}^{N} (p_y \log p_y),
\]

where

\[
p_y = f(i, j) / S,
\]

\[
S = \sum_{i=1}^{M} \sum_{j=1}^{N} f(i, j).
\]

The entropy gives additive property information of an image. The local entropy of block \((p, q)\), where \( p, q \) is a subimage, \( H_f \) is called local entropy.

The local entropy difference vector \( D_{F,G} \) is defined in (3) and (4) is called as the local entropy difference vector between \( F \) and \( G \).

3. The DZJ-I Array Computer

Image processing tasks in remote sensing and computer vision require an enormous amount of computation, especially in practical, real-time applications. Therefore, DZJ-I, a processor array aimed at low-and intermediate-level image processing operations is designed and implemented by the Parallel Computing Laboratory of Harbin Institute of Technology (HIT). Its architecture is shown in Fig. 1.

The essential feature of DZJ-I is its nonlinear storage schemes and compound multistage interconnection network which
provide conflict-free access of rows, columns, diagonals, contiguous blocks and distributed blocks of a matrix \([5, 6]\).
Fig. 2 (e) is the matching result using the proposed algorithm. The comparisons illustrate that the proposed approach performs image matching task more effectively than those to be compared with under complex matching conditions in natural environment.

Fig. 2: (a) Reference image. (b) Real-time image. (c) The matching result of MAD algorithm. (d) The matching result of minimum entropy difference algorithm. (e) The matching result using the proposed algorithm.

6. Conclusion

The proposed algorithm based on the LEDV introduces spatial information into the definition of image entropy. By employing a thresholding operation, the contribution of a mismatching block to the matching result is limited to reciprocal of the blocks number. The transform from (1) to (2) made it possible to store a logarithmic table in the local memory and suitable for parallel processing and the processing is markedly sped up. Experiment results confirm that the proposed algorithm is robust to irradiation distortion, geometric distortion, local severe noise interference and occlusion.

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8. References (This is “Header 1” style)

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