Probabilistic Correspondence Matching using Random Walk with Restart

Changjae Oh
ocj1211@yonsei.ac.kr

Bumsub Ham
mimo@yonsei.ac.kr

Kwanghoon Sohn
khsohn@yonsei.ac.kr

School of Electrical and Electronic Engineering
Yonsei University
Seoul, Korea

Introduction - Local correspondence matching methods are mainly composed of three steps: matching cost computation, cost aggregation, and disparity computation. Let us assume that a truncated absolute difference is used in matching cost computation. Each step can be represented as following probability inferring problem.

\[ p(\alpha) = \max(\alpha - \sum_{i \in N} w(x,y) p(\alpha) \sum_{y \in N} w(x,y)) \]

where \( x \) and \( y \) are the reference image and the weight between \( x \) and \( y \) with the threshold \( \alpha \).

Proposed Method - Since correspondence matching method can be regarded as probability inferring problem, the probability optimization can be used as cost aggregation. In this paper, we present the cost plane optimization using RWR framework.

Consider the cost plane as an undirected weighted graph. We present steady-state probability computation by the RWR with the given graph. Let us denote the initial cost plane as \( P_0 = (p_0(x,d))_{i,j} \) and the adjacency matrix as \( W = [w]_{m \times n} \), where \( m \) and \( n \) are the reference image and the weight between \( x \) and \( y \), respectively. The RWR can be formulated in an iterative manner as follows:

\[ P_{n+1} = \alpha P_n W + (1 - \alpha) P_0 \]

The performance and the computation time largely depends on this parameter [1, 2]. The global relationship between points or the steady-state solution can be captured by using an adjacent neighborhood only. Accordingly, the proposed method gives high quality matching performance in a semi-global manner with low complexity.

Experimental Results - The proposed method as shown in Figure 1 was compared with other state-of-the-art cost aggregation methods: adaptive weight (AW) [3], cost filter (CF) [4], anisotropic diffusion (AD) [1], and geodesic diffusion (GD) [2]. Note that AD is not the main proposal of [1], but just the part of their method. Table 1 shows the bad matching errors evaluated by the Middlebury website [5]. The symbol * indicates the results of the Middlebury evaluation website. It shows that the proposed method shows competitive results with state-of-the-art methods. The comparison of the computation times of AW, CF, GD, AD, and the proposed method are 12.1, 1.18, 0.93, 2.19, 1.0, respectively, when the computation time of the proposed method is normalized to 1.0. In order to compare the performance when the window size of each algorithm is similar, we conducted another experiment by changing the window size of AW and CF to 3x3 which is the similar to that used in AD, GD and the proposed method. Figure 2b and Figure 2c show the degraded results in AW and CF, which means that the results of these methods heavily depend on the window size.

Table 1: Object evaluation for the proposed method

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Epoxy</th>
<th>Venus</th>
<th>Ready</th>
<th>Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>AW [1]</td>
<td>2.77</td>
<td>0.46</td>
<td>11.2</td>
<td>8.80</td>
</tr>
<tr>
<td>AD [1]</td>
<td>1.85</td>
<td>0.79</td>
<td>1.18</td>
<td>0.24</td>
</tr>
<tr>
<td>CD [4]</td>
<td>2.34</td>
<td>0.45</td>
<td>12.4</td>
<td>8.85</td>
</tr>
<tr>
<td>GD [2]</td>
<td>2.90</td>
<td>0.45</td>
<td>11.5</td>
<td>7.92</td>
</tr>
</tbody>
</table>

Figure 1: Disparity estimation results of the proposed method.

Figure 2: Advantage of our method. Disparity estimation results using the smallest window in cost aggregation. (a) The ground truth. 3x3 size window are used in (b) Adaptive weight [3], (c) Costfilter [4], and 4-neighor pixels are used in (d) Anisotropic diffusion [1], (d) Geodiff [2], (e) Proposed method.