Disp/DSM post-filtering Manual – v1

Xu Huang

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# 1. Introduction to the disparity/DSM post-filtering

In a normal dense image matching (DIM) process, the corresponding matching results or digital surface model (DSM) products contain obvious uncertainties, resulting in noisy surfaces in matching results or DSM. This program is used to filter disparities in the matching results or the elevations in the DSM so that the matching results or DSM after the post-filtering can obtain smooth surfaces while reserve sharp boundaries.

# 2. Input of the post-filtering

The input of the post-filtering program is a simple xml document. An empty xml document can be generated by double clicking the Disp\_Filtering.exe. The format of the xml document is as follows:

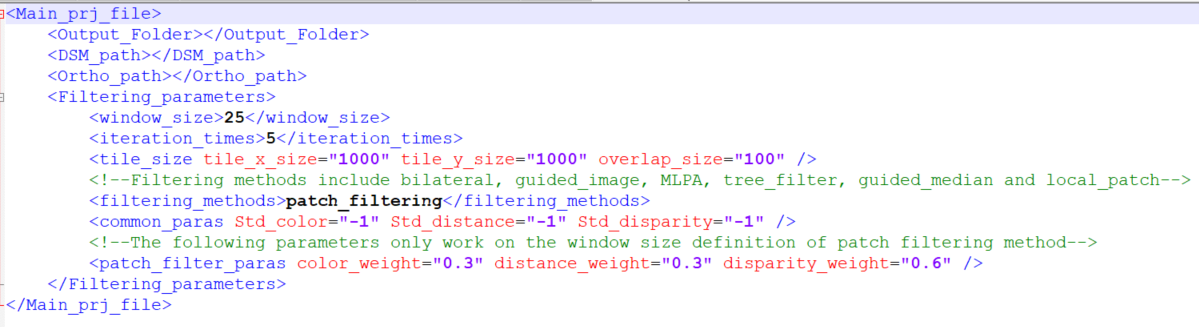


Figure 1. xml document of the post-filtering program

“**Output\_Folder**”: The path of the output folder which stores the filtering results

“**DSM\_path**”: the path of the input original DSM

“**Ortho\_path**”: the path of the input orthophoto, which should have the same size with the input DSM, and has one-to-one corresponding pixels with DSM in the image space. It should be noted that the input orthophoto should be 8 bits.

“**window\_size**”: the total pixel number in the local filtering window. For example, the window size with 25 pixels mean the 5x5 filtering window.

“**iteration\_times**”: the times of the post-filtering on the matching results or DSM

“**tile\_size**”: divide the whole disparity image or the DSM into several blocks, where **tile\_x\_size** means the block size in row directions, **tile\_y\_size** means the block size in column direction and **overlap\_size** means the overlap size between adjacent blocks. It should be noted that if **local\_patch** is chosen as the filtering method, the tile\_size is recommend to set as 1000x1000, larger tile size will demand high compute memory.

“**Filtering\_methods**”: **bilateral** means bilateral filtering, **guided\_image** means guided image filtering, **MLPA** means multipoint filtering with local polynomial approximation, **tree\_filter** means global filtering with the minimum spanning tree, **guided\_median** means image-guided median filtering and **local\_patch** means post-filtering with surface orientation constraints. It should be noted that **tree\_filter** results are not depended on the **window\_size** or **std\_distance** or **std\_disparity**.

“**common\_paras**”: the parameters that are used in all the filtering methods, where **std\_color** means the threshold of color difference between the center pixel and the surrounding pixels in the filtering window, **std\_distance** means the threshold of the distance between the center pixel and the surrounding pixel in the image space, **std\_disparity** means the threshold of the disparity/elevations differences between the center pixel and the surrounding pixels. “-1” means the default values will be used in the filtering.

“**patch\_filter\_paras**”: the unique parameters in the **local\_patch**, where the **color\_weight** means the weight of the color differences between the center pixel and the surrounding pixels in the adaptive window definition, **distance\_weight** means the weight of the distance between the center pixel and the surrounding pixels in the image space, and **disparity\_weight** means the weight of the disparity/elevation differences between the center pixel and the surrounding pixels.

# 3. Output of the post-filtering

All the output results will be put in the folder with the given path “**Output\_Folder**”. The output names of filtering results with different filtering methods will be decided by the combination of the input DSM name and the filtering method name. An example is given as follows:

![C:\Users\huang.3651\Documents\Tencent Files\3137529334\Image\C2C\[$8F_RL](WQDF)@A5@INTRY.png](data:image/png;base64,)

Figure 2. The post-filtering results

In Figure 2, \*\_bilateral.tif means the filtering results of the bilateral filtering.

\*\_guided\_image.tif means the filtering results of the guided image filtering.

\*\_guided\_median.tif means the filtering results of the image-guided median filtering.

\*\_local\_patch.tif means the filtering results of the post-filtering with surface orientation constraints

\*\_MLPA means the filtering results of multipoint filtering with local polynomial approximation

\*\_tree\_filter means the global filtering with the minimum spanning tree

The corresponding txt files store the running time of each filtering methods.

# 4. principles of the post-filtering process

1. bilateral filtering: please refer to the paper “Yoon, K., & Kweon, I., 2005. Locally adaptive support-weight approach for visual correspondence search. In: 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05). IEEE, pp. 924-31.”

2. guided image filtering: please refer to the paper “He, K., Sun, J., & Tang, X., 2013. Guided Image Filtering. IEEE Trans. Pattern Anal. Mach. Intell. 35, 1397-409.”

3. MLPA filtering: please refer to the paper “Tan, X., Sun, C., & Pham, T.D., 2016. Edge-aware filtering with local polynomial approximation and rectangle-based weighting. IEEE Trans. Cybern. 46, 2693-705.”

4. image-guided median filtering: please refer to the paper “Ma, Z., He, K., Wei, Y., Sun, J., & Wu, E. (2013). Constant time weighted median filtering for stereo matching and beyond. In Proceedings of the IEEE International Conference on Computer Vision (pp. 49-56).”

5. tree filtering: please refer to the paper “Yang, Q. (2014). Stereo matching using tree filtering. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *37*(4), 834-846.”

6. post-filtering with surface orientation constraints: please refer to the paper “A post-filtering with surface orientation constraints for stereo dense image matching” (unpublished at present).

The basic principle of the post-filtering with surface orientation constraints is:

“In general, our proposed post-filtering method consists of two main components. 1) Adaptive window selection, which formulates the window selection as a region growing problem. We select each pixel as the initial seed point and examine whether its neighbor pixels can be added into the region by considering their color/intensity differences, spatial distances in image space and their disparity differences. The region growing process is iterated on, thus forming an irregular window. 2) Post-filtering with surface orientation constraints, where the solution of the post-filtering is obtained iteratively in two steps. The first step is to obtain surface orientations of each pixel by computing the tangent disparity plane based on its local adaptive window. The second step aligns surface orientations of the center pixels consistent with their surrounding pixels so that smoother disparities will be obtained. Then, the smoother disparities will be utilized in the first step to compute more accurate surface orientations, which are then used in the second step to obtain better filtering results. A general workflow of the proposed method is shown in Fig. 2. The inputs of our proposed method are intensity/color image and the corresponding disparity image (Fig. 2(a)). Then, both the intensity/color image and the disparity image are used in the adaptive window selection of each pixel, as shown in Fig. 2(b), where the lower image shows the adaptive window (white pixels) centered at the red pixel, and the upper image visualizes the process of adaptive window selection in a 3D space consisted of the intensity/color difference (deltaC), the spatial distance (deltaS) and the disparity difference (deltaD). The origin of the 3D space is the center pixel itself, and the blue and red circles represent its surrounding pixels, where red circles are close to the center pixel in the 3D space so that they are selected during the adaptive window selection process, and the blue circles are not selected in the adaptive window. After the adaptive window selection, the surface orientations of each pixel are iteratively refined, as shown in Fig. 2(c), where the top image shows the surface orientations of original disparity surfaces with blue lines representing surface normal vectors, and the lower image shows the surface after the first iteration. Finally, the disparities with smoother surface orientations are output, as shown in Fig. 2(d).

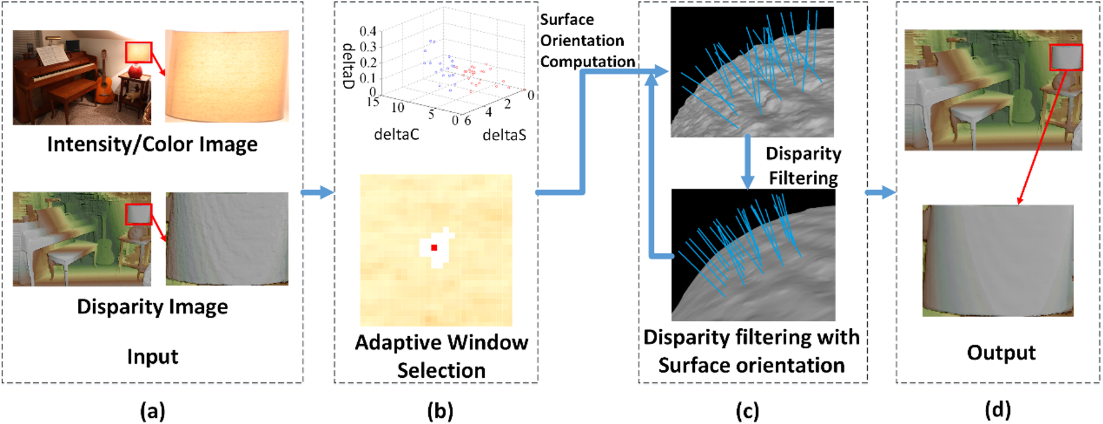


Figure 3. The workflow of our proposed method.

”

# 5. Pseudocode

**Input**: A xml document (Figure 1)

**Output**: filtered DSM (Figure 2)

**Progress**:

//conduct filtering in each block one by one

//Then write the filtering results of each block in the final filtering products.

for (int i = 0; i < blockNum; i++)

{

//keyword is extracted from the input xml document

If (filter\_methods == keyword)

{

//the filtering results will be put in the “block\_data”

Filter\_methods\_fun(block\_data, block\_w, block\_h, filter\_paras)

}

//add the blockwise filtering results in the final products of the whole //region

Add\_to\_final\_products(block\_data, output\_path)

}