**Normalization results for pairs 1\_0.ppm\_1\_2.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_cartooncity**

**1\_0.ppm: 1\_2.ppm: **

**Table 1 - Found homography parameters and normalization accuracy assessment**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 90,054 img2: 63,521 | h11 | h12 | h13 | h21 | h22 | h23 | h31 | h32 | h33 | avg ErrPar (param) | avg ErrIM (pixel) | max ErrIM | avg ErrCPM (corner) | max ErrCPM | Expert rate |
| SIFT | 0,089 | 0,01 | 131,833 | -0,147 | 0,472 | 88,343 | -0,001 | 0 | 1 | 0,291 | 0,71 | 3,583 | 4,435 | 10,266 |  |
| SURF128 | 0,092 | 0,006 | 130,91 | -0,146 | 0,47 | 87,741 | -0,001 | 0 | 1 | 0,306 | 1,121 | 3,779 | 5,65 | 10,2 |  |
| SURF64 | 0,084 | 0,003 | 136,367 | -0,146 | 0,464 | 88,88 | -0,001 | 0 | 1 | 0,546 | 1,038 | 3,309 | 12,958 | 25,899 |  |
| ORB | 0,091 | 0,008 | 130,913 | -0,146 | 0,471 | 88,129 | -0,001 | 0 | 1 | 0,257 | 1,032 | 3,789 | 4,381 | 8,717 |  |
| ORB1000 | 0,096 | -0,001 | 129,122 | -0,147 | 0,469 | 89,533 | -0,001 | -0 | 1 | 0,567 | 0,676 | 1,497 | 19,65 | 50,723 |  |
| BRISK | 0,089 | 0,006 | 133,51 | -0,147 | 0,469 | 88,628 | -0,001 | 0 | 1 | 0,252 | 0,891 | 4,12 | 4,25 | 7,453 |  |
| KAZE | 0,088 | 0,008 | 133,199 | -0,147 | 0,469 | 89,155 | -0,001 | 0 | 1 | 0,344 | 0,882 | 3,81 | 5,582 | 11,035 |  |
| AKAZE | 0,088 | 0,008 | 133,051 | -0,147 | 0,469 | 88,806 | -0,001 | 0 | 1 | 0,299 | 0,725 | 3,698 | 5,111 | 10,518 |  |
| Original matrix | 0,091 | 0,007 | 132,72 | -0,147 | 0,473 | 88,51 | -0,001 | 0 | 1,003 |  |  |  |  |  |  |

where h11, h12, h13, h21, h22, h23, h31, h32, h33 - parameters of found homography matrix H\* or of original one H;   
avgErrPar - average error of found parameters, the accuracy of found homography matrix parameters with a preliminary minimax normalization of found and original matrices;  
avgErrIM - average error of inlier coordinate matching;  
inliers - correct matches; outliers - false matches;  
maxErrIM – maximum error of inlier coordinate matching;  
avgErrCPM - average error of corner point matching;  
maxErrCPM - maximum error of corner point matching;  
expert rate - experts assessment of normalization accuracy with a 5-point scale: 0 - normalization failed, 1 - insufficient, 2 - satisfactory, 3 - good, 4 – excellent.

**Table 2 - Quantitative evaluation of descriptors, precision and recall estimation (with found overlap)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | NP1 | NP2 | NM | NI | DP1 | DP2 | OP1 | OP2 | NPO1 | NPO2 | NMO | DPO1 | DPO2 | Precision | RecallO1 | Comments |
| SIFT | 11196 | 6304 | 1202 | 944 | 0,0111 | 0,0098 | 90,0185 | 63,7063 | 10148 | 5138 | 1174 | 0,0112 | 0,0125 | 0,7854 | 0,093 |  |
| SURF128 | 16204 | 8571 | 488 | 327 | 0,0161 | 0,0133 | 90,0298 | 63,9113 | 15307 | 7103 | 473 | 0,0169 | 0,0173 | 0,6701 | 0,0214 |  |
| SURF64 | 16204 | 8571 | 741 | 451 | 0,0161 | 0,0133 | 89,9715 | 63,658 | 15295 | 7060 | 725 | 0,0169 | 0,0172 | 0,6086 | 0,0295 |  |
| ORB | 64719 | 36859 | 1874 | 1518 | 0,0644 | 0,0572 | 90,0146 | 63,8759 | 61480 | 33043 | 1854 | 0,0679 | 0,0803 | 0,81 | 0,0247 |  |
| ORB1000 | 1000 | 1000 | 31 | 22 | 0,001 | 0,0016 | 89,9166 | 64,5444 | 982 | 999 | 31 | 0,0011 | 0,0024 | 0,7097 | 0,0224 |  |
| BRISK | 27371 | 15261 | 879 | 669 | 0,0272 | 0,0237 | 89,9793 | 63,7487 | 25638 | 13784 | 873 | 0,0283 | 0,0336 | 0,7611 | 0,0261 |  |
| KAZE | 6700 | 3485 | 509 | 427 | 0,0067 | 0,0054 | 90,028 | 63,7052 | 6153 | 3127 | 504 | 0,0068 | 0,0076 | 0,8389 | 0,0694 |  |
| AKAZE | 7407 | 3832 | 453 | 328 | 0,0074 | 0,006 | 90,0467 | 63,72 | 6967 | 3495 | 447 | 0,0077 | 0,0085 | 0,7241 | 0,0471 |  |

where NP - number of found key points; NP1, NP2 - number of found key points for image1 and image2 respectively;  
NM - number of matches found with NNDR method, NM=NI+NO;  
NI - number of inliers found with RANSAC method;  
NO - number of outliers discarded with RANSAC method;   
DP - density of key points (per cent), DP= NP/(height x width) , height, width - vertical and horizontal image sizes respectively (pixels)  
DP1, DP2 - density of key points points for image1 and image2 respectively;  
OP1, OP2 - overlap percentage for image1 and image2 respectively;  
NPO1, NPO2 - number of found key points on overlap for image1 and image2 respectivelyy;  
NMO - number of matches on overlap found with NNDR method;  
DPO1, DPO2 - density of key points points on overlap for image1 and image2 respectively;   
OA - overlap area (pixels), OA1, OA2 - overlap area for image1 and image2 respectively;  
DPO1= NPO1/OA1; DPO2= NPO2/OA2;  
Precision = NI/ NM - the rate to evaluate the part of inliers to all found matches with NNDR method;  
RecallO1 = NI/ NPO1 - completeness of inlier retrieval relative to the number of all key points on overlap for image1. The rate illustrates usefulness of the found key points for normalization.

**Table 3 - Estimation of time costs**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | NP1 | NP2 | DesT1, sec | DesT2, sec | MatchT, sec | InlierT, sec | AvgDesT, ms | AvgMatchT, ms | AvgInlierT, ms | TotalNormT, sec |
| SIFT | 11196 | 6304 | 0,323906 | 0,214515 | 0,904479 | 0,001493 | 0,031479 | 0,752478 | 0,001581 | 1,444394 |
| SURF128 | 16204 | 8571 | 0,675072 | 0,363475 | 1,979178 | 0,00122 | 0,042033 | 4,055691 | 0,003731 | 3,018945 |
| SURF64 | 16204 | 8571 | 0,665635 | 0,348333 | 0,828394 | 0,001834 | 0,040859 | 1,117941 | 0,004066 | 1,844196 |
| ORB | 64719 | 36859 | 0,141629 | 0,085631 | 8,638956 | 0,001354 | 0,002255 | 4,609901 | 0,000891 | 8,867569 |
| ORB1000 | 1000 | 1000 | 0,042371 | 0,026648 | 0,004093 | 0,000669 | 0,034509 | 0,132041 | 0,030394 | 0,073781 |
| BRISK | 27371 | 15261 | 0,478869 | 0,246712 | 1,620263 | 0,000969 | 0,01683 | 1,843302 | 0,001448 | 2,346813 |
| KAZE | 6700 | 3485 | 0,661146 | 0,418399 | 0,278431 | 0,000688 | 0,109367 | 0,547015 | 0,00161 | 1,358663 |
| AKAZE | 7407 | 3832 | 0,123661 | 0,081798 | 0,206819 | 0,000721 | 0,01902 | 0,456554 | 0,002198 | 0,412999 |

where DesT – descriptor creation time (time for key point detection and descriptor computation), DesT1, DesT2 – creation time of descriptors for image1 and image2 respectively;  
MatchT - retrieval time of matching found with NNDR method for the pair;  
InlierT – inlier retrieval time found with RANSAC method for the pair;  
AvgDesT – average time for one descriptor creation;  
AvgMatchT - average time for one match retrieval with NNDR method;  
AvgInlierT – average time for one inlier retrieval with RANSAC method;  
TotalNormT – total normalization time for the pair.