**Normalization results for pairs 1\_0.ppm\_1\_5.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_boat**

**1\_0.ppm: 1\_5.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 17,88 | 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 | 0,434 | -0,048 | 262,662 | 0,066 | 0,431 | 172,848 | 0 | 0 | 1 | 0,384 | 0,781 | 2,852 | 3,253 | 7 |  |
| SURF128 | 0,408 | -0,067 | 266,631 | 0,053 | 0,401 | 177,453 | -0 | -0 | 1 | 0,462 | 1,197 | 3,579 | 6,236 | 13,129 |  |
| SURF64 | 0,428 | -0,054 | 264,013 | 0,064 | 0,424 | 173,534 | 0 | 0 | 1 | 0,239 | 1,166 | 3,804 | 2,551 | 3,691 |  |
| ORB | 0,44 | -0,057 | 262,249 | 0,069 | 0,424 | 173,165 | 0 | -0 | 1 | 0,379 | 0,915 | 3,447 | 5,497 | 9,277 |  |
| ORB1000 | 0,436 | -0,038 | 262,095 | 0,065 | 0,444 | 172,02 | 0 | 0 | 1 | 0,514 | 0,895 | 2,214 | 8,256 | 9,72 |  |
| BRISK | 0,446 | -0,061 | 262,335 | 0,074 | 0,424 | 172,111 | 0 | -0 | 1 | 0,488 | 0,969 | 3,034 | 7,909 | 13,268 |  |
| KAZE | 0,433 | -0,063 | 264,195 | 0,067 | 0,417 | 173,994 | 0 | -0 | 1 | 0,316 | 1,142 | 3,328 | 4,897 | 9,182 |  |
| AKAZE | 0,435 | -0,045 | 262,382 | 0,067 | 0,434 | 172,209 | 0 | 0 | 1 | 0,447 | 1,02 | 3,052 | 4,554 | 8,386 |  |
| Original matrix | 0,422 | -0,056 | 265,09 | 0,061 | 0,42 | 174,7 | 0 | -0 | 1 |  |  |  |  |  |  |

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 | 8849 | 4932 | 517 | 395 | 0,0153 | 0,0085 | 100 | 17,9168 | 8849 | 2000 | 517 | 0,0153 | 0,0193 | 0,764 | 0,0446 |  |
| SURF128 | 6737 | 4100 | 261 | 187 | 0,0117 | 0,0071 | 100 | 18,0164 | 6737 | 1336 | 261 | 0,0117 | 0,0128 | 0,7165 | 0,0278 |  |
| SURF64 | 6737 | 4100 | 391 | 307 | 0,0117 | 0,0071 | 100 | 17,9145 | 6737 | 1332 | 391 | 0,0117 | 0,0129 | 0,7852 | 0,0456 |  |
| ORB | 34746 | 16930 | 1260 | 936 | 0,0601 | 0,0293 | 100 | 18,0747 | 34746 | 8881 | 1260 | 0,0601 | 0,085 | 0,7429 | 0,0269 |  |
| ORB1000 | 1000 | 1000 | 118 | 111 | 0,0017 | 0,0017 | 100 | 17,9412 | 1000 | 751 | 118 | 0,0017 | 0,0072 | 0,9407 | 0,111 |  |
| BRISK | 13777 | 5965 | 564 | 387 | 0,0238 | 0,0103 | 100 | 18,1031 | 13777 | 3321 | 564 | 0,0238 | 0,0317 | 0,6862 | 0,0281 |  |
| KAZE | 3281 | 1781 | 202 | 146 | 0,0057 | 0,0031 | 100 | 17,9706 | 3281 | 971 | 202 | 0,0057 | 0,0093 | 0,7228 | 0,0445 |  |
| AKAZE | 3694 | 1714 | 198 | 158 | 0,0064 | 0,003 | 100 | 17,8666 | 3694 | 1035 | 198 | 0,0064 | 0,01 | 0,798 | 0,0428 |  |

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 | 8849 | 4932 | 0,424015 | 0,355128 | 0,886256 | 0,000839 | 0,05996 | 1,714227 | 0,002124 | 1,666238 |
| SURF128 | 6737 | 4100 | 0,526812 | 0,391474 | 0,673661 | 0,00096 | 0,086838 | 2,581078 | 0,005134 | 1,592908 |
| SURF64 | 6737 | 4100 | 0,707352 | 0,598068 | 0,342021 | 0,000714 | 0,125432 | 0,874733 | 0,002325 | 1,648155 |
| ORB | 34746 | 16930 | 0,121446 | 0,053247 | 2,93737 | 0,001188 | 0,00332 | 2,331246 | 0,001269 | 3,113252 |
| ORB1000 | 1000 | 1000 | 0,034266 | 0,021619 | 0,032197 | 0,000323 | 0,027942 | 0,272858 | 0,002912 | 0,088405 |
| BRISK | 13777 | 5965 | 0,338788 | 0,133176 | 0,470021 | 0,000983 | 0,023458 | 0,83337 | 0,002541 | 0,942969 |
| KAZE | 3281 | 1781 | 0,914131 | 0,772512 | 0,134329 | 0,000703 | 0,356182 | 0,664995 | 0,004816 | 1,821675 |
| AKAZE | 3694 | 1714 | 0,203925 | 0,16975 | 0,099155 | 0,000681 | 0,07712 | 0,500782 | 0,004307 | 0,47351 |

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.