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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 88,493 img2: 50,526 | 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 | 0,201 | 0,014 | 173,772 | -0,133 | 0,54 | 11,876 | -0 | 0 | 1 | 0,29 | 0,884 | 3,712 | 5,829 | 10,347 |  |
| SURF128 | 0,189 | 0,011 | 179,206 | -0,136 | 0,53 | 16,375 | -0 | 0 | 1 | 0,726 | 1,146 | 3,233 | 17,227 | 34,814 |  |
| SURF64 | 0,2 | 0,016 | 171,742 | -0,135 | 0,54 | 12,788 | -0 | 0 | 1 | 0,341 | 1,255 | 4,092 | 4,597 | 7,395 |  |
| ORB | 0,202 | 0,01 | 174,914 | -0,131 | 0,538 | 11,813 | -0 | 0 | 1 | 0,485 | 1,096 | 4,215 | 5,213 | 14,552 |  |
| ORB1000 | 0,193 | 0,01 | 177,791 | -0,134 | 0,531 | 15,023 | -0 | 0 | 1 | 0,621 | 0,926 | 2,86 | 12,859 | 28,03 |  |
| BRISK | 0,2 | 0,014 | 173,932 | -0,133 | 0,541 | 11,562 | -0 | 0 | 1 | 0,284 | 1,08 | 3,618 | 6,399 | 10,82 |  |
| KAZE | 0,192 | 0,009 | 178,791 | -0,134 | 0,531 | 14,615 | -0 | 0 | 1 | 0,612 | 1,057 | 3,259 | 13,824 | 31,533 |  |
| AKAZE | 0,198 | 0,009 | 176,634 | -0,133 | 0,535 | 13,316 | -0 | 0 | 1 | 0,579 | 1,012 | 3,076 | 7,78 | 22,056 |  |
| Original matrix | 0,209 | 0,015 | 174,06 | -0,134 | 0,55 | 11,64 | -0 | 0 | 1,018 |  |  |  |  |  |  |

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 | 3361 | 2703 | 749 | 552 | 0,0032 | 0,0042 | 88,3914 | 50,3931 | 3292 | 1938 | 743 | 0,0036 | 0,006 | 0,737 | 0,1677 |  |
| SURF128 | 7603 | 5799 | 743 | 459 | 0,0073 | 0,009 | 88,6207 | 50,0224 | 7455 | 3506 | 738 | 0,0081 | 0,0109 | 0,6178 | 0,0616 |  |
| SURF64 | 7603 | 5799 | 838 | 492 | 0,0073 | 0,009 | 88,3483 | 50,6341 | 7447 | 3528 | 834 | 0,0081 | 0,0108 | 0,5871 | 0,0661 |  |
| ORB | 19105 | 12619 | 1434 | 1072 | 0,0184 | 0,0196 | 88,4977 | 50,3811 | 18935 | 11365 | 1428 | 0,0206 | 0,035 | 0,7476 | 0,0566 |  |
| ORB1000 | 1000 | 1000 | 138 | 110 | 0,001 | 0,0016 | 88,5602 | 50,2313 | 1000 | 1000 | 138 | 0,0011 | 0,0031 | 0,7971 | 0,11 |  |
| BRISK | 6549 | 4267 | 713 | 571 | 0,0063 | 0,0066 | 88,3305 | 50,3591 | 6515 | 4067 | 713 | 0,0071 | 0,0125 | 0,8008 | 0,0876 |  |
| KAZE | 4081 | 2060 | 494 | 368 | 0,0039 | 0,0032 | 88,5496 | 50,1375 | 4049 | 1938 | 493 | 0,0044 | 0,006 | 0,7449 | 0,0909 |  |
| AKAZE | 3884 | 1939 | 385 | 285 | 0,0037 | 0,003 | 88,5509 | 50,2586 | 3857 | 1831 | 385 | 0,0042 | 0,0057 | 0,7403 | 0,0739 |  |

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 | 3361 | 2703 | 0,239756 | 0,159958 | 0,09439 | 0,000925 | 0,065255 | 0,12602 | 0,001675 | 0,495029 |
| SURF128 | 7603 | 5799 | 0,424418 | 0,276369 | 0,551653 | 0,001709 | 0,05174 | 0,742467 | 0,003723 | 1,25415 |
| SURF64 | 7603 | 5799 | 0,402114 | 0,266317 | 0,274156 | 0,001651 | 0,049406 | 0,327155 | 0,003355 | 0,944237 |
| ORB | 19105 | 12619 | 0,066197 | 0,039237 | 0,813227 | 0,001243 | 0,003286 | 0,567104 | 0,001159 | 0,919905 |
| ORB1000 | 1000 | 1000 | 0,033357 | 0,022202 | 0,006299 | 0,00072 | 0,027779 | 0,045644 | 0,006541 | 0,062578 |
| BRISK | 6549 | 4267 | 0,122497 | 0,077367 | 0,109229 | 0,000787 | 0,018417 | 0,153196 | 0,001378 | 0,309881 |
| KAZE | 4081 | 2060 | 0,717437 | 0,460773 | 0,096059 | 0,000877 | 0,199737 | 0,19445 | 0,002381 | 1,275146 |
| AKAZE | 3884 | 1939 | 0,129556 | 0,082375 | 0,026485 | 0,000731 | 0,037919 | 0,068791 | 0,002564 | 0,239146 |

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.