**Normalization results for pairs 1\_0.ppm\_1\_4.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_bird**

**1\_0.ppm: 1\_4.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 69,808 img2: 72,542 | 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 | 2,733 | 0,013 | -57,644 | 0,811 | 2,488 | -955,849 | 0,002 | 0 | 1 | 0,782 | 0,919 | 3,299 | 36,754 | 58,345 |  |
| SURF128 | 2,677 | 0,004 | -49,953 | 0,785 | 2,436 | -931,266 | 0,002 | 0 | 1 | 0,696 | 1,391 | 4,225 | 29,515 | 45,141 |  |
| SURF64 | 2,677 | 0,004 | -49,617 | 0,784 | 2,442 | -933,458 | 0,002 | 0 | 1 | 0,697 | 1,35 | 3,324 | 29,611 | 42,827 |  |
| ORB | 2,69 | 0 | -49,207 | 0,794 | 2,445 | -937,372 | 0,002 | 0 | 1 | 0,77 | 1,367 | 3,435 | 33,471 | 49,543 |  |
| ORB1000 | 2,697 | 0,017 | -58,491 | 0,794 | 2,461 | -943,618 | 0,002 | 0 | 1 | 0,658 | 1,25 | 2,569 | 29,194 | 45,649 |  |
| BRISK | 2,73 | 0,017 | -58,528 | 0,803 | 2,501 | -959,415 | 0,002 | 0 | 1 | 0,728 | 1,167 | 3,711 | 29,686 | 49,772 |  |
| KAZE | 2,746 | 0,029 | -64,747 | 0,811 | 2,521 | -970,082 | 0,002 | 0 | 1 | 0,713 | 1,347 | 3,959 | 31,689 | 52,339 |  |
| AKAZE | 2,703 | 0,005 | -51,661 | 0,802 | 2,468 | -947,889 | 0,002 | 0 | 1 | 0,791 | 1,15 | 3,58 | 36,124 | 53,189 |  |
| Original matrix | 2,618 | 0,043 | -65,797 | 0,744 | 2,395 | -903,27 | 0,002 | 0 | 0,99 |  |  |  |  |  |  |

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 | 4277 | 468 | 266 | 0,0032 | 0,0043 | 69,6377 | 71,4337 | 2808 | 2178 | 435 | 0,0039 | 0,003 | 0,5684 | 0,0947 |  |
| SURF128 | 7603 | 8014 | 502 | 230 | 0,0073 | 0,008 | 69,5416 | 71,7059 | 6392 | 5492 | 475 | 0,0088 | 0,0076 | 0,4582 | 0,036 |  |
| SURF64 | 7603 | 8014 | 533 | 249 | 0,0073 | 0,008 | 69,4656 | 71,6923 | 6386 | 5490 | 499 | 0,0088 | 0,0076 | 0,4672 | 0,039 |  |
| ORB | 19105 | 19781 | 684 | 401 | 0,0184 | 0,0197 | 69,5601 | 71,5856 | 16999 | 14004 | 656 | 0,0235 | 0,0195 | 0,5863 | 0,0236 |  |
| ORB1000 | 1000 | 1000 | 79 | 60 | 0,001 | 0,001 | 69,4748 | 71,708 | 946 | 973 | 79 | 0,0013 | 0,0013 | 0,7595 | 0,0634 |  |
| BRISK | 6549 | 7114 | 338 | 234 | 0,0063 | 0,0071 | 69,3999 | 71,6747 | 5860 | 5273 | 331 | 0,0081 | 0,0073 | 0,6923 | 0,0399 |  |
| KAZE | 4081 | 3333 | 328 | 195 | 0,0039 | 0,0033 | 69,4053 | 71,5903 | 3599 | 2838 | 320 | 0,005 | 0,0039 | 0,5945 | 0,0542 |  |
| AKAZE | 3884 | 3087 | 201 | 109 | 0,0037 | 0,0031 | 69,4801 | 71,5078 | 3456 | 2616 | 195 | 0,0048 | 0,0036 | 0,5423 | 0,0315 |  |

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 | 4277 | 0,216346 | 0,230153 | 0,16559 | 0,001539 | 0,05909 | 0,353824 | 0,005784 | 0,613628 |
| SURF128 | 7603 | 8014 | 0,504952 | 0,537314 | 1,09974 | 0,003324 | 0,06673 | 2,190716 | 0,01445 | 2,145329 |
| SURF64 | 7603 | 8014 | 0,996143 | 0,721802 | 0,607609 | 0,00336 | 0,110543 | 1,139978 | 0,013492 | 2,328913 |
| ORB | 19105 | 19781 | 0,255245 | 0,215061 | 2,056238 | 0,011431 | 0,012116 | 3,006195 | 0,028506 | 2,537974 |
| ORB1000 | 1000 | 1000 | 0,037872 | 0,065666 | 0,031422 | 0,000585 | 0,051768 | 0,397748 | 0,009745 | 0,135545 |
| BRISK | 6549 | 7114 | 0,162544 | 0,201376 | 0,304658 | 0,000851 | 0,026563 | 0,901355 | 0,003636 | 0,669429 |
| KAZE | 4081 | 3333 | 1,576346 | 1,524572 | 0,339902 | 0,001341 | 0,42184 | 1,036286 | 0,006879 | 3,442162 |
| AKAZE | 3884 | 3087 | 0,317347 | 0,266886 | 0,137778 | 0,038362 | 0,08408 | 0,685463 | 0,351946 | 0,760373 |

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.