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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 0 img2: 0 | 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 | -0,048 | 0,012 | 256,23 | -0,186 | 0,659 | -82,68 | -0,001 | 0 | 1 | 0,115 | 1,095 | 3,165 | 29,28 | 50,314 |  |
| SURF128 | 0,109 | -0,042 | 202,074 | -0,065 | 0,745 | -204,896 | -0,001 | -0 | 1 | 0,18 | 1,044 | 2,407 | 210,372 | 315,869 |  |
| SURF64 | -0,067 | 0,059 | 250,171 | -0,175 | 0,698 | -112,275 | -0,001 | 0 | 1 | 0,132 | 1,314 | 2,883 | 102,824 | 274,793 |  |
| ORB | -2,215 | 1,005 | 415,536 | -2,539 | 1,162 | 469,966 | -0,005 | 0,002 | 1 | 0,828 | 1,114 | 2,6 | 1473,755 | 3651,271 |  |
| ORB1000 | -0,525 | 0,204 | 357,193 | -0,848 | 0,39 | 391,334 | -0,001 | 0 | 1 | 0,343 | 0,209 | 0,52 | 1298,594 | 2177,779 |  |
| BRISK | -0,056 | 0,033 | 255,427 | -0,196 | 0,684 | -86,06 | -0,001 | 0 | 1 | 0,119 | 1,068 | 2,626 | 53,51 | 135,932 |  |
| KAZE | -0,024 | 0,006 | 248,263 | -0,175 | 0,679 | -98,21 | -0,001 | 0 | 1 | 0,118 | 1,367 | 2,227 | 25,034 | 45,627 |  |
| AKAZE | -0,667 | 0,059 | 569,647 | -0,17 | 0,004 | 154,783 | -0,001 | 0 | 1 | 0,359 | 77,598 | 373,555 | 839,857 | 1296,09 |  |
| Original matrix | -0,033 | 0,009 | 255,62 | -0,184 | 0,673 | -86,488 | -0,001 | 0 | 1,009 |  |  |  |  |  |  |

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 | 2344 | 137 | 37 | 0,0032 | 0,0036 | 56,2066 | 56,0639 | 2606 | 1361 | 111 | 0,0045 | 0,0038 | 0,2701 | 0,0142 |  |
| SURF128 | 7603 | 5404 | 170 | 23 | 0,0073 | 0,0084 | 58,1779 | 57,7393 | 5522 | 4001 | 142 | 0,0091 | 0,0108 | 0,1353 | 0,0042 |  |
| SURF64 | 7603 | 5404 | 138 | 23 | 0,0073 | 0,0084 | 46,797 | 55,8445 | 6007 | 3642 | 113 | 0,0124 | 0,0101 | 0,1667 | 0,0038 |  |
| ORB | 19105 | 10420 | 161 | 9 | 0,0184 | 0,0162 | 99,7613 | 61,7855 | 19050 | 8629 | 161 | 0,0184 | 0,0217 | 0,0559 | 0,0005 |  |
| ORB1000 | 1000 | 1000 | 10 | 5 | 0,001 | 0,0016 | 0 | 33,4656 | 692 | 612 | 8 | ∞ | 0,0028 | 0,5 | 0,0072 |  |
| BRISK | 6549 | 3776 | 54 | 20 | 0,0063 | 0,0059 | 51,7195 | 55,1362 | 5419 | 2911 | 47 | 0,0101 | 0,0082 | 0,3704 | 0,0037 |  |
| KAZE | 4081 | 1689 | 31 | 14 | 0,0039 | 0,0026 | 60,096 | 55,7805 | 3283 | 1448 | 26 | 0,0053 | 0,004 | 0,4516 | 0,0043 |  |
| AKAZE | 3884 | 1434 | 38 | 6 | 0,0037 | 0,0022 | 58,9531 | 95,5892 | 3828 | 1421 | 36 | 0,0062 | 0,0023 | 0,1579 | 0,0016 |  |

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 | 2344 | 0,237916 | 0,142837 | 0,133891 | 0,029983 | 0,065862 | 0,977307 | 0,810353 | 0,544627 |
| SURF128 | 7603 | 5404 | 0,446809 | 0,18699 | 0,324595 | 0,050717 | 0,046684 | 1,90938 | 2,205073 | 1,00911 |
| SURF64 | 7603 | 5404 | 0,303363 | 0,19269 | 0,179457 | 0,049123 | 0,037778 | 1,30041 | 2,135782 | 0,724632 |
| ORB | 19105 | 10420 | 0,056915 | 0,045043 | 0,456351 | 0,049853 | 0,00365 | 2,834481 | 5,539234 | 0,608163 |
| ORB1000 | 1000 | 1000 | 0,030157 | 0,019071 | 0,004074 | 0,002093 | 0,024613 | 0,407381 | 0,418611 | 0,055394 |
| BRISK | 6549 | 3776 | 0,106811 | 0,06376 | 0,078171 | 0,007085 | 0,016597 | 1,447613 | 0,354235 | 0,255827 |
| KAZE | 4081 | 1689 | 0,544423 | 0,319924 | 0,061516 | 0,003214 | 0,161409 | 1,984391 | 0,229546 | 0,929076 |
| AKAZE | 3884 | 1434 | 0,111432 | 0,06574 | 0,020555 | 0,049572 | 0,037267 | 0,540923 | 8,261974 | 0,2473 |

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.