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

**1\_0.ppm: 1\_1.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 99,506 img2: 47,998 | 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 | 0,327 | -0,001 | 169,417 | -0,088 | 0,493 | 72,533 | -0 | 0 | 1 | 0,258 | 0,573 | 3,121 | 0,94 | 1,967 |  |
| SURF128 | 0,331 | 0 | 168,339 | -0,086 | 0,495 | 71,383 | -0 | 0 | 1 | 0,499 | 0,956 | 4,008 | 1,717 | 2,339 |  |
| SURF64 | 0,327 | -0,002 | 169,811 | -0,088 | 0,492 | 72,735 | -0 | 0 | 1 | 0,414 | 0,998 | 3,75 | 1,298 | 3,178 |  |
| ORB | 0,328 | -0,004 | 170,89 | -0,087 | 0,492 | 72,302 | -0 | 0 | 1 | 0,522 | 0,921 | 3,683 | 2,776 | 5,764 |  |
| ORB1000 | 0,329 | -0,001 | 169,223 | -0,088 | 0,494 | 72,395 | -0 | 0 | 1 | 0,265 | 0,927 | 2,704 | 1,063 | 1,406 |  |
| BRISK | 0,33 | -0,001 | 168,815 | -0,086 | 0,494 | 70,74 | -0 | 0 | 1 | 0,538 | 0,906 | 3,176 | 2,27 | 2,865 |  |
| KAZE | 0,328 | 0 | 168,801 | -0,088 | 0,495 | 71,778 | -0 | 0 | 1 | 0,26 | 0,994 | 3,429 | 0,737 | 1,038 |  |
| AKAZE | 0,329 | -0,001 | 169,163 | -0,088 | 0,494 | 71,798 | -0 | 0 | 1 | 0,239 | 0,843 | 3,772 | 0,84 | 1,161 |  |
| Original matrix | 0,328 | -0 | 168,52 | -0,088 | 0,493 | 72,043 | -0 | 0 | 0,998 |  |  |  |  |  |  |

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 | 3200 | 1142 | 1007 | 0,0032 | 0,005 | 99,51 | 47,9506 | 3361 | 1933 | 1142 | 0,0033 | 0,0063 | 0,8818 | 0,2996 |  |
| SURF128 | 7603 | 6261 | 1369 | 1015 | 0,0073 | 0,0097 | 99,5373 | 47,9112 | 7603 | 3857 | 1369 | 0,0074 | 0,0125 | 0,7414 | 0,1335 |  |
| SURF64 | 7603 | 6261 | 1450 | 1231 | 0,0073 | 0,0097 | 99,5192 | 47,9349 | 7603 | 3858 | 1450 | 0,0074 | 0,0125 | 0,849 | 0,1619 |  |
| ORB | 19105 | 17234 | 3740 | 3258 | 0,0184 | 0,0268 | 99,5498 | 47,9103 | 19105 | 15257 | 3740 | 0,0185 | 0,0495 | 0,8711 | 0,1705 |  |
| ORB1000 | 1000 | 1000 | 250 | 236 | 0,001 | 0,0016 | 99,5196 | 48,0232 | 1000 | 1000 | 250 | 0,001 | 0,0032 | 0,944 | 0,236 |  |
| BRISK | 6549 | 6142 | 1485 | 1116 | 0,0063 | 0,0095 | 99,5383 | 47,9864 | 6549 | 5587 | 1485 | 0,0063 | 0,0181 | 0,7515 | 0,1704 |  |
| KAZE | 4081 | 2502 | 835 | 685 | 0,0039 | 0,0039 | 99,483 | 48,012 | 4081 | 2324 | 835 | 0,0039 | 0,0075 | 0,8204 | 0,1679 |  |
| AKAZE | 3884 | 2313 | 952 | 849 | 0,0037 | 0,0036 | 99,4984 | 48,0266 | 3884 | 2191 | 952 | 0,0038 | 0,0071 | 0,8918 | 0,2186 |  |

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 | 3200 | 0,241987 | 0,153162 | 0,174512 | 0,004868 | 0,05993 | 0,152812 | 0,004834 | 0,574529 |
| SURF128 | 7603 | 6261 | 0,654635 | 0,337753 | 0,840387 | 0,001201 | 0,070023 | 0,613869 | 0,001183 | 1,833976 |
| SURF64 | 7603 | 6261 | 0,508631 | 0,386201 | 0,375352 | 0,001003 | 0,06429 | 0,258863 | 0,000814 | 1,271187 |
| ORB | 19105 | 17234 | 0,061943 | 0,047553 | 1,389281 | 0,002418 | 0,003 | 0,371465 | 0,000742 | 1,501194 |
| ORB1000 | 1000 | 1000 | 0,033376 | 0,021612 | 0,007052 | 0,000407 | 0,027493 | 0,028209 | 0,001722 | 0,062446 |
| BRISK | 6549 | 6142 | 0,365469 | 0,240517 | 0,299208 | 0,001254 | 0,047482 | 0,201487 | 0,001123 | 0,906448 |
| KAZE | 4081 | 2502 | 0,663422 | 0,406429 | 0,120428 | 0,000996 | 0,162502 | 0,144225 | 0,001454 | 1,191276 |
| AKAZE | 3884 | 2313 | 0,137076 | 0,086394 | 0,041343 | 0,000987 | 0,036321 | 0,043427 | 0,001162 | 0,265801 |

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.