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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 20,589 | 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 | 0,46 | 0,002 | 42,863 | 0,004 | 0,457 | 107,463 | 0 | 0 | 1 | 0,136 | 0,361 | 2,664 | 0,586 | 0,846 |  |
| SURF128 | 0,458 | 0,001 | 43,137 | 0,001 | 0,456 | 107,855 | 0 | 0 | 1 | 0,281 | 0,751 | 3,943 | 1,445 | 1,871 |  |
| SURF64 | 0,463 | 0,003 | 41,89 | 0,004 | 0,46 | 107,07 | 0 | 0 | 1 | 0,243 | 0,786 | 4,56 | 0,887 | 1,966 |  |
| ORB | 0,461 | 0,002 | 42,609 | 0,004 | 0,457 | 107,383 | 0 | 0 | 1 | 0,135 | 0,7 | 2,518 | 1,219 | 1,992 |  |
| ORB1000 | 0,45 | 0,011 | 45,651 | -0 | 0,463 | 107,97 | -0 | 0 | 1 | 0,697 | 0,793 | 1,934 | 6,645 | 16,882 |  |
| BRISK | 0,462 | 0,001 | 42,576 | 0,005 | 0,458 | 106,819 | 0 | -0 | 1 | 0,215 | 0,567 | 2,912 | 1,312 | 2,41 |  |
| KAZE | 0,466 | 0,004 | 41,459 | 0,007 | 0,463 | 105,938 | 0 | 0 | 1 | 0,482 | 0,819 | 2,298 | 1,701 | 4,035 |  |
| AKAZE | 0,466 | 0,001 | 41,929 | 0,006 | 0,459 | 106,846 | 0 | 0 | 1 | 0,312 | 0,57 | 1,995 | 1,84 | 3,715 |  |
| Original matrix | 0,461 | 0,002 | 42,778 | 0,004 | 0,457 | 107,3 | 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 | 3009 | 2199 | 630 | 553 | 0,0068 | 0,005 | 100 | 20,5852 | 3009 | 1014 | 630 | 0,0068 | 0,0112 | 0,8778 | 0,1838 |  |
| SURF128 | 3561 | 2495 | 477 | 403 | 0,0081 | 0,0057 | 100 | 20,6153 | 3561 | 976 | 477 | 0,0081 | 0,0107 | 0,8449 | 0,1132 |  |
| SURF64 | 3561 | 2495 | 536 | 452 | 0,0081 | 0,0057 | 100 | 20,6444 | 3561 | 977 | 536 | 0,0081 | 0,0107 | 0,8433 | 0,1269 |  |
| ORB | 8107 | 7399 | 870 | 818 | 0,0184 | 0,0168 | 100 | 20,6798 | 8107 | 3213 | 870 | 0,0184 | 0,0352 | 0,9402 | 0,1009 |  |
| ORB1000 | 1000 | 1000 | 37 | 26 | 0,0023 | 0,0023 | 100 | 20,264 | 1000 | 195 | 37 | 0,0023 | 0,0022 | 0,7027 | 0,026 |  |
| BRISK | 2298 | 2216 | 305 | 282 | 0,0052 | 0,005 | 100 | 20,6764 | 2298 | 867 | 305 | 0,0052 | 0,0095 | 0,9246 | 0,1227 |  |
| KAZE | 961 | 1056 | 96 | 77 | 0,0022 | 0,0024 | 100 | 20,6643 | 961 | 380 | 96 | 0,0022 | 0,0042 | 0,8021 | 0,0801 |  |
| AKAZE | 825 | 911 | 80 | 72 | 0,0019 | 0,0021 | 100 | 20,6968 | 825 | 340 | 80 | 0,0019 | 0,0037 | 0,9 | 0,0873 |  |

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 | 3009 | 2199 | 0,186733 | 0,165862 | 0,112327 | 0,000683 | 0,068742 | 0,178296 | 0,001234 | 0,465605 |
| SURF128 | 3561 | 2495 | 0,292659 | 0,234671 | 0,156963 | 0,000603 | 0,08812 | 0,329061 | 0,001497 | 0,684896 |
| SURF64 | 3561 | 2495 | 0,258819 | 0,197316 | 0,086175 | 0,000628 | 0,075882 | 0,160775 | 0,00139 | 0,542939 |
| ORB | 8107 | 7399 | 0,028951 | 0,02607 | 0,261555 | 0,000789 | 0,003547 | 0,300637 | 0,000964 | 0,317364 |
| ORB1000 | 1000 | 1000 | 0,017489 | 0,016235 | 0,013505 | 0,000709 | 0,016861 | 0,364996 | 0,027254 | 0,047937 |
| BRISK | 2298 | 2216 | 0,047965 | 0,041386 | 0,030266 | 0,000392 | 0,019773 | 0,099232 | 0,001389 | 0,120008 |
| KAZE | 961 | 1056 | 0,483365 | 0,417422 | 0,05137 | 0,000629 | 0,449133 | 0,5351 | 0,008174 | 0,952786 |
| AKAZE | 825 | 911 | 0,072416 | 0,095459 | 0,013824 | 0,000353 | 0,09628 | 0,172804 | 0,004901 | 0,182052 |

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.