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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 84,565 img2: 68,601 | 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 | 0,419 | 0,031 | 60,7 | -0,086 | 0,881 | 94,437 | -0 | 0 | 1 | 0,379 | 0,756 | 2,969 | 1,481 | 1,648 |  |
| SURF128 | 0,421 | 0,031 | 59,97 | -0,085 | 0,882 | 94,291 | -0 | 0 | 1 | 0,276 | 1,117 | 3,057 | 1,241 | 2,86 |  |
| SURF64 | 0,42 | 0,033 | 59,814 | -0,085 | 0,883 | 94,241 | -0 | 0 | 1 | 0,3 | 1,119 | 2,973 | 1,434 | 1,955 |  |
| ORB | 0,42 | 0,033 | 59,566 | -0,086 | 0,884 | 94,411 | -0 | 0 | 1 | 0,311 | 1,005 | 3,501 | 1,295 | 1,503 |  |
| ORB1000 | 0,421 | 0,036 | 57,316 | -0,091 | 0,881 | 98,176 | -0 | 0 | 1 | 0,699 | 0,836 | 1,696 | 4,011 | 8,18 |  |
| BRISK | 0,42 | 0,033 | 59,887 | -0,085 | 0,883 | 94,096 | -0 | 0 | 1 | 0,292 | 0,822 | 3,145 | 1,259 | 2,102 |  |
| KAZE | 0,415 | 0,035 | 61,255 | -0,088 | 0,882 | 95,271 | -0 | 0 | 1 | 0,636 | 1,123 | 2,862 | 4,165 | 9,147 |  |
| AKAZE | 0,425 | 0,03 | 57,501 | -0,085 | 0,884 | 93,85 | -0 | 0 | 1 | 0,324 | 0,877 | 2,796 | 4,259 | 8,474 |  |
| Original matrix | 0,422 | 0,032 | 60,169 | -0,085 | 0,886 | 93,738 | -0 | 0 | 1,001 |  |  |  |  |  |  |

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 | 10356 | 11047 | 431 | 389 | 0,0148 | 0,0185 | 84,6174 | 68,6547 | 9074 | 7561 | 429 | 0,0153 | 0,0184 | 0,9026 | 0,0429 |  |
| SURF128 | 10409 | 7850 | 82 | 66 | 0,0149 | 0,0131 | 84,4954 | 68,75 | 9220 | 5848 | 80 | 0,0156 | 0,0142 | 0,8049 | 0,0072 |  |
| SURF64 | 10409 | 7850 | 195 | 171 | 0,0149 | 0,0131 | 84,6126 | 68,7114 | 9238 | 5848 | 193 | 0,0156 | 0,0142 | 0,8769 | 0,0185 |  |
| ORB | 58740 | 44767 | 419 | 288 | 0,0839 | 0,0748 | 84,5751 | 68,7296 | 54521 | 36492 | 408 | 0,0921 | 0,0887 | 0,6874 | 0,0053 |  |
| ORB1000 | 1000 | 1000 | 14 | 10 | 0,0014 | 0,0017 | 84,5156 | 68,9143 | 968 | 741 | 14 | 0,0016 | 0,0018 | 0,7143 | 0,0103 |  |
| BRISK | 21926 | 15663 | 350 | 319 | 0,0313 | 0,0262 | 84,6374 | 68,6969 | 20133 | 12282 | 348 | 0,034 | 0,0299 | 0,9114 | 0,0158 |  |
| KAZE | 2672 | 2531 | 161 | 123 | 0,0038 | 0,0042 | 84,7519 | 68,6456 | 2396 | 1659 | 161 | 0,004 | 0,004 | 0,764 | 0,0513 |  |
| AKAZE | 3390 | 2906 | 105 | 79 | 0,0048 | 0,0049 | 84,4839 | 69,0396 | 3100 | 2232 | 104 | 0,0052 | 0,0054 | 0,7524 | 0,0255 |  |

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 | 10356 | 11047 | 0,592638 | 0,620261 | 1,800942 | 0,000513 | 0,056686 | 4,17852 | 0,001318 | 3,014355 |
| SURF128 | 10409 | 7850 | 0,384855 | 0,318757 | 1,041715 | 0,000442 | 0,038789 | 12,703837 | 0,006702 | 1,745768 |
| SURF64 | 10409 | 7850 | 0,383146 | 0,320257 | 0,480944 | 0,000511 | 0,038803 | 2,466377 | 0,002988 | 1,184858 |
| ORB | 58740 | 44767 | 0,115291 | 0,09196 | 8,360812 | 0,000884 | 0,002008 | 19,954204 | 0,003068 | 8,568946 |
| ORB1000 | 1000 | 1000 | 0,032623 | 0,027639 | 0,00342 | 0,000628 | 0,03013 | 0,244297 | 0,062771 | 0,06431 |
| BRISK | 21926 | 15663 | 0,373263 | 0,258261 | 1,318351 | 0,000454 | 0,016755 | 3,766716 | 0,001422 | 1,950328 |
| KAZE | 2672 | 2531 | 0,438078 | 0,366892 | 0,075304 | 0,000622 | 0,154455 | 0,467724 | 0,005053 | 0,880895 |
| AKAZE | 3390 | 2906 | 0,094654 | 0,08483 | 0,030708 | 0,000691 | 0,028556 | 0,29246 | 0,00874 | 0,210883 |

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.