**Normalization results for pairs 1\_0.ppm\_1\_3.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_lbricks**

**1\_0.ppm: 1\_3.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 85,375 img2: 74,965 | 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 | 0,543 | 0,011 | 66,098 | -0,063 | 0,871 | 106,074 | -0 | 0 | 1 | 0,344 | 0,555 | 3,409 | 0,766 | 1,074 |  |
| SURF128 | 0,541 | 0,012 | 65,946 | -0,065 | 0,869 | 106,822 | -0 | 0 | 1 | 0,537 | 0,802 | 3,119 | 1,763 | 2,688 |  |
| SURF64 | 0,538 | 0,012 | 67,421 | -0,065 | 0,868 | 106,754 | -0 | 0 | 1 | 0,706 | 0,898 | 3,394 | 2,817 | 5,189 |  |
| ORB | 0,542 | 0,013 | 66,069 | -0,064 | 0,872 | 106,481 | -0 | 0 | 1 | 0,391 | 0,902 | 3,903 | 1,184 | 1,798 |  |
| ORB1000 | 0,535 | 0,015 | 67,19 | -0,066 | 0,869 | 107,008 | -0 | 0 | 1 | 0,898 | 0,915 | 2,613 | 4,013 | 7,57 |  |
| BRISK | 0,542 | 0,012 | 66,036 | -0,064 | 0,871 | 106,389 | -0 | 0 | 1 | 0,353 | 0,7 | 3,075 | 1,028 | 1,328 |  |
| KAZE | 0,541 | 0,011 | 66,379 | -0,064 | 0,87 | 106,238 | -0 | 0 | 1 | 0,455 | 0,825 | 2,719 | 1,29 | 1,528 |  |
| AKAZE | 0,54 | 0,013 | 66,624 | -0,065 | 0,87 | 106,844 | -0 | 0 | 1 | 0,616 | 0,671 | 2,901 | 2,087 | 3,675 |  |
| Original matrix | 0,544 | 0,012 | 65,787 | -0,063 | 0,873 | 105,67 | -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 | 10356 | 10633 | 2137 | 1892 | 0,0148 | 0,0178 | 85,375 | 75,0217 | 9124 | 8141 | 2134 | 0,0153 | 0,0181 | 0,8854 | 0,2074 |  |
| SURF128 | 10409 | 7909 | 442 | 385 | 0,0149 | 0,0132 | 85,4853 | 75,0453 | 9315 | 6425 | 441 | 0,0156 | 0,0143 | 0,871 | 0,0413 |  |
| SURF64 | 10409 | 7909 | 833 | 641 | 0,0149 | 0,0132 | 85,5154 | 74,8874 | 9323 | 6415 | 832 | 0,0156 | 0,0143 | 0,7695 | 0,0688 |  |
| ORB | 58740 | 44836 | 3150 | 2965 | 0,0839 | 0,0749 | 85,3586 | 74,9703 | 54902 | 39963 | 3141 | 0,0919 | 0,0891 | 0,9413 | 0,054 |  |
| ORB1000 | 1000 | 1000 | 86 | 68 | 0,0014 | 0,0017 | 85,3739 | 74,8969 | 978 | 815 | 86 | 0,0016 | 0,0018 | 0,7907 | 0,0695 |  |
| BRISK | 21926 | 15970 | 1828 | 1785 | 0,0313 | 0,0267 | 85,4174 | 75,0089 | 20257 | 13727 | 1825 | 0,0339 | 0,0306 | 0,9765 | 0,0881 |  |
| KAZE | 2672 | 2496 | 572 | 515 | 0,0038 | 0,0042 | 85,4056 | 75,0219 | 2410 | 1765 | 572 | 0,004 | 0,0039 | 0,9003 | 0,2137 |  |
| AKAZE | 3390 | 2941 | 436 | 402 | 0,0048 | 0,0049 | 85,4516 | 74,9452 | 3128 | 2444 | 436 | 0,0052 | 0,0054 | 0,922 | 0,1285 |  |

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 | 10633 | 0,299047 | 0,266248 | 2,157139 | 0,001532 | 0,026957 | 1,009424 | 0,000809 | 2,723966 |
| SURF128 | 10409 | 7909 | 0,470625 | 0,344062 | 1,122473 | 0,000825 | 0,044357 | 2,539532 | 0,002143 | 1,937985 |
| SURF64 | 10409 | 7909 | 0,468705 | 0,360349 | 0,537246 | 0,000817 | 0,045294 | 0,644953 | 0,001274 | 1,367117 |
| ORB | 58740 | 44836 | 0,123378 | 0,093712 | 8,718554 | 0,002119 | 0,002095 | 2,767794 | 0,000714 | 8,937762 |
| ORB1000 | 1000 | 1000 | 0,030351 | 0,024937 | 0,004485 | 0,00048 | 0,027643 | 0,052156 | 0,007062 | 0,060254 |
| BRISK | 21926 | 15970 | 0,345105 | 0,278554 | 1,322073 | 0,001007 | 0,01659 | 0,723234 | 0,000563 | 1,946739 |
| KAZE | 2672 | 2496 | 0,395647 | 0,344866 | 0,070222 | 0,000749 | 0,143119 | 0,122765 | 0,001453 | 0,811484 |
| AKAZE | 3390 | 2941 | 0,084172 | 0,068824 | 0,040263 | 0,000435 | 0,024115 | 0,092346 | 0,001081 | 0,193694 |

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.