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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 79,754 img2: 57,291 | 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 | 0,23 | 0,043 | 131,362 | -0,116 | 0,891 | 97,629 | -0 | 0 | 1 | 0,005 | 0,722 | 2,11 | 25,896 | 60,131 |  |
| SURF128 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,169 | -1 |  | ~ | ~ |  |
| SURF64 | 0,377 | -0,064 | 103,533 | 0,016 | 0,98 | 9,889 | -0 | -0 | 1 | 0,032 | 0,589 | 1,187 | 97,385 | 175,833 |  |
| ORB | 3,129 | -1,816 | -1744,225 | 0,004 | -4,393 | 729,895 | 0,003 | -0,016 | 1 | 0,523 | 0,03 | 0,062 | 631,274 | 842,518 |  |
| ORB1000 | 0,152 | -6,285 | 632,591 | -1,069 | 0,729 | 32,457 | -0,015 | 0,006 | 1 | 0,353 | 0 | 0 | 697,203 | 1066,177 |  |
| BRISK | 0,249 | 0,033 | 125,698 | -0,104 | 0,902 | 90,605 | -0 | 0 | 1 | 0,001 | 0,824 | 2,629 | 8,453 | 15,516 |  |
| KAZE | -0,398 | -0,433 | 323,863 | -0,008 | 0,029 | 6,413 | -0,001 | -0,001 | 1 | 0,089 | 0,065 | 0,161 | 710,734 | 1164,077 |  |
| AKAZE | 0,49 | -2,004 | 697,509 | 0,283 | -0,865 | 276,968 | 0 | -0,003 | 1 | 0,185 | 0 | 0 | 543,068 | 659,259 |  |
| Original matrix | 0,258 | 0,033 | 121,63 | -0,102 | 0,909 | 89,437 | -0 | 0 | 1,002 |  |  |  |  |  |  |

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 | 10835 | 33 | 12 | 0,0148 | 0,0181 | 80,3827 | 56,1922 | 8736 | 6231 | 29 | 0,0155 | 0,0185 | 0,3636 | 0,0014 |  |
| SURF128 | 10409 | 7549 | 3 | 0 | 0,0149 | 0,0126 | 0 | 0 | 0 | 0 | 0 | � | � | 0 | � |  |
| SURF64 | 10409 | 7549 | 28 | 6 | 0,0149 | 0,0126 | 74,6813 | 60,3284 | 8198 | 4935 | 21 | 0,0157 | 0,0137 | 0,2143 | 0,0007 |  |
| ORB | 58740 | 44177 | 98 | 5 | 0,0839 | 0,0738 | 62,139 | 99,0246 | 43124 | 43604 | 69 | 0,0991 | 0,0736 | 0,051 | 0,0001 |  |
| ORB1000 | 1000 | 1000 | 4 | 4 | 0,0014 | 0,0017 | 41,3416 | 97,8798 | 587 | 977 | 4 | 0,002 | 0,0017 | 1 | 0,0068 |  |
| BRISK | 21926 | 15687 | 25 | 15 | 0,0313 | 0,0262 | 79,7733 | 56,741 | 19234 | 10323 | 24 | 0,0344 | 0,0304 | 0,6 | 0,0008 |  |
| KAZE | 2672 | 2442 | 11 | 5 | 0,0038 | 0,0041 | 42,0426 | 36,4534 | 1444 | 789 | 11 | 0,0049 | 0,0036 | 0,4545 | 0,0035 |  |
| AKAZE | 3390 | 2870 | 7 | 4 | 0,0048 | 0,0048 | 59,5294 | 87,2258 | 2504 | 2492 | 6 | 0,006 | 0,0048 | 0,5714 | 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 | 10356 | 10835 | 0,23325 | 0,199838 | 1,466185 | 0,008013 | 0,020483 | 44,429857 | 0,66779 | 1,907286 |
| SURF128 | 10409 | 7549 | 0,388496 | 0,306715 | 1,088746 | 0 | 0,038976 | 362,915219 | 0 | 1,783957 |
| SURF64 | 10409 | 7549 | 0,517362 | 0,254848 | 0,432487 | 0,060085 | 0,041731 | 15,445982 | 10,014095 | 1,264782 |
| ORB | 58740 | 44177 | 0,118343 | 0,089397 | 8,989135 | 0,113692 | 0,002018 | 91,725867 | 22,73847 | 9,310567 |
| ORB1000 | 1000 | 1000 | 0,035892 | 0,026871 | 0,00372 | 0,000047 | 0,031381 | 0,930048 | 0,011776 | 0,06653 |
| BRISK | 21926 | 15687 | 0,340644 | 0,255822 | 1,242074 | 0,001132 | 0,015921 | 49,682945 | 0,075457 | 1,839671 |
| KAZE | 2672 | 2442 | 0,424293 | 0,352495 | 0,060894 | 0,003172 | 0,151569 | 5,535838 | 0,634402 | 0,840855 |
| AKAZE | 3390 | 2870 | 0,090407 | 0,083392 | 0,040659 | 0,001158 | 0,027862 | 5,808372 | 0,28945 | 0,215615 |

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.