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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 53,148 img2: 76,003 | 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 | 0,024 | 0,023 | 184,115 | -0,123 | 0,616 | 124,833 | -0,001 | 0 | 1 | 0,131 | 0,828 | 3,191 | 45,737 | 62,826 |  |
| SURF128 | 0,016 | 0,018 | 191,622 | -0,121 | 0,607 | 123,195 | -0,001 | 0 | 1 | 0,12 | 1,344 | 3,824 | 12,877 | 20,006 |  |
| SURF64 | 0,024 | 0,009 | 185,539 | -0,122 | 0,609 | 124,585 | -0,001 | 0 | 1 | 0,128 | 1,347 | 3,239 | 45,761 | 81,512 |  |
| ORB | 0,018 | 0,018 | 188,262 | -0,124 | 0,609 | 126,571 | -0,001 | 0 | 1 | 0,118 | 1,392 | 3,721 | 24,478 | 35,571 |  |
| ORB1000 | 0,791 | -0,213 | -483,888 | 0,121 | 1,063 | -161,35 | -0 | -0 | 1 | 0,985 | 1,229 | 1,939 | 2145,482 | 3418,593 |  |
| BRISK | 0,024 | 0,018 | 184,339 | -0,122 | 0,612 | 124,515 | -0,001 | 0 | 1 | 0,124 | 1,158 | 3,589 | 47,985 | 61,42 |  |
| KAZE | 0,024 | 0,016 | 184,93 | -0,122 | 0,615 | 125,121 | -0,001 | 0 | 1 | 0,124 | 1,246 | 3,069 | 49,009 | 60,816 |  |
| AKAZE | 0,022 | 0,027 | 184,398 | -0,122 | 0,615 | 124,371 | -0,001 | 0 | 1 | 0,135 | 1,437 | 3,451 | 39,47 | 66,807 |  |
| Original matrix | 0,013 | 0,014 | 193,52 | -0,124 | 0,603 | 126,7 | -0,001 | 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 | 17804 | 4367 | 486 | 326 | 0,0128 | 0,0068 | 53,1261 | 76,7051 | 8601 | 3343 | 446 | 0,0117 | 0,0068 | 0,6708 | 0,0379 |  |
| SURF128 | 18208 | 6376 | 191 | 105 | 0,0131 | 0,0099 | 53,2094 | 76,1412 | 9915 | 5021 | 180 | 0,0134 | 0,0102 | 0,5497 | 0,0106 |  |
| SURF64 | 18208 | 6376 | 328 | 151 | 0,0131 | 0,0099 | 52,7021 | 76,9261 | 9825 | 5064 | 299 | 0,0134 | 0,0102 | 0,4604 | 0,0154 |  |
| ORB | 63449 | 11680 | 512 | 195 | 0,0457 | 0,0181 | 52,9753 | 76,3903 | 31842 | 8382 | 395 | 0,0433 | 0,017 | 0,3809 | 0,0061 |  |
| ORB1000 | 1000 | 1000 | 17 | 11 | 0,0007 | 0,0016 | 8,1648 | 100 | 203 | 1000 | 14 | 0,0018 | 0,0016 | 0,6471 | 0,0542 |  |
| BRISK | 18557 | 3238 | 177 | 101 | 0,0134 | 0,005 | 53,0747 | 76,7915 | 9173 | 2082 | 160 | 0,0124 | 0,0042 | 0,5706 | 0,011 |  |
| KAZE | 4397 | 1341 | 86 | 55 | 0,0032 | 0,0021 | 52,963 | 76,7874 | 2282 | 877 | 83 | 0,0031 | 0,0018 | 0,6395 | 0,0241 |  |
| AKAZE | 4765 | 1154 | 87 | 42 | 0,0034 | 0,0018 | 53,3267 | 76,5604 | 2386 | 783 | 69 | 0,0032 | 0,0016 | 0,4828 | 0,0176 |  |

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 | 17804 | 4367 | 0,413837 | 0,157918 | 0,911915 | 0,000931 | 0,029702 | 1,876367 | 0,002856 | 1,484601 |
| SURF128 | 18208 | 6376 | 0,760618 | 0,254674 | 1,331041 | 0,00165 | 0,040857 | 6,968801 | 0,015714 | 2,347984 |
| SURF64 | 18208 | 6376 | 0,846009 | 0,250292 | 0,740033 | 0,003427 | 0,042859 | 2,256197 | 0,022697 | 1,839761 |
| ORB | 63449 | 11680 | 0,151053 | 0,038375 | 2,269433 | 0,007447 | 0,002832 | 4,432486 | 0,038189 | 2,466308 |
| ORB1000 | 1000 | 1000 | 0,052556 | 0,021199 | 0,003879 | 0,000922 | 0,036876 | 0,228191 | 0,083781 | 0,078555 |
| BRISK | 18557 | 3238 | 0,31045 | 0,060542 | 0,219633 | 0,001436 | 0,017713 | 1,240862 | 0,014214 | 0,592061 |
| KAZE | 4397 | 1341 | 0,797801 | 0,36688 | 0,060723 | 0,000924 | 0,227514 | 0,706079 | 0,016799 | 1,226327 |
| AKAZE | 4765 | 1154 | 0,171391 | 0,074661 | 0,020374 | 0,002683 | 0,050332 | 0,234182 | 0,063869 | 0,269108 |

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.