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

**1\_0.ppm: 1\_1.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 94,676 img2: 69,07 | 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 | 0,877 | 0,313 | -39,255 | -0,185 | 0,936 | 153,89 | 0 | -0 | 1 | 0,309 | 0,6 | 3,102 | 1,38 | 2,902 |  |
| SURF128 | 0,886 | 0,318 | -41,178 | -0,182 | 0,944 | 152,832 | 0 | -0 | 1 | 0,456 | 1,261 | 3,26 | 1,687 | 3,308 |  |
| SURF64 | 0,88 | 0,311 | -39,047 | -0,183 | 0,936 | 153,406 | 0 | -0 | 1 | 0,246 | 1,228 | 3,944 | 1,335 | 1,913 |  |
| ORB | 0,892 | 0,316 | -42,57 | -0,175 | 0,943 | 150,878 | 0 | -0 | 1 | 0,603 | 1,103 | 4,736 | 2,836 | 3,46 |  |
| ORB1000 | 0,882 | 0,316 | -40,793 | -0,183 | 0,938 | 153,192 | 0 | -0 | 1 | 0,244 | 1,102 | 3,426 | 1,057 | 1,957 |  |
| BRISK | 0,88 | 0,317 | -40,305 | -0,184 | 0,938 | 153,554 | 0 | -0 | 1 | 0,309 | 1,05 | 4,262 | 1,096 | 2,035 |  |
| KAZE | 0,881 | 0,314 | -40,075 | -0,183 | 0,935 | 153,766 | 0 | -0 | 1 | 0,186 | 1,051 | 3,245 | 0,453 | 0,807 |  |
| AKAZE | 0,886 | 0,319 | -41,488 | -0,183 | 0,945 | 152,538 | 0 | -0 | 1 | 0,504 | 0,918 | 4,028 | 1,792 | 2,429 |  |
| Original matrix | 0,882 | 0,314 | -39,976 | -0,182 | 0,936 | 153,25 | 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 | 2674 | 3062 | 1125 | 937 | 0,0052 | 0,006 | 94,6939 | 69,2203 | 2448 | 2121 | 1115 | 0,005 | 0,006 | 0,8329 | 0,3828 |  |
| SURF128 | 4796 | 5002 | 834 | 614 | 0,0094 | 0,0098 | 94,7025 | 68,9982 | 4543 | 3862 | 831 | 0,0094 | 0,0109 | 0,7362 | 0,1352 |  |
| SURF64 | 4796 | 5002 | 1060 | 782 | 0,0094 | 0,0098 | 94,6818 | 69,1365 | 4541 | 3870 | 1056 | 0,0094 | 0,0109 | 0,7377 | 0,1722 |  |
| ORB | 9147 | 10889 | 2895 | 2165 | 0,0179 | 0,0213 | 94,5691 | 69,0684 | 9006 | 9123 | 2893 | 0,0186 | 0,0258 | 0,7478 | 0,2404 |  |
| ORB1000 | 1000 | 1000 | 392 | 365 | 0,002 | 0,002 | 94,6389 | 69,3025 | 983 | 936 | 392 | 0,002 | 0,0026 | 0,9311 | 0,3713 |  |
| BRISK | 3523 | 4287 | 1200 | 1002 | 0,0069 | 0,0084 | 94,6955 | 69,1848 | 3409 | 3445 | 1198 | 0,007 | 0,0097 | 0,835 | 0,2939 |  |
| KAZE | 2045 | 2321 | 1019 | 895 | 0,004 | 0,0045 | 94,6803 | 69,0922 | 1935 | 1744 | 1019 | 0,004 | 0,0049 | 0,8783 | 0,4625 |  |
| AKAZE | 1755 | 2009 | 673 | 517 | 0,0034 | 0,0039 | 94,66 | 69,1709 | 1702 | 1672 | 672 | 0,0035 | 0,0047 | 0,7682 | 0,3038 |  |

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 | 2674 | 3062 | 0,195633 | 0,209546 | 0,258367 | 0,005307 | 0,070797 | 0,229659 | 0,005664 | 0,668852 |
| SURF128 | 4796 | 5002 | 1,675022 | 0,585266 | 0,505062 | 0,000906 | 0,233129 | 0,605589 | 0,001475 | 2,766255 |
| SURF64 | 4796 | 5002 | 0,369171 | 0,430604 | 0,257077 | 0,001128 | 0,08153 | 0,242525 | 0,001442 | 1,05798 |
| ORB | 9147 | 10889 | 0,060231 | 0,072134 | 0,814651 | 0,001776 | 0,006604 | 0,281399 | 0,00082 | 0,948791 |
| ORB1000 | 1000 | 1000 | 0,057226 | 0,028183 | 0,015285 | 0,000549 | 0,042703 | 0,038992 | 0,001504 | 0,101243 |
| BRISK | 3523 | 4287 | 0,153804 | 0,22554 | 0,243125 | 0,053444 | 0,048133 | 0,202604 | 0,053337 | 0,675914 |
| KAZE | 2045 | 2321 | 0,850467 | 0,927867 | 0,140585 | 0,001054 | 0,407823 | 0,137964 | 0,001177 | 1,919973 |
| AKAZE | 1755 | 2009 | 0,143249 | 0,167862 | 0,064066 | 0,000821 | 0,082589 | 0,095194 | 0,001587 | 0,375999 |

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.