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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 86,862 img2: 59,527 | 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 | 1,295 | 0,003 | 86,701 | 0,353 | 1,155 | -294,905 | 0,001 | 0 | 1 | 0,37 | 0,961 | 4,475 | 3,977 | 6,139 |  |
| SURF128 | 1,313 | -0,006 | 91,185 | 0,366 | 1,163 | -300,902 | 0,001 | 0 | 1 | 0,55 | 1,242 | 3,42 | 18,74 | 31,606 |  |
| SURF64 | 1,291 | -0,014 | 94,479 | 0,358 | 1,137 | -291,76 | 0,001 | 0 | 1 | 0,448 | 1,254 | 3,533 | 15,439 | 29,978 |  |
| ORB | 1,302 | -0,007 | 91,357 | 0,363 | 1,152 | -296,82 | 0,001 | 0 | 1 | 0,429 | 1,169 | 4,006 | 14,173 | 24,094 |  |
| ORB1000 | 1,322 | -0,006 | 89,811 | 0,375 | 1,164 | -302,614 | 0,001 | 0 | 1 | 0,674 | 0,982 | 2,957 | 24,959 | 42,02 |  |
| BRISK | 1,301 | -0,014 | 94,34 | 0,365 | 1,15 | -297,397 | 0,001 | 0 | 1 | 0,588 | 0,992 | 4,626 | 23,475 | 40,199 |  |
| KAZE | 1,311 | -0,004 | 90,508 | 0,365 | 1,166 | -301,824 | 0,001 | 0 | 1 | 0,538 | 1,092 | 4,834 | 15,115 | 25,114 |  |
| AKAZE | 1,312 | -0,005 | 91,496 | 0,369 | 1,167 | -302,758 | 0,001 | 0 | 1 | 0,6 | 1,02 | 3,769 | 20,403 | 33,903 |  |
| Original matrix | 1,287 | -0,004 | 90,117 | 0,35 | 1,142 | -290,48 | 0,001 | 0 | 0,999 |  |  |  |  |  |  |

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 | 3361 | 3708 | 695 | 491 | 0,0032 | 0,0058 | 86,7022 | 59,469 | 3143 | 1960 | 685 | 0,0035 | 0,0051 | 0,7065 | 0,1562 |  |
| SURF128 | 7603 | 6610 | 794 | 537 | 0,0073 | 0,0103 | 86,6589 | 58,8479 | 7236 | 4052 | 775 | 0,008 | 0,0107 | 0,6763 | 0,0742 |  |
| SURF64 | 7603 | 6610 | 825 | 531 | 0,0073 | 0,0103 | 86,7439 | 59,0385 | 7241 | 4066 | 809 | 0,008 | 0,0107 | 0,6436 | 0,0733 |  |
| ORB | 19105 | 18831 | 1359 | 990 | 0,0184 | 0,0292 | 86,734 | 59,0464 | 18542 | 13625 | 1351 | 0,0206 | 0,0358 | 0,7285 | 0,0534 |  |
| ORB1000 | 1000 | 1000 | 137 | 108 | 0,001 | 0,0016 | 86,7792 | 58,7286 | 996 | 972 | 137 | 0,0011 | 0,0026 | 0,7883 | 0,1084 |  |
| BRISK | 6549 | 6845 | 696 | 486 | 0,0063 | 0,0106 | 86,6196 | 58,7737 | 6352 | 5080 | 694 | 0,0071 | 0,0134 | 0,6983 | 0,0765 |  |
| KAZE | 4081 | 2374 | 552 | 407 | 0,0039 | 0,0037 | 86,6001 | 59,011 | 3950 | 2070 | 551 | 0,0044 | 0,0054 | 0,7373 | 0,103 |  |
| AKAZE | 3884 | 2275 | 402 | 314 | 0,0037 | 0,0035 | 86,6187 | 58,7563 | 3793 | 1963 | 402 | 0,0042 | 0,0052 | 0,7811 | 0,0828 |  |

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 | 3361 | 3708 | 0,224674 | 0,156618 | 0,155023 | 0,001044 | 0,054542 | 0,223054 | 0,002127 | 0,537359 |
| SURF128 | 7603 | 6610 | 0,434946 | 0,304085 | 0,697082 | 0,001092 | 0,051605 | 0,877937 | 0,002032 | 1,437205 |
| SURF64 | 7603 | 6610 | 0,407812 | 0,280753 | 0,295157 | 0,001268 | 0,048056 | 0,357765 | 0,002388 | 0,98499 |
| ORB | 19105 | 18831 | 0,06009 | 0,048625 | 1,158282 | 0,001203 | 0,002863 | 0,852304 | 0,001215 | 1,268201 |
| ORB1000 | 1000 | 1000 | 0,031885 | 0,022241 | 0,006797 | 0,000504 | 0,027062 | 0,049612 | 0,004668 | 0,061427 |
| BRISK | 6549 | 6845 | 0,118272 | 0,120621 | 0,149773 | 0,000969 | 0,01784 | 0,215191 | 0,001994 | 0,389635 |
| KAZE | 4081 | 2374 | 0,675375 | 0,382605 | 0,099681 | 0,000791 | 0,163328 | 0,180581 | 0,001942 | 1,158451 |
| AKAZE | 3884 | 2275 | 0,139308 | 0,077694 | 0,029335 | 0,001019 | 0,035009 | 0,072971 | 0,003245 | 0,247356 |

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.