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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 44,02 | 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 | 0,668 | 0,002 | 83,008 | 0,002 | 0,668 | 28,817 | 0 | 0 | 1 | 0,095 | 0,354 | 2,736 | 0,457 | 0,865 |  |
| SURF128 | 0,668 | 0,002 | 82,911 | 0,002 | 0,668 | 28,706 | 0 | 0 | 1 | 0,092 | 0,725 | 3,112 | 0,462 | 0,859 |  |
| SURF64 | 0,668 | 0,002 | 82,856 | 0,002 | 0,668 | 28,746 | 0 | 0 | 1 | 0,232 | 0,772 | 3,588 | 0,571 | 1,067 |  |
| ORB | 0,666 | 0,001 | 83,182 | 0,002 | 0,665 | 29,141 | 0 | 0 | 1 | 0,353 | 0,78 | 3,512 | 1,437 | 3,337 |  |
| ORB1000 | 0,676 | -0 | 81,623 | 0,004 | 0,67 | 28,069 | 0 | -0 | 1 | 0,69 | 0,908 | 3,177 | 2,71 | 5,726 |  |
| BRISK | 0,671 | 0,001 | 82,364 | 0,003 | 0,67 | 28,42 | 0 | 0 | 1 | 0,324 | 0,653 | 3,843 | 1,286 | 2,892 |  |
| KAZE | 0,67 | 0,003 | 82,311 | 0,003 | 0,67 | 28,449 | 0 | 0 | 1 | 0,192 | 0,648 | 2,675 | 0,735 | 1,159 |  |
| AKAZE | 0,669 | 0,002 | 82,509 | 0,002 | 0,669 | 28,509 | 0 | 0 | 1 | 0,155 | 0,52 | 2,649 | 0,724 | 1,294 |  |
| Original matrix | 0,668 | 0,003 | 82,885 | 0,002 | 0,669 | 28,8 | 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 | 3009 | 3580 | 1236 | 1159 | 0,0068 | 0,0081 | 100 | 44,0887 | 3009 | 2374 | 1236 | 0,0068 | 0,0122 | 0,9377 | 0,3852 |  |
| SURF128 | 3561 | 3326 | 920 | 867 | 0,0081 | 0,0075 | 100 | 44,0975 | 3561 | 2029 | 920 | 0,0081 | 0,0104 | 0,9424 | 0,2435 |  |
| SURF64 | 3561 | 3326 | 1040 | 980 | 0,0081 | 0,0075 | 100 | 44,0975 | 3561 | 2029 | 1040 | 0,0081 | 0,0104 | 0,9423 | 0,2752 |  |
| ORB | 8107 | 10897 | 2483 | 2207 | 0,0184 | 0,0247 | 100 | 44,2128 | 8107 | 7660 | 2483 | 0,0184 | 0,0393 | 0,8888 | 0,2722 |  |
| ORB1000 | 1000 | 1000 | 134 | 101 | 0,0023 | 0,0023 | 100 | 44,36 | 1000 | 437 | 134 | 0,0023 | 0,0022 | 0,7537 | 0,101 |  |
| BRISK | 2298 | 3254 | 708 | 613 | 0,0052 | 0,0074 | 100 | 44,213 | 2298 | 2137 | 708 | 0,0052 | 0,011 | 0,8658 | 0,2668 |  |
| KAZE | 961 | 1580 | 299 | 274 | 0,0022 | 0,0036 | 100 | 44,0864 | 961 | 921 | 299 | 0,0022 | 0,0047 | 0,9164 | 0,2851 |  |
| AKAZE | 825 | 1465 | 277 | 260 | 0,0019 | 0,0033 | 100 | 44,1463 | 825 | 962 | 277 | 0,0019 | 0,0049 | 0,9386 | 0,3152 |  |

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 | 3009 | 3580 | 0,176919 | 0,165453 | 0,210305 | 0,000911 | 0,052505 | 0,17015 | 0,000786 | 0,553588 |
| SURF128 | 3561 | 3326 | 0,203151 | 0,222308 | 0,194315 | 0,000594 | 0,061943 | 0,211212 | 0,000685 | 0,620368 |
| SURF64 | 3561 | 3326 | 0,239761 | 0,248395 | 0,145285 | 0,000749 | 0,071005 | 0,139697 | 0,000764 | 0,634191 |
| ORB | 8107 | 10897 | 0,057475 | 0,032797 | 0,41714 | 0,00149 | 0,005049 | 0,167998 | 0,000675 | 0,508902 |
| ORB1000 | 1000 | 1000 | 0,017414 | 0,018314 | 0,012495 | 0,000787 | 0,017863 | 0,093245 | 0,007796 | 0,04901 |
| BRISK | 2298 | 3254 | 0,079628 | 0,12537 | 0,120864 | 0,000577 | 0,036589 | 0,170712 | 0,000941 | 0,326439 |
| KAZE | 961 | 1580 | 0,422621 | 0,404026 | 0,051688 | 0,000759 | 0,347742 | 0,172871 | 0,002769 | 0,879095 |
| AKAZE | 825 | 1465 | 0,166566 | 0,137289 | 0,045533 | 0,000411 | 0,147804 | 0,164379 | 0,00158 | 0,349799 |

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.