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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 39,077 | 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 | 0,393 | -0,486 | 422,079 | 0,487 | 0,397 | -0,646 | 0 | 0 | 1 | 0,106 | 0,674 | 3,422 | 1,009 | 1,655 |  |
| SURF128 | 0,4 | -0,482 | 420,868 | 0,494 | 0,403 | -2,667 | 0 | 0 | 1 | 0,56 | 1,149 | 3,479 | 3,552 | 6,371 |  |
| SURF64 | 0,396 | -0,48 | 421,482 | 0,491 | 0,405 | -2,892 | 0 | 0 | 1 | 0,468 | 1,246 | 3,562 | 4,582 | 5,115 |  |
| ORB | 0,396 | -0,484 | 421,073 | 0,49 | 0,399 | -1,454 | 0 | 0 | 1 | 0,289 | 0,999 | 3,832 | 1,379 | 2,366 |  |
| ORB1000 | 0,401 | -0,48 | 420,381 | 0,496 | 0,408 | -4,107 | 0 | 0 | 1 | 0,746 | 0,959 | 3,221 | 4,504 | 6,597 |  |
| BRISK | 0,397 | -0,481 | 420,876 | 0,491 | 0,405 | -2,939 | 0 | 0 | 1 | 0,503 | 0,96 | 3,588 | 3,259 | 4,662 |  |
| KAZE | 0,39 | -0,484 | 421,191 | 0,483 | 0,395 | 0,463 | -0 | -0 | 1 | 0,171 | 1,023 | 3,576 | 1,112 | 1,402 |  |
| AKAZE | 0,394 | -0,487 | 421,48 | 0,487 | 0,396 | -1,053 | 0 | -0 | 1 | 0,116 | 0,88 | 4,518 | 0,888 | 1,558 |  |
| Original matrix | 0,392 | -0,486 | 421,69 | 0,485 | 0,395 | -0,098 | 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 | 8849 | 6888 | 1104 | 998 | 0,0153 | 0,0119 | 100 | 39,1258 | 8849 | 3966 | 1104 | 0,0153 | 0,0175 | 0,904 | 0,1128 |  |
| SURF128 | 6737 | 4768 | 397 | 299 | 0,0117 | 0,0082 | 99,9981 | 38,8981 | 6737 | 2721 | 397 | 0,0117 | 0,0121 | 0,7531 | 0,0444 |  |
| SURF64 | 6737 | 4768 | 640 | 445 | 0,0117 | 0,0082 | 99,9976 | 39,0853 | 6737 | 2725 | 640 | 0,0117 | 0,0121 | 0,6953 | 0,0661 |  |
| ORB | 34746 | 24873 | 3648 | 3282 | 0,0601 | 0,043 | 99,9997 | 39,0853 | 34746 | 17335 | 3648 | 0,0601 | 0,0767 | 0,8997 | 0,0945 |  |
| ORB1000 | 1000 | 1000 | 240 | 230 | 0,0017 | 0,0017 | 99,9945 | 39,1299 | 1000 | 860 | 240 | 0,0017 | 0,0038 | 0,9583 | 0,23 |  |
| BRISK | 13777 | 9092 | 1317 | 1067 | 0,0238 | 0,0157 | 99,9976 | 39,068 | 13777 | 6312 | 1317 | 0,0238 | 0,028 | 0,8102 | 0,0774 |  |
| KAZE | 3281 | 2291 | 598 | 488 | 0,0057 | 0,004 | 99,9997 | 39,045 | 3281 | 1637 | 598 | 0,0057 | 0,0073 | 0,8161 | 0,1487 |  |
| AKAZE | 3694 | 2416 | 522 | 439 | 0,0064 | 0,0042 | 99,9997 | 39,1277 | 3694 | 1830 | 522 | 0,0064 | 0,0081 | 0,841 | 0,1188 |  |

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 | 8849 | 6888 | 0,194134 | 0,17015 | 0,736675 | 0,000754 | 0,02332 | 0,667278 | 0,000755 | 1,101714 |
| SURF128 | 6737 | 4768 | 0,267445 | 0,195959 | 0,379638 | 0,000686 | 0,040397 | 0,956266 | 0,002293 | 0,843728 |
| SURF64 | 6737 | 4768 | 0,259603 | 0,201488 | 0,206886 | 0,002066 | 0,040395 | 0,323258 | 0,004643 | 0,670043 |
| ORB | 34746 | 24873 | 0,072587 | 0,055849 | 2,883759 | 0,002387 | 0,002167 | 0,790504 | 0,000727 | 3,014582 |
| ORB1000 | 1000 | 1000 | 0,023745 | 0,020809 | 0,004035 | 0,000536 | 0,022276 | 0,016812 | 0,002329 | 0,049125 |
| BRISK | 13777 | 9092 | 0,198918 | 0,135432 | 0,449106 | 0,000954 | 0,014666 | 0,341006 | 0,000894 | 0,784409 |
| KAZE | 3281 | 2291 | 0,59965 | 0,437873 | 0,111588 | 0,000613 | 0,186945 | 0,186602 | 0,001256 | 1,149724 |
| AKAZE | 3694 | 2416 | 0,127079 | 0,110317 | 0,061286 | 0,000693 | 0,04003 | 0,117406 | 0,001577 | 0,299375 |

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.