**Normalization results for pairs 1\_0.ppm\_1\_2.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_boat**

**1\_0.ppm: 1\_2.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 98,317 img2: 53,102 | 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 | 0,569 | 0,471 | 25,397 | -0,468 | 0,565 | 348,487 | 0 | -0 | 1 | 0,064 | 0,471 | 3,123 | 0,355 | 0,433 |  |
| SURF128 | 0,568 | 0,472 | 25,186 | -0,47 | 0,567 | 348,607 | 0 | 0 | 1 | 0,257 | 1,132 | 4,256 | 0,997 | 2,195 |  |
| SURF64 | 0,566 | 0,466 | 26,304 | -0,467 | 0,56 | 348,372 | 0 | -0 | 1 | 0,381 | 1,158 | 4,018 | 1,464 | 1,962 |  |
| ORB | 0,568 | 0,468 | 26,223 | -0,467 | 0,562 | 348,551 | 0 | -0 | 1 | 0,26 | 0,911 | 4,129 | 0,96 | 1,242 |  |
| ORB1000 | 0,566 | 0,469 | 26,283 | -0,468 | 0,564 | 348,117 | 0 | -0 | 1 | 0,214 | 0,892 | 2,77 | 1,172 | 1,285 |  |
| BRISK | 0,574 | 0,474 | 24,293 | -0,467 | 0,568 | 348,301 | 0 | 0 | 1 | 0,355 | 0,92 | 3,712 | 1,597 | 2,807 |  |
| KAZE | 0,567 | 0,469 | 25,732 | -0,468 | 0,565 | 348,099 | 0 | -0 | 1 | 0,135 | 0,837 | 4,3 | 0,493 | 0,572 |  |
| AKAZE | 0,568 | 0,467 | 26,098 | -0,467 | 0,563 | 348,157 | 0 | -0 | 1 | 0,216 | 0,73 | 4,149 | 0,791 | 1,028 |  |
| Original matrix | 0,569 | 0,47 | 25,352 | -0,468 | 0,565 | 348,28 | 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 | 6558 | 1828 | 1744 | 0,0153 | 0,0113 | 98,3204 | 53,0775 | 8750 | 4476 | 1825 | 0,0154 | 0,0146 | 0,954 | 0,1993 |  |
| SURF128 | 6737 | 5519 | 604 | 485 | 0,0117 | 0,0095 | 98,2896 | 53,191 | 6690 | 3752 | 603 | 0,0118 | 0,0122 | 0,803 | 0,0725 |  |
| SURF64 | 6737 | 5519 | 926 | 723 | 0,0117 | 0,0095 | 98,3313 | 53,0922 | 6692 | 3751 | 921 | 0,0118 | 0,0122 | 0,7808 | 0,108 |  |
| ORB | 34746 | 30841 | 6858 | 5607 | 0,0601 | 0,0534 | 98,3497 | 53,008 | 34697 | 24552 | 6858 | 0,061 | 0,0801 | 0,8176 | 0,1616 |  |
| ORB1000 | 1000 | 1000 | 358 | 309 | 0,0017 | 0,0017 | 98,3261 | 53,0742 | 1000 | 873 | 358 | 0,0018 | 0,0028 | 0,8631 | 0,309 |  |
| BRISK | 13777 | 12276 | 2161 | 1550 | 0,0238 | 0,0212 | 98,3365 | 52,9986 | 13725 | 9425 | 2161 | 0,0241 | 0,0308 | 0,7173 | 0,1129 |  |
| KAZE | 3281 | 2807 | 913 | 755 | 0,0057 | 0,0049 | 98,3176 | 53,0922 | 3276 | 2130 | 913 | 0,0058 | 0,0069 | 0,8269 | 0,2305 |  |
| AKAZE | 3694 | 2931 | 696 | 607 | 0,0064 | 0,0051 | 98,3152 | 53,0785 | 3690 | 2378 | 696 | 0,0065 | 0,0078 | 0,8721 | 0,1645 |  |

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 | 6558 | 0,186213 | 0,172086 | 0,732684 | 0,001392 | 0,023641 | 0,400811 | 0,000798 | 1,092375 |
| SURF128 | 6737 | 5519 | 0,262383 | 0,212927 | 0,475992 | 0,000636 | 0,038763 | 0,788067 | 0,001311 | 0,951938 |
| SURF64 | 6737 | 5519 | 0,261682 | 0,192622 | 0,259395 | 0,000915 | 0,036871 | 0,280124 | 0,001265 | 0,714614 |
| ORB | 34746 | 30841 | 0,07844 | 0,068488 | 3,377269 | 0,003629 | 0,002238 | 0,492456 | 0,000647 | 3,527826 |
| ORB1000 | 1000 | 1000 | 0,024221 | 0,022879 | 0,005185 | 0,000574 | 0,023549 | 0,014481 | 0,001858 | 0,052858 |
| BRISK | 13777 | 12276 | 0,206437 | 0,183118 | 0,678678 | 0,001477 | 0,01495 | 0,314057 | 0,000952 | 1,06971 |
| KAZE | 3281 | 2807 | 0,387316 | 0,36921 | 0,119799 | 0,000884 | 0,124789 | 0,131214 | 0,00117 | 0,877209 |
| AKAZE | 3694 | 2931 | 0,0742 | 0,068171 | 0,034224 | 0,000687 | 0,021672 | 0,049172 | 0,001131 | 0,177281 |

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.