**Normalization results for pairs 1\_0.ppm\_1\_4.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_boat**

**1\_0.ppm: 1\_4.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 28,71 | 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 | 0,102 | 0,529 | 205,193 | -0,524 | 0,092 | 534,828 | 0 | -0 | 1 | 0,088 | 0,736 | 3,881 | 0,981 | 1,864 |  |
| SURF128 | 0,103 | 0,53 | 204,765 | -0,525 | 0,091 | 535,236 | 0 | -0 | 1 | 0,176 | 1,108 | 3,927 | 1,484 | 2,784 |  |
| SURF64 | 0,103 | 0,534 | 204,418 | -0,525 | 0,094 | 535,471 | 0 | 0 | 1 | 0,298 | 1,102 | 3,284 | 2,115 | 3,433 |  |
| ORB | 0,099 | 0,519 | 206,488 | -0,524 | 0,09 | 532,354 | 0 | -0 | 1 | 0,361 | 0,998 | 4,971 | 3,249 | 4,442 |  |
| ORB1000 | 0,098 | 0,533 | 205,382 | -0,527 | 0,101 | 531,948 | 0 | 0 | 1 | 0,379 | 0,913 | 2,648 | 4,223 | 7,128 |  |
| BRISK | 0,096 | 0,529 | 205,552 | -0,529 | 0,093 | 534,196 | -0 | 0 | 1 | 0,316 | 0,989 | 3,494 | 3,271 | 6,125 |  |
| KAZE | 0,103 | 0,534 | 204,45 | -0,526 | 0,095 | 535,366 | 0 | 0 | 1 | 0,3 | 1,027 | 3,108 | 1,9 | 3,238 |  |
| AKAZE | 0,101 | 0,516 | 206,711 | -0,522 | 0,09 | 531,493 | 0 | -0 | 1 | 0,298 | 0,889 | 3,701 | 3,779 | 6,037 |  |
| Original matrix | 0,101 | 0,526 | 205,32 | -0,524 | 0,091 | 533,83 | 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 | 5269 | 728 | 617 | 0,0153 | 0,0091 | 100 | 28,6962 | 8849 | 2788 | 728 | 0,0153 | 0,0168 | 0,8475 | 0,0697 |  |
| SURF128 | 6737 | 4591 | 405 | 341 | 0,0117 | 0,0079 | 100 | 28,7035 | 6737 | 2272 | 405 | 0,0117 | 0,0137 | 0,842 | 0,0506 |  |
| SURF64 | 6737 | 4591 | 660 | 537 | 0,0117 | 0,0079 | 100 | 28,7073 | 6737 | 2271 | 660 | 0,0117 | 0,0137 | 0,8136 | 0,0797 |  |
| ORB | 34746 | 20993 | 2342 | 1771 | 0,0601 | 0,0363 | 100 | 28,8341 | 34746 | 14422 | 2342 | 0,0601 | 0,0865 | 0,7562 | 0,051 |  |
| ORB1000 | 1000 | 1000 | 199 | 184 | 0,0017 | 0,0017 | 100 | 28,696 | 1000 | 897 | 199 | 0,0017 | 0,0054 | 0,9246 | 0,184 |  |
| BRISK | 13777 | 7853 | 964 | 719 | 0,0238 | 0,0136 | 100 | 28,9022 | 13777 | 5365 | 964 | 0,0238 | 0,0321 | 0,7459 | 0,0522 |  |
| KAZE | 3281 | 1950 | 361 | 296 | 0,0057 | 0,0034 | 100 | 28,724 | 3281 | 1413 | 361 | 0,0057 | 0,0085 | 0,8199 | 0,0902 |  |
| AKAZE | 3694 | 1901 | 444 | 363 | 0,0064 | 0,0033 | 100 | 28,7341 | 3694 | 1486 | 444 | 0,0064 | 0,0089 | 0,8176 | 0,0983 |  |

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 | 5269 | 0,41435 | 0,504068 | 0,916079 | 0,000655 | 0,071245 | 1,258349 | 0,001061 | 1,835152 |
| SURF128 | 6737 | 4591 | 0,507865 | 0,407306 | 0,569263 | 0,004215 | 0,082051 | 1,405588 | 0,01236 | 1,488649 |
| SURF64 | 6737 | 4591 | 0,630143 | 0,491963 | 0,329564 | 0,000681 | 0,100346 | 0,499339 | 0,001268 | 1,452351 |
| ORB | 34746 | 20993 | 0,114412 | 0,062158 | 3,541559 | 0,001841 | 0,003126 | 1,512194 | 0,001039 | 3,71997 |
| ORB1000 | 1000 | 1000 | 0,032117 | 0,053913 | 0,030418 | 0,00796 | 0,043014 | 0,152855 | 0,043262 | 0,124408 |
| BRISK | 13777 | 7853 | 0,294735 | 0,180892 | 0,77844 | 0,001129 | 0,022213 | 0,80751 | 0,001569 | 1,255196 |
| KAZE | 3281 | 1950 | 1,137662 | 0,785976 | 0,172583 | 0,000796 | 0,374903 | 0,47807 | 0,00269 | 2,097019 |
| AKAZE | 3694 | 1901 | 0,191226 | 0,143695 | 0,080453 | 0,000619 | 0,063677 | 0,181201 | 0,001704 | 0,415992 |

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.