**Normalization results for pairs 1\_0.ppm\_1\_5.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_bark**

**1\_0.ppm: 1\_5.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 6,268 | 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 | -0,215 | -0,126 | 585,952 | 0,126 | -0,217 | 355,324 | 0 | -0 | 1 | 0,112 | 0,121 | 1,093 | 1,99 | 2,388 |  |
| SURF128 | -0,223 | -0,12 | 585,271 | 0,119 | -0,214 | 355,591 | -0 | 0 | 1 | 0,116 | 0,693 | 1,528 | 2,916 | 3,4 |  |
| SURF64 | -0,219 | -0,128 | 584,926 | 0,122 | -0,218 | 355,266 | -0 | -0 | 1 | 0,113 | 0,752 | 1,922 | 1,55 | 2,257 |  |
| ORB | -0,214 | -0,142 | 584,218 | 0,125 | -0,226 | 354,645 | 0 | -0 | 1 | 0,12 | 0,552 | 1,488 | 5,183 | 8,143 |  |
| ORB1000 | -0,087 | -0,181 | 112,553 | 0,073 | -0,249 | 65,771 | 0,001 | -0,003 | 1 | 0,497 | 0 | 0 | 472,909 | 601,379 |  |
| BRISK | -0,219 | -0,117 | 585,954 | 0,125 | -0,212 | 354,855 | -0 | 0 | 1 | 0,116 | 0,584 | 2,281 | 2,294 | 3,259 |  |
| KAZE | -0,207 | -0,126 | 585,53 | 0,133 | -0,22 | 355,462 | 0 | -0 | 1 | 0,116 | 0,38 | 0,805 | 4,356 | 6,12 |  |
| AKAZE | -0,92 | 0,252 | 493,665 | -0,582 | 0,142 | 338,872 | -0,002 | 0,001 | 1 | 0,649 | 0,103 | 0,209 | 713,99 | 1547,42 |  |
| Original matrix | -0,217 | -0,126 | 585,55 | 0,125 | -0,217 | 355,1 | -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 | 3702 | 4626 | 264 | 257 | 0,0095 | 0,0118 | 100 | 6,2658 | 3702 | 378 | 264 | 0,0095 | 0,0154 | 0,9735 | 0,0694 |  |
| SURF128 | 3633 | 4485 | 54 | 39 | 0,0093 | 0,0115 | 100 | 6,2776 | 3633 | 373 | 54 | 0,0093 | 0,0152 | 0,7222 | 0,0107 |  |
| SURF64 | 3633 | 4485 | 80 | 68 | 0,0093 | 0,0115 | 100 | 6,2804 | 3633 | 374 | 80 | 0,0093 | 0,0152 | 0,85 | 0,0187 |  |
| ORB | 9421 | 17559 | 92 | 62 | 0,0241 | 0,0448 | 100 | 6,2697 | 9421 | 1835 | 92 | 0,0241 | 0,0747 | 0,6739 | 0,0066 |  |
| ORB1000 | 1000 | 1000 | 13 | 4 | 0,0026 | 0,0026 | 73,3254 | 99,086 | 683 | 996 | 10 | 0,0024 | 0,0026 | 0,3077 | 0,0059 |  |
| BRISK | 2223 | 5000 | 102 | 94 | 0,0057 | 0,0128 | 100 | 6,3018 | 2223 | 464 | 102 | 0,0057 | 0,0188 | 0,9216 | 0,0423 |  |
| KAZE | 760 | 862 | 12 | 11 | 0,0019 | 0,0022 | 100 | 6,228 | 760 | 53 | 12 | 0,0019 | 0,0022 | 0,9167 | 0,0145 |  |
| AKAZE | 705 | 904 | 9 | 5 | 0,0018 | 0,0023 | 0 | 49,3319 | 617 | 351 | 8 | ∞ | 0,0018 | 0,5556 | 0,0081 |  |

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 | 3702 | 4626 | 0,168493 | 0,163741 | 0,292989 | 0,000367 | 0,040454 | 1,109806 | 0,001427 | 0,62559 |
| SURF128 | 3633 | 4485 | 0,212152 | 0,220056 | 0,277318 | 0,000605 | 0,053729 | 5,135512 | 0,015517 | 0,710131 |
| SURF64 | 3633 | 4485 | 0,230247 | 0,21549 | 0,127447 | 0,000428 | 0,055711 | 1,593084 | 0,006294 | 0,573612 |
| ORB | 9421 | 17559 | 0,02824 | 0,041995 | 0,695122 | 0,000939 | 0,002694 | 7,555674 | 0,015145 | 0,766296 |
| ORB1000 | 1000 | 1000 | 0,018501 | 0,017945 | 0,016783 | 0,015581 | 0,018222 | 1,291001 | 3,895296 | 0,06881 |
| BRISK | 2223 | 5000 | 0,041987 | 0,091213 | 0,08174 | 0,000308 | 0,018564 | 0,801377 | 0,003275 | 0,215248 |
| KAZE | 760 | 862 | 0,863067 | 0,43993 | 0,055576 | 0,000317 | 0,822986 | 4,631353 | 0,028827 | 1,358891 |
| AKAZE | 705 | 904 | 0,077773 | 0,087003 | 0,013069 | 0,001586 | 0,103279 | 1,45207 | 0,317235 | 0,179431 |

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.