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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 99,12 img2: 38,233 | 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 | 0,291 | 0,55 | 103,185 | -0,549 | 0,293 | 523,038 | -0 | 0 | 1 | 0,333 | 0,628 | 2,534 | 1,076 | 2,095 |  |
| SURF128 | 0,295 | 0,553 | 102,319 | -0,55 | 0,298 | 523,117 | 0 | 0 | 1 | 0,259 | 1,137 | 3,695 | 1,138 | 1,677 |  |
| SURF64 | 0,279 | 0,548 | 104,535 | -0,558 | 0,294 | 522,595 | -0 | 0 | 1 | 0,686 | 1,188 | 3,482 | 5,817 | 10,161 |  |
| ORB | 0,293 | 0,55 | 102,838 | -0,549 | 0,293 | 522,895 | -0 | 0 | 1 | 0,347 | 0,928 | 3,786 | 1,114 | 2,227 |  |
| ORB1000 | 0,287 | 0,55 | 103,619 | -0,552 | 0,293 | 522,786 | -0 | 0 | 1 | 0,46 | 0,916 | 2,487 | 2,503 | 4,659 |  |
| BRISK | 0,289 | 0,55 | 103,02 | -0,55 | 0,292 | 522,456 | -0 | 0 | 1 | 0,487 | 0,923 | 3,797 | 2,157 | 4,383 |  |
| KAZE | 0,285 | 0,547 | 103,837 | -0,554 | 0,293 | 522,487 | -0 | 0 | 1 | 0,602 | 0,838 | 3,432 | 4,005 | 6,431 |  |
| AKAZE | 0,293 | 0,553 | 102,302 | -0,55 | 0,296 | 523,082 | -0 | 0 | 1 | 0,185 | 0,777 | 3,118 | 0,524 | 0,956 |  |
| Original matrix | 0,292 | 0,552 | 102,92 | -0,55 | 0,296 | 523,18 | -0 | 0 | 1,001 |  |  |  |  |  |  |

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 | 10261 | 7417 | 1333 | 1225 | 0,0178 | 0,0128 | 99,1099 | 38,2768 | 10164 | 3532 | 1332 | 0,0177 | 0,016 | 0,919 | 0,1205 |  |
| SURF128 | 6299 | 5537 | 431 | 354 | 0,0109 | 0,0096 | 99,0891 | 38,2618 | 6267 | 2762 | 431 | 0,0109 | 0,0125 | 0,8213 | 0,0565 |  |
| SURF64 | 6299 | 5537 | 654 | 404 | 0,0109 | 0,0096 | 99,1559 | 38,7253 | 6270 | 2776 | 654 | 0,0109 | 0,0124 | 0,6177 | 0,0644 |  |
| ORB | 37625 | 30015 | 5232 | 5004 | 0,0651 | 0,0519 | 99,1045 | 38,2903 | 37605 | 18109 | 5232 | 0,0656 | 0,0818 | 0,9564 | 0,1331 |  |
| ORB1000 | 1000 | 1000 | 178 | 161 | 0,0017 | 0,0017 | 99,1261 | 38,4689 | 1000 | 574 | 178 | 0,0017 | 0,0026 | 0,9045 | 0,161 |  |
| BRISK | 14959 | 11843 | 1793 | 1503 | 0,0259 | 0,0205 | 99,1163 | 38,458 | 14927 | 6977 | 1793 | 0,0261 | 0,0314 | 0,8383 | 0,1007 |  |
| KAZE | 2922 | 2083 | 542 | 361 | 0,0051 | 0,0036 | 99,1571 | 38,4965 | 2911 | 1208 | 542 | 0,0051 | 0,0054 | 0,6661 | 0,124 |  |
| AKAZE | 3255 | 2258 | 486 | 442 | 0,0056 | 0,0039 | 99,117 | 38,3033 | 3252 | 1426 | 486 | 0,0057 | 0,0064 | 0,9095 | 0,1359 |  |

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 | 10261 | 7417 | 0,234861 | 0,178491 | 1,072169 | 0,001013 | 0,023476 | 0,804327 | 0,000827 | 1,486534 |
| SURF128 | 6299 | 5537 | 0,264497 | 0,224994 | 0,455622 | 0,000619 | 0,041312 | 1,057127 | 0,001749 | 0,945732 |
| SURF64 | 6299 | 5537 | 0,281428 | 0,23739 | 0,244024 | 0,001269 | 0,043775 | 0,373125 | 0,003142 | 0,764111 |
| ORB | 37625 | 30015 | 0,078112 | 0,064215 | 4,014615 | 0,003315 | 0,002107 | 0,767319 | 0,000662 | 4,160257 |
| ORB1000 | 1000 | 1000 | 0,025278 | 0,02258 | 0,003083 | 0,000431 | 0,023928 | 0,017317 | 0,002675 | 0,051371 |
| BRISK | 14959 | 11843 | 0,242276 | 0,18218 | 0,688266 | 0,001302 | 0,015788 | 0,383862 | 0,000866 | 1,114024 |
| KAZE | 2922 | 2083 | 0,38322 | 0,405882 | 0,078335 | 0,00102 | 0,163002 | 0,144529 | 0,002825 | 0,868458 |
| AKAZE | 3255 | 2258 | 0,078429 | 0,0698 | 0,042447 | 0,000547 | 0,027503 | 0,087338 | 0,001237 | 0,191222 |

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.