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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 96,549 img2: 59,738 | 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 | 1,548 | 0,115 | 154,476 | 0,403 | 1,374 | -170,47 | 0,001 | 0 | 1 | 0,154 | 1,002 | 3,282 | 3,549 | 8,441 |  |
| SURF128 | 1,528 | 0,119 | 158,801 | 0,396 | 1,372 | -168,282 | 0,001 | 0 | 1 | 0,288 | 1,56 | 4,023 | 4,314 | 7,098 |  |
| SURF64 | 1,555 | 0,119 | 154,776 | 0,404 | 1,382 | -171,649 | 0,001 | 0 | 1 | 0,205 | 1,526 | 3,608 | 5,178 | 15,045 |  |
| ORB | 1,534 | 0,087 | 166,29 | 0,403 | 1,339 | -160,881 | 0,001 | 0 | 1 | 0,505 | 1,377 | 4,02 | 5,992 | 8,31 |  |
| ORB1000 | 1,509 | 0,117 | 165,345 | 0,395 | 1,363 | -165,57 | 0,001 | 0 | 1 | 0,419 | 1,189 | 3,217 | 9,293 | 13,378 |  |
| BRISK | 1,508 | 0,103 | 162,967 | 0,385 | 1,349 | -161,657 | 0,001 | 0 | 1 | 0,579 | 1,354 | 3,97 | 9,762 | 16,564 |  |
| KAZE | 1,555 | 0,138 | 153,748 | 0,408 | 1,395 | -174,024 | 0,001 | 0 | 1 | 0,369 | 1,427 | 3,451 | 8,368 | 16,424 |  |
| AKAZE | 1,564 | 0,106 | 157,243 | 0,413 | 1,37 | -170,049 | 0,001 | 0 | 1 | 0,258 | 1,249 | 3,086 | 4,556 | 8,522 |  |
| Original matrix | 1,547 | 0,117 | 155,75 | 0,404 | 1,373 | -170,1 | 0,001 | 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 | 13974 | 8980 | 2075 | 1362 | 0,0147 | 0,0094 | 96,5525 | 60,0414 | 13473 | 8164 | 2071 | 0,0147 | 0,0143 | 0,6564 | 0,1011 |  |
| SURF128 | 14804 | 9122 | 947 | 575 | 0,0156 | 0,0096 | 96,6154 | 59,5268 | 14512 | 7333 | 947 | 0,0158 | 0,0129 | 0,6072 | 0,0396 |  |
| SURF64 | 14804 | 9122 | 1413 | 859 | 0,0156 | 0,0096 | 96,5744 | 59,9877 | 14512 | 7360 | 1412 | 0,0158 | 0,0129 | 0,6079 | 0,0592 |  |
| ORB | 64986 | 30895 | 4004 | 2456 | 0,0683 | 0,0325 | 96,7566 | 59,5976 | 64441 | 29509 | 4004 | 0,07 | 0,052 | 0,6134 | 0,0381 |  |
| ORB1000 | 1000 | 1000 | 205 | 144 | 0,0011 | 0,0011 | 96,6784 | 58,6721 | 1000 | 940 | 205 | 0,0011 | 0,0017 | 0,7024 | 0,144 |  |
| BRISK | 27221 | 9603 | 1790 | 1116 | 0,0286 | 0,0101 | 96,6647 | 59,9916 | 26803 | 9212 | 1789 | 0,0291 | 0,0161 | 0,6235 | 0,0416 |  |
| KAZE | 4180 | 2017 | 744 | 452 | 0,0044 | 0,0021 | 96,5992 | 58,9412 | 4035 | 1792 | 744 | 0,0044 | 0,0032 | 0,6075 | 0,112 |  |
| AKAZE | 5089 | 2117 | 544 | 346 | 0,0053 | 0,0022 | 96,609 | 59,8642 | 4999 | 1981 | 544 | 0,0054 | 0,0035 | 0,636 | 0,0692 |  |

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 | 13974 | 8980 | 0,445282 | 0,572354 | 2,588729 | 0,001795 | 0,0478 | 1,24758 | 0,001317 | 3,60816 |
| SURF128 | 14804 | 9122 | 0,910017 | 0,693159 | 2,563848 | 0,001473 | 0,068729 | 2,707337 | 0,002561 | 4,168497 |
| SURF64 | 14804 | 9122 | 0,989495 | 0,770788 | 1,436989 | 0,002631 | 0,075668 | 1,016977 | 0,003062 | 3,199903 |
| ORB | 64986 | 30895 | 0,198361 | 0,096759 | 9,565977 | 0,008228 | 0,003091 | 2,389105 | 0,003349 | 9,869324 |
| ORB1000 | 1000 | 1000 | 0,041038 | 0,031283 | 0,003872 | 0,000939 | 0,036159 | 0,018886 | 0,006523 | 0,077131 |
| BRISK | 27221 | 9603 | 0,480861 | 0,154856 | 1,007015 | 0,001798 | 0,016895 | 0,562578 | 0,00161 | 1,644531 |
| KAZE | 4180 | 2017 | 0,661486 | 0,586338 | 0,116305 | 0,001514 | 0,224473 | 0,156324 | 0,00335 | 1,365644 |
| AKAZE | 5089 | 2117 | 0,13957 | 0,110785 | 0,036832 | 0,001138 | 0,039877 | 0,067706 | 0,003288 | 0,288324 |

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.