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

**1\_0.ppm: 1\_1.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 98,335 img2: 70,367 | 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 | 1,309 | 0,059 | 22,469 | 0,234 | 1,131 | -91,865 | 0,001 | 0 | 1 | 0,247 | 0,824 | 4,109 | 0,595 | 1,606 |  |
| SURF128 | 1,306 | 0,062 | 22,902 | 0,233 | 1,135 | -92,145 | 0,001 | 0 | 1 | 0,257 | 1,11 | 3,777 | 1,167 | 2,115 |  |
| SURF64 | 1,311 | 0,063 | 21,443 | 0,235 | 1,137 | -92,661 | 0,001 | 0 | 1 | 0,397 | 1,123 | 4,391 | 0,966 | 1,92 |  |
| ORB | 1,299 | 0,063 | 24,43 | 0,231 | 1,131 | -90,671 | 0,001 | 0 | 1 | 0,454 | 1,041 | 4,18 | 2,106 | 3,076 |  |
| ORB1000 | 1,295 | 0,063 | 25,462 | 0,229 | 1,132 | -90,89 | 0 | 0 | 1 | 0,587 | 1,107 | 4,015 | 3,463 | 4,311 |  |
| BRISK | 1,308 | 0,062 | 22,09 | 0,233 | 1,134 | -92,112 | 0,001 | 0 | 1 | 0,227 | 1,046 | 4,772 | 1,152 | 2,671 |  |
| KAZE | 1,297 | 0,058 | 26,119 | 0,229 | 1,127 | -89,558 | 0,001 | 0 | 1 | 0,636 | 0,932 | 4,286 | 1,47 | 3,134 |  |
| AKAZE | 1,3 | 0,062 | 24,386 | 0,231 | 1,131 | -91,026 | 0,001 | 0 | 1 | 0,35 | 0,914 | 3,351 | 1,333 | 2,029 |  |
| Original matrix | 1,307 | 0,061 | 22,417 | 0,233 | 1,132 | -91,859 | 0,001 | 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 | 13974 | 12245 | 4674 | 4341 | 0,0147 | 0,0129 | 98,3377 | 70,4833 | 13752 | 10784 | 4671 | 0,0147 | 0,0161 | 0,9288 | 0,3157 |  |
| SURF128 | 14804 | 12145 | 2477 | 2109 | 0,0156 | 0,0128 | 98,3289 | 70,2172 | 14682 | 9833 | 2477 | 0,0157 | 0,0147 | 0,8514 | 0,1436 |  |
| SURF64 | 14804 | 12145 | 3581 | 3007 | 0,0156 | 0,0128 | 98,3222 | 70,3104 | 14681 | 9840 | 3581 | 0,0157 | 0,0147 | 0,8397 | 0,2048 |  |
| ORB | 64986 | 48261 | 12808 | 9152 | 0,0683 | 0,0507 | 98,3575 | 70,1563 | 64782 | 45174 | 12808 | 0,0692 | 0,0677 | 0,7146 | 0,1413 |  |
| ORB1000 | 1000 | 1000 | 347 | 279 | 0,0011 | 0,0011 | 98,3437 | 70,1179 | 1000 | 967 | 347 | 0,0011 | 0,0014 | 0,804 | 0,279 |  |
| BRISK | 27221 | 16357 | 4787 | 3722 | 0,0286 | 0,0172 | 98,3305 | 70,4213 | 27035 | 15273 | 4787 | 0,0289 | 0,0228 | 0,7775 | 0,1377 |  |
| KAZE | 4180 | 2847 | 1451 | 1011 | 0,0044 | 0,003 | 98,3843 | 70,1325 | 4108 | 2500 | 1451 | 0,0044 | 0,0037 | 0,6968 | 0,2461 |  |
| AKAZE | 5089 | 3288 | 1254 | 1102 | 0,0053 | 0,0035 | 98,3491 | 70,173 | 5048 | 3006 | 1254 | 0,0054 | 0,0045 | 0,8788 | 0,2183 |  |

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 | 12245 | 0,319797 | 0,314499 | 2,544144 | 0,009242 | 0,024284 | 0,544318 | 0,002128 | 3,187683 |
| SURF128 | 14804 | 12145 | 0,890671 | 0,805796 | 2,864912 | 0,001577 | 0,063255 | 1,156605 | 0,000747 | 4,562956 |
| SURF64 | 14804 | 12145 | 0,662721 | 0,627831 | 1,374419 | 0,002283 | 0,04823 | 0,383808 | 0,000759 | 2,667255 |
| ORB | 64986 | 48261 | 0,135109 | 0,102353 | 10,611605 | 0,008368 | 0,002099 | 0,828513 | 0,000914 | 10,857436 |
| ORB1000 | 1000 | 1000 | 0,039942 | 0,033966 | 0,00431 | 0,000644 | 0,036953 | 0,012421 | 0,002308 | 0,078862 |
| BRISK | 27221 | 16357 | 0,435024 | 0,236651 | 1,423004 | 0,003141 | 0,015224 | 0,297264 | 0,000843 | 2,097819 |
| KAZE | 4180 | 2847 | 0,573904 | 0,546562 | 0,140434 | 0,001453 | 0,164637 | 0,096784 | 0,001436 | 1,262353 |
| AKAZE | 5089 | 3288 | 0,151171 | 0,210658 | 0,173889 | 0,000824 | 0,046886 | 0,138667 | 0,000747 | 0,536541 |

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.