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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 92,4 img2: 39,275 | 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 | 0,186 | 0,025 | 83,09 | -0,248 | 0,677 | 124,251 | -0 | 0 | 1 | 0,122 | 1,334 | 3,131 | 9,893 | 27,174 |  |
| SURF128 | 0,189 | 0,036 | 80,031 | -0,244 | 0,706 | 109,642 | -0 | 0 | 1 | 0,19 | 1,551 | 3,365 | 11,534 | 24,327 |  |
| SURF64 | 0,18 | 0,032 | 86,436 | -0,246 | 0,686 | 119,502 | -0 | 0 | 1 | 0,14 | 1,654 | 3,606 | 8,755 | 16,667 |  |
| ORB | 0,176 | 0,04 | 82,464 | -0,254 | 0,682 | 125,901 | -0 | 0 | 1 | 0,133 | 1,44 | 3,395 | 9,454 | 23,429 |  |
| ORB1000 | 0,337 | -0,564 | 136,002 | 0,019 | -0,019 | 135,406 | 0 | -0,001 | 1 | 0,918 | 0 | 0 | 593,389 | 1164,744 |  |
| BRISK | 0,177 | 0,03 | 86,611 | -0,248 | 0,672 | 125,609 | -0 | 0 | 1 | 0,134 | 1,269 | 2,893 | 8,072 | 18,27 |  |
| KAZE | 0,174 | 0,031 | 88,778 | -0,25 | 0,673 | 126,759 | -0 | 0 | 1 | 0,145 | 1,351 | 3,019 | 14,012 | 29,036 |  |
| AKAZE | 0,183 | 0,035 | 87,312 | -0,247 | 0,701 | 116,869 | -0 | 0 | 1 | 0,156 | 1,248 | 2,591 | 12,742 | 22,781 |  |
| Original matrix | 0,182 | 0,033 | 82,883 | -0,25 | 0,683 | 123,62 | -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 | 13974 | 5427 | 320 | 178 | 0,0147 | 0,0057 | 92,5549 | 39,548 | 12877 | 4062 | 317 | 0,0146 | 0,0108 | 0,5563 | 0,0138 |  |
| SURF128 | 14804 | 6277 | 101 | 56 | 0,0156 | 0,0066 | 91,7359 | 39,5982 | 13768 | 4248 | 99 | 0,0158 | 0,0113 | 0,5545 | 0,0041 |  |
| SURF64 | 14804 | 6277 | 186 | 89 | 0,0156 | 0,0066 | 92,3118 | 38,9381 | 13847 | 4184 | 181 | 0,0158 | 0,0113 | 0,4785 | 0,0064 |  |
| ORB | 64986 | 16770 | 333 | 92 | 0,0683 | 0,0176 | 92,2955 | 39,1371 | 61819 | 13590 | 325 | 0,0704 | 0,0365 | 0,2763 | 0,0015 |  |
| ORB1000 | 1000 | 1000 | 7 | 4 | 0,0011 | 0,0011 | 63,1437 | 48,2043 | 747 | 722 | 7 | 0,0012 | 0,0016 | 0,5714 | 0,0054 |  |
| BRISK | 27221 | 4315 | 202 | 107 | 0,0286 | 0,0045 | 92,5624 | 39,0508 | 25669 | 3459 | 199 | 0,0291 | 0,0093 | 0,5297 | 0,0042 |  |
| KAZE | 4180 | 1205 | 129 | 86 | 0,0044 | 0,0013 | 92,5389 | 38,8733 | 3811 | 827 | 129 | 0,0043 | 0,0022 | 0,6667 | 0,0226 |  |
| AKAZE | 5089 | 1154 | 71 | 32 | 0,0053 | 0,0012 | 92,1254 | 38,8344 | 4744 | 850 | 69 | 0,0054 | 0,0023 | 0,4507 | 0,0067 |  |

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 | 5427 | 0,584929 | 0,367083 | 0,947879 | 0,001691 | 0,054749 | 2,962122 | 0,009499 | 1,901581 |
| SURF128 | 14804 | 6277 | 0,598618 | 0,295008 | 1,078134 | 0,002971 | 0,043717 | 10,674593 | 0,053059 | 1,974731 |
| SURF64 | 14804 | 6277 | 0,511575 | 0,313309 | 0,557704 | 0,002746 | 0,042234 | 2,99841 | 0,030858 | 1,385335 |
| ORB | 64986 | 16770 | 0,134845 | 0,050415 | 3,469929 | 0,023329 | 0,00254 | 10,420208 | 0,253573 | 3,678518 |
| ORB1000 | 1000 | 1000 | 0,038799 | 0,02684 | 0,003364 | 0,001092 | 0,032819 | 0,4805 | 0,272981 | 0,070095 |
| BRISK | 27221 | 4315 | 0,423111 | 0,070341 | 0,433168 | 0,001846 | 0,015922 | 2,144398 | 0,017251 | 0,928466 |
| KAZE | 4180 | 1205 | 0,555692 | 0,502777 | 0,056173 | 0,001735 | 0,275091 | 0,435446 | 0,020178 | 1,116377 |
| AKAZE | 5089 | 1154 | 0,116089 | 0,104886 | 0,021701 | 0,003347 | 0,05685 | 0,305642 | 0,104597 | 0,246023 |

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.