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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 97,79 img2: 76,414 | 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 | 0,857 | 0,216 | 9,914 | -0,212 | 0,858 | 130,701 | 0 | 0 | 1 | 0,072 | 0,61 | 3,032 | 0,306 | 0,546 |  |
| SURF128 | 0,854 | 0,215 | 10,119 | -0,213 | 0,852 | 132,316 | -0 | -0 | 1 | 0,421 | 1,127 | 4,714 | 1,502 | 2,21 |  |
| SURF64 | 0,858 | 0,22 | 9,138 | -0,213 | 0,862 | 130,722 | -0 | 0 | 1 | 0,22 | 1,135 | 3,427 | 1,986 | 2,931 |  |
| ORB | 0,857 | 0,216 | 9,922 | -0,213 | 0,859 | 130,674 | 0 | 0 | 1 | 0,11 | 1,012 | 4,128 | 0,576 | 0,876 |  |
| ORB1000 | 0,855 | 0,206 | 11,959 | -0,21 | 0,849 | 131,699 | 0 | -0 | 1 | 0,569 | 0,953 | 3,207 | 2,913 | 3,968 |  |
| BRISK | 0,855 | 0,214 | 10,478 | -0,212 | 0,853 | 131,296 | -0 | -0 | 1 | 0,299 | 0,853 | 4,941 | 1,14 | 1,458 |  |
| KAZE | 0,855 | 0,216 | 10,218 | -0,213 | 0,86 | 130,406 | -0 | 0 | 1 | 0,271 | 0,851 | 4,459 | 1,367 | 1,699 |  |
| AKAZE | 0,857 | 0,216 | 9,776 | -0,212 | 0,858 | 130,658 | 0 | -0 | 1 | 0,069 | 0,869 | 3,893 | 0,205 | 0,386 |  |
| Original matrix | 0,858 | 0,217 | 9,484 | -0,212 | 0,859 | 130,48 | 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 | 8849 | 8545 | 2431 | 2354 | 0,0153 | 0,0148 | 97,7981 | 76,374 | 8788 | 7151 | 2429 | 0,0155 | 0,0162 | 0,9683 | 0,2679 |  |
| SURF128 | 6737 | 7200 | 946 | 684 | 0,0117 | 0,0125 | 97,8022 | 76,2725 | 6706 | 6215 | 946 | 0,0119 | 0,0141 | 0,723 | 0,102 |  |
| SURF64 | 6737 | 7200 | 1443 | 999 | 0,0117 | 0,0125 | 97,8839 | 76,1981 | 6708 | 6213 | 1443 | 0,0119 | 0,0141 | 0,6923 | 0,1489 |  |
| ORB | 34746 | 37254 | 8319 | 7384 | 0,0601 | 0,0645 | 97,7886 | 76,3803 | 34734 | 34041 | 8319 | 0,0615 | 0,0771 | 0,8876 | 0,2126 |  |
| ORB1000 | 1000 | 1000 | 408 | 327 | 0,0017 | 0,0017 | 97,8149 | 76,328 | 1000 | 971 | 408 | 0,0018 | 0,0022 | 0,8015 | 0,327 |  |
| BRISK | 13777 | 15054 | 3593 | 3054 | 0,0238 | 0,026 | 97,7927 | 76,3398 | 13764 | 13354 | 3593 | 0,0244 | 0,0303 | 0,85 | 0,2219 |  |
| KAZE | 3281 | 3338 | 1641 | 1140 | 0,0057 | 0,0058 | 97,8133 | 76,374 | 3274 | 2985 | 1641 | 0,0058 | 0,0068 | 0,6947 | 0,3482 |  |
| AKAZE | 3694 | 3659 | 1408 | 1318 | 0,0064 | 0,0063 | 97,7905 | 76,3938 | 3692 | 3372 | 1408 | 0,0065 | 0,0076 | 0,9361 | 0,357 |  |

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 | 8849 | 8545 | 0,280164 | 0,257099 | 1,150925 | 0,005654 | 0,030873 | 0,473436 | 0,002401 | 1,693841 |
| SURF128 | 6737 | 7200 | 0,609515 | 0,402999 | 0,725798 | 0,000943 | 0,073222 | 0,767228 | 0,001378 | 1,739255 |
| SURF64 | 6737 | 7200 | 0,341775 | 0,373571 | 0,4049 | 0,001261 | 0,051307 | 0,280596 | 0,001262 | 1,121508 |
| ORB | 34746 | 37254 | 0,081143 | 0,103025 | 5,570727 | 0,005816 | 0,00255 | 0,669638 | 0,000787 | 5,760711 |
| ORB1000 | 1000 | 1000 | 0,02418 | 0,024932 | 0,005841 | 0,000584 | 0,024555 | 0,014315 | 0,001785 | 0,055537 |
| BRISK | 13777 | 15054 | 0,343553 | 0,405252 | 1,262372 | 0,001959 | 0,025927 | 0,351342 | 0,000641 | 2,013137 |
| KAZE | 3281 | 3338 | 0,411342 | 0,396612 | 0,116695 | 0,001452 | 0,122093 | 0,071112 | 0,001273 | 0,926101 |
| AKAZE | 3694 | 3659 | 0,081308 | 0,098337 | 0,058039 | 0,000882 | 0,024442 | 0,04122 | 0,000669 | 0,238566 |

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.