**Normalization results for pairs 20\_0.png\_20\_1.png from subset png\picture\_inside**

**20\_0.png: 20\_1.png: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 0 img2: 0 | 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 | 0,926 | -0,022 | 250,056 | -0,039 | 0,937 | 57,181 | -0 | -0 | 1 | 0 | 0,283 | 1,934 | ~ | ~ |  |
| SURF128 | 0,923 | -0,023 | 250,129 | -0,04 | 0,935 | 57,288 | -0 | -0 | 1 | 0 | 0,509 | 3,136 | ~ | ~ |  |
| SURF64 | 0,925 | -0,022 | 249,96 | -0,039 | 0,937 | 57,166 | -0 | -0 | 1 | 0 | 0,517 | 3,391 | ~ | ~ |  |
| ORB | 0,924 | -0,022 | 250,02 | -0,04 | 0,936 | 57,19 | -0 | -0 | 1 | 0 | 0,829 | 3,202 | ~ | ~ |  |
| ORB1000 | 0,926 | -0,026 | 249,706 | -0,038 | 0,931 | 57,488 | -0 | -0 | 1 | 0 | 0,887 | 2,799 | ~ | ~ |  |
| BRISK | 0,924 | -0,025 | 250,254 | -0,04 | 0,934 | 57,281 | -0 | -0 | 1 | 0 | 0,555 | 2,655 | ~ | ~ |  |
| KAZE | 0,924 | -0,023 | 249,956 | -0,04 | 0,936 | 57,288 | -0 | -0 | 1 | 0 | 0,326 | 1,926 | ~ | ~ |  |
| AKAZE | 0,927 | -0,022 | 249,818 | -0,038 | 0,938 | 56,764 | -0 | -0 | 1 | 0 | 0,284 | 2,288 | ~ | ~ |  |
| Original matrix |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 1329 | 2531 | 682 | 652 | 0,0055 | 0,0105 | 51,8154 | 51,08 | 968 | 977 | 665 | 0,0078 | 0,008 | 0,956 | 0,6736 |  |
| SURF128 | 1914 | 2469 | 676 | 621 | 0,008 | 0,0103 | 51,8088 | 51,0779 | 1192 | 1304 | 654 | 0,0096 | 0,0106 | 0,9186 | 0,521 |  |
| SURF64 | 1914 | 2469 | 793 | 707 | 0,008 | 0,0103 | 51,8225 | 51,0946 | 1192 | 1304 | 768 | 0,0096 | 0,0106 | 0,8916 | 0,5931 |  |
| ORB | 4470 | 10000 | 1671 | 1629 | 0,0186 | 0,0417 | 51,8679 | 51,0979 | 3038 | 4015 | 1661 | 0,0244 | 0,0327 | 0,9749 | 0,5362 |  |
| ORB1000 | 1000 | 1000 | 292 | 225 | 0,0042 | 0,0042 | 51,8383 | 51,0921 | 820 | 414 | 287 | 0,0066 | 0,0034 | 0,7705 | 0,2744 |  |
| BRISK | 1862 | 4179 | 679 | 630 | 0,0078 | 0,0174 | 51,7921 | 51,0721 | 1290 | 1688 | 674 | 0,0104 | 0,0138 | 0,9278 | 0,4884 |  |
| KAZE | 608 | 1099 | 330 | 313 | 0,0025 | 0,0046 | 51,81 | 51,0983 | 481 | 442 | 326 | 0,0039 | 0,0036 | 0,9485 | 0,6507 |  |
| AKAZE | 490 | 1048 | 235 | 230 | 0,002 | 0,0044 | 51,8596 | 51,1525 | 377 | 439 | 232 | 0,003 | 0,0036 | 0,9787 | 0,6101 |  |

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 | 1329 | 2531 | 0,062872 | 0,064383 | 0,036584 | 0,000918 | 0,036372 | 0,053642 | 0,001407 | 0,164757 |
| SURF128 | 1914 | 2469 | 0,08518 | 0,097653 | 0,053399 | 0,000555 | 0,042027 | 0,078991 | 0,000893 | 0,236787 |
| SURF64 | 1914 | 2469 | 0,086546 | 0,076871 | 0,031251 | 0,000739 | 0,038175 | 0,039409 | 0,001045 | 0,195408 |
| ORB | 4470 | 10000 | 0,014166 | 0,024133 | 0,129637 | 0,000866 | 0,002791 | 0,07758 | 0,000531 | 0,168802 |
| ORB1000 | 1000 | 1000 | 0,009002 | 0,010261 | 0,004722 | 0,000573 | 0,009631 | 0,016171 | 0,002547 | 0,024559 |
| BRISK | 1862 | 4179 | 0,029693 | 0,060769 | 0,019753 | 0,000531 | 0,015243 | 0,029091 | 0,000843 | 0,110747 |
| KAZE | 608 | 1099 | 0,236072 | 0,138164 | 0,006845 | 0,000584 | 0,256996 | 0,020741 | 0,001865 | 0,381664 |
| AKAZE | 490 | 1048 | 0,026869 | 0,018972 | 0,002805 | 0,000344 | 0,036468 | 0,011936 | 0,001497 | 0,04899 |

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.