**Normalization results for pairs 1\_0.png\_1\_1.png from subset png\building**

**1\_0.png: 1\_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 | 0,735 | 0,004 | 64,703 | -0,004 | 0,731 | 72,7 | 0 | -0 | 1 | 0 | 0,254 | 2,792 | ~ | ~ |  |
| SURF128 | 0,736 | 0,004 | 64,511 | -0,004 | 0,732 | 72,394 | 0 | -0 | 1 | 0 | 0,606 | 4,07 | ~ | ~ |  |
| SURF64 | 0,736 | 0,005 | 64,387 | -0,004 | 0,732 | 72,466 | 0 | -0 | 1 | 0 | 0,648 | 3,075 | ~ | ~ |  |
| ORB | 0,74 | 0,005 | 63,944 | -0,002 | 0,734 | 72,006 | 0 | -0 | 1 | 0 | 0,811 | 3,657 | ~ | ~ |  |
| ORB1000 | 0,735 | 0,004 | 64,476 | -0,004 | 0,728 | 72,739 | 0 | -0 | 1 | 0 | 0,878 | 2,702 | ~ | ~ |  |
| BRISK | 0,736 | 0,003 | 64,5 | -0,003 | 0,731 | 72,278 | 0 | -0 | 1 | 0 | 0,655 | 3,962 | ~ | ~ |  |
| KAZE | 0,734 | 0,004 | 64,687 | -0,005 | 0,73 | 72,806 | 0 | -0 | 1 | 0 | 0,553 | 3,211 | ~ | ~ |  |
| AKAZE | 0,737 | 0,002 | 64,506 | -0,003 | 0,73 | 72,478 | 0 | -0 | 1 | 0 | 0,355 | 1,815 | ~ | ~ |  |
| 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 | 3050 | 2431 | 1250 | 1168 | 0,0127 | 0,0101 | 100 | 53,7867 | 3050 | 1921 | 1250 | 0,0127 | 0,0149 | 0,9344 | 0,383 |  |
| SURF128 | 2975 | 2467 | 810 | 759 | 0,0124 | 0,0103 | 100 | 53,8071 | 2975 | 1957 | 810 | 0,0124 | 0,0152 | 0,937 | 0,2551 |  |
| SURF64 | 2975 | 2467 | 1000 | 927 | 0,0124 | 0,0103 | 100 | 53,8208 | 2975 | 1957 | 1000 | 0,0124 | 0,0152 | 0,927 | 0,3116 |  |
| ORB | 8923 | 9046 | 2374 | 2145 | 0,0372 | 0,0377 | 100 | 53,9504 | 8923 | 7908 | 2374 | 0,0372 | 0,0611 | 0,9035 | 0,2404 |  |
| ORB1000 | 1000 | 1000 | 241 | 204 | 0,0042 | 0,0042 | 100 | 53,7679 | 1000 | 947 | 241 | 0,0042 | 0,0073 | 0,8465 | 0,204 |  |
| BRISK | 3722 | 3373 | 913 | 837 | 0,0155 | 0,0141 | 100 | 53,8829 | 3722 | 2832 | 913 | 0,0155 | 0,0219 | 0,9168 | 0,2249 |  |
| KAZE | 1205 | 935 | 340 | 294 | 0,005 | 0,0039 | 100 | 53,7713 | 1205 | 790 | 340 | 0,005 | 0,0061 | 0,8647 | 0,244 |  |
| AKAZE | 1117 | 990 | 264 | 250 | 0,0047 | 0,0041 | 100 | 53,9258 | 1117 | 881 | 264 | 0,0047 | 0,0068 | 0,947 | 0,2238 |  |

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 | 3050 | 2431 | 0,075429 | 0,058081 | 0,077536 | 0,000841 | 0,02431 | 0,062028 | 0,00072 | 0,211887 |
| SURF128 | 2975 | 2467 | 0,097893 | 0,09184 | 0,082552 | 0,000643 | 0,035066 | 0,101915 | 0,000846 | 0,272927 |
| SURF64 | 2975 | 2467 | 0,105245 | 0,079869 | 0,043479 | 0,00068 | 0,033875 | 0,043479 | 0,000733 | 0,229272 |
| ORB | 8923 | 9046 | 0,021728 | 0,020928 | 0,362917 | 0,001494 | 0,002374 | 0,152871 | 0,000696 | 0,407067 |
| ORB1000 | 1000 | 1000 | 0,010388 | 0,009751 | 0,004715 | 0,000474 | 0,010069 | 0,019563 | 0,002325 | 0,025329 |
| BRISK | 3722 | 3373 | 0,059919 | 0,046805 | 0,036063 | 0,000584 | 0,014987 | 0,039498 | 0,000697 | 0,143371 |
| KAZE | 1205 | 935 | 0,14603 | 0,132481 | 0,011477 | 0,000428 | 0,131438 | 0,033756 | 0,001457 | 0,290416 |
| AKAZE | 1117 | 990 | 0,022453 | 0,01748 | 0,004264 | 0,000408 | 0,018878 | 0,016152 | 0,001632 | 0,044606 |

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.