**Normalization results for pairs 3\_0.png\_3\_1.png from subset png\building**

**3\_0.png: 3\_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 | 0,499 | -0,002 | 133,301 | 0,002 | 0,494 | 114,206 | 0 | -0 | 1 | 0 | 0,259 | 3,081 | ~ | ~ |  |
| SURF128 | 0,501 | -0,006 | 133,07 | 0,003 | 0,491 | 113,984 | 0 | -0 | 1 | 0 | 0,534 | 4,995 | ~ | ~ |  |
| SURF64 | 0,501 | -0,006 | 133,039 | 0,004 | 0,491 | 113,692 | 0 | -0 | 1 | 0 | 0,627 | 3,731 | ~ | ~ |  |
| ORB | 0,503 | -0,009 | 133,199 | 0,004 | 0,489 | 113,97 | 0 | -0 | 1 | 0 | 0,727 | 2,587 | ~ | ~ |  |
| ORB1000 | 0,508 | -0,008 | 132,664 | 0,006 | 0,492 | 113,623 | 0 | -0 | 1 | 0 | 0,729 | 2,887 | ~ | ~ |  |
| BRISK | 0,501 | -0,004 | 132,755 | 0,002 | 0,492 | 114,18 | 0 | -0 | 1 | 0 | 0,575 | 2,449 | ~ | ~ |  |
| KAZE | 0,49 | -0,005 | 133,717 | -0,002 | 0,488 | 114,305 | -0 | -0 | 1 | 0 | 0,827 | 2,977 | ~ | ~ |  |
| AKAZE | 0,502 | -0,01 | 132,997 | 0,003 | 0,487 | 114,056 | 0 | -0 | 1 | 0 | 0,435 | 2,633 | ~ | ~ |  |
| 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 | 1235 | 1195 | 352 | 316 | 0,0051 | 0,005 | 100 | 24,5554 | 1235 | 518 | 352 | 0,0051 | 0,0088 | 0,8977 | 0,2559 |  |
| SURF128 | 2240 | 2469 | 477 | 417 | 0,0093 | 0,0103 | 100 | 24,6079 | 2240 | 842 | 477 | 0,0093 | 0,0143 | 0,8742 | 0,1862 |  |
| SURF64 | 2240 | 2469 | 578 | 495 | 0,0093 | 0,0103 | 100 | 24,5658 | 2240 | 842 | 578 | 0,0093 | 0,0143 | 0,8564 | 0,221 |  |
| ORB | 3610 | 4526 | 547 | 506 | 0,015 | 0,0189 | 100 | 24,6717 | 3610 | 2660 | 547 | 0,015 | 0,0449 | 0,925 | 0,1402 |  |
| ORB1000 | 1000 | 1000 | 188 | 169 | 0,0042 | 0,0042 | 100 | 24,7283 | 1000 | 775 | 188 | 0,0042 | 0,0131 | 0,8989 | 0,169 |  |
| BRISK | 1265 | 1644 | 251 | 240 | 0,0053 | 0,0069 | 100 | 24,6504 | 1265 | 958 | 251 | 0,0053 | 0,0162 | 0,9562 | 0,1897 |  |
| KAZE | 819 | 738 | 150 | 130 | 0,0034 | 0,0031 | 100 | 24,7046 | 819 | 436 | 150 | 0,0034 | 0,0074 | 0,8667 | 0,1587 |  |
| AKAZE | 615 | 618 | 146 | 134 | 0,0026 | 0,0026 | 100 | 24,6908 | 615 | 410 | 146 | 0,0026 | 0,0069 | 0,9178 | 0,2179 |  |

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 | 1235 | 1195 | 0,061639 | 0,063735 | 0,01754 | 0,000409 | 0,051622 | 0,04983 | 0,001292 | 0,143323 |
| SURF128 | 2240 | 2469 | 0,083164 | 0,090873 | 0,069927 | 0,000732 | 0,036965 | 0,146597 | 0,001754 | 0,244695 |
| SURF64 | 2240 | 2469 | 0,086942 | 0,083626 | 0,02746 | 0,000583 | 0,036341 | 0,047507 | 0,001177 | 0,198611 |
| ORB | 3610 | 4526 | 0,012355 | 0,013628 | 0,041839 | 0,000561 | 0,003216 | 0,076487 | 0,001109 | 0,068382 |
| ORB1000 | 1000 | 1000 | 0,008776 | 0,008866 | 0,004223 | 0,00033 | 0,00882 | 0,022462 | 0,001955 | 0,022196 |
| BRISK | 1265 | 1644 | 0,021048 | 0,029208 | 0,008417 | 0,000316 | 0,017202 | 0,033532 | 0,001315 | 0,058988 |
| KAZE | 819 | 738 | 0,144915 | 0,147165 | 0,006647 | 0,000391 | 0,188175 | 0,044311 | 0,003006 | 0,299117 |
| AKAZE | 615 | 618 | 0,022558 | 0,019481 | 0,00167 | 0,000322 | 0,0341 | 0,011437 | 0,002404 | 0,044031 |

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.