**Normalization results for pairs 10\_0.png\_10\_1.png from subset png\building**

**10\_0.png: 10\_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 | 0,695 | -0,005 | 204,105 | 0,03 | 0,679 | 90,767 | 0 | 0 | 1 | 0 | 0,501 | 1,966 | ~ | ~ |  |
| SURF128 | 0,662 | -0,15 | 213,424 | 0,026 | 0,577 | 96,063 | 0 | -0 | 1 | 0 | 0,854 | 2,203 | ~ | ~ |  |
| SURF64 | 0,668 | -0,1 | 211,113 | 0,026 | 0,6 | 95,955 | 0 | -0 | 1 | 0 | 0,986 | 2,766 | ~ | ~ |  |
| ORB | 0,75 | 0,223 | 189,9 | 0,036 | 0,79 | 88,271 | 0 | 0,001 | 1 | 0 | 0,816 | 2,902 | ~ | ~ |  |
| ORB1000 | 0,698 | 0,088 | 199,265 | 0,025 | 0,688 | 93,801 | 0 | 0 | 1 | 0 | 0,835 | 2,072 | ~ | ~ |  |
| BRISK | 0,708 | -0,063 | 204,394 | 0,038 | 0,634 | 92,67 | 0 | -0 | 1 | 0 | 0,761 | 2,893 | ~ | ~ |  |
| KAZE | 0,696 | -0,03 | 205,473 | 0,03 | 0,655 | 93,035 | 0 | -0 | 1 | 0 | 0,624 | 1,626 | ~ | ~ |  |
| AKAZE | 0,725 | -0,02 | 200,9 | 0,04 | 0,69 | 88,343 | 0 | -0 | 1 | 0 | 0,649 | 2,325 | ~ | ~ |  |
| 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 | 1173 | 1143 | 86 | 60 | 0,0049 | 0,0048 | 100 | 39,5692 | 1173 | 653 | 86 | 0,0049 | 0,0069 | 0,6977 | 0,0512 |  |
| SURF128 | 1786 | 1542 | 89 | 46 | 0,0074 | 0,0064 | 100 | 42,6163 | 1786 | 1054 | 89 | 0,0074 | 0,0103 | 0,5169 | 0,0258 |  |
| SURF64 | 1786 | 1542 | 128 | 56 | 0,0074 | 0,0064 | 100 | 40,6088 | 1786 | 1040 | 128 | 0,0074 | 0,0107 | 0,4375 | 0,0314 |  |
| ORB | 5498 | 6922 | 175 | 110 | 0,0229 | 0,0288 | 100 | 34,6258 | 5498 | 3964 | 175 | 0,0229 | 0,0477 | 0,6286 | 0,02 |  |
| ORB1000 | 1000 | 1000 | 101 | 61 | 0,0042 | 0,0042 | 100 | 36,0996 | 1000 | 642 | 101 | 0,0042 | 0,0074 | 0,604 | 0,061 |  |
| BRISK | 2238 | 2786 | 87 | 52 | 0,0093 | 0,0116 | 100 | 40,5721 | 2238 | 1677 | 87 | 0,0093 | 0,0172 | 0,5977 | 0,0232 |  |
| KAZE | 793 | 872 | 35 | 21 | 0,0033 | 0,0036 | 100 | 39,3079 | 793 | 490 | 35 | 0,0033 | 0,0052 | 0,6 | 0,0265 |  |
| AKAZE | 693 | 856 | 32 | 23 | 0,0029 | 0,0036 | 100 | 41,2533 | 693 | 525 | 32 | 0,0029 | 0,0053 | 0,7188 | 0,0332 |  |

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 | 1173 | 1143 | 0,052532 | 0,051569 | 0,065622 | 0,008404 | 0,04495 | 0,76305 | 0,14006 | 0,178127 |
| SURF128 | 1786 | 1542 | 0,216179 | 0,052539 | 0,02306 | 0,00195 | 0,077555 | 0,259106 | 0,042399 | 0,293729 |
| SURF64 | 1786 | 1542 | 0,054701 | 0,058801 | 0,014892 | 0,005956 | 0,03438 | 0,116346 | 0,106349 | 0,13435 |
| ORB | 5498 | 6922 | 0,015692 | 0,021044 | 0,087152 | 0,001099 | 0,002947 | 0,498011 | 0,009991 | 0,124987 |
| ORB1000 | 1000 | 1000 | 0,009502 | 0,009238 | 0,003461 | 0,0012 | 0,009369 | 0,034268 | 0,019674 | 0,023401 |
| BRISK | 2238 | 2786 | 0,035853 | 0,041571 | 0,040194 | 0,001851 | 0,01547 | 0,462004 | 0,035597 | 0,119469 |
| KAZE | 793 | 872 | 0,181629 | 0,118022 | 0,007481 | 0,001164 | 0,182193 | 0,213752 | 0,055426 | 0,308296 |
| AKAZE | 693 | 856 | 0,020862 | 0,020884 | 0,00263 | 0,000592 | 0,027249 | 0,082176 | 0,025748 | 0,044968 |

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.