**Normalization results for pairs 15\_0.png\_15\_1.png from subset png\graffiti\_picture\_outside**

**15\_0.png: 15\_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 ErrIM (pixel) | max ErrIM | Expert rate |
| SIFT | 0,402 | -0,017 | 84,758 | -0,12 | 0,659 | 74,701 | -0,001 | 0 | 1 | 0,767 | 3,26 |  |
| SURF128 | 0,403 | -0,017 | 84,309 | -0,12 | 0,659 | 74,69 | -0,001 | 0 | 1 | 0,983 | 3,44 |  |
| SURF64 | 0,402 | -0,016 | 84,511 | -0,12 | 0,66 | 74,717 | -0,001 | 0 | 1 | 1,006 | 4,225 |  |
| ORB | 0,397 | -0,014 | 85,055 | -0,123 | 0,661 | 75,232 | -0,001 | 0 | 1 | 0,982 | 4,131 |  |
| ORB1000 | 0,395 | -0,018 | 86,085 | -0,122 | 0,656 | 75,281 | -0,001 | 0 | 1 | 0,97 | 3,841 |  |
| BRISK | 0,401 | -0,016 | 84,606 | -0,121 | 0,659 | 74,999 | -0,001 | 0 | 1 | 0,906 | 3,413 |  |
| KAZE | 0,402 | -0,014 | 84,144 | -0,121 | 0,663 | 74,514 | -0,001 | 0 | 1 | 0,939 | 3,521 |  |
| AKAZE | 0,4 | -0,017 | 85,013 | -0,121 | 0,658 | 74,918 | -0,001 | 0 | 1 | 0,778 | 2,676 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 2025 | 1750 | 639 | 499 | 0,0084 | 0,0073 | 99,9012 | 57,9525 | 2025 | 1351 | 639 | 0,0084 | 0,0097 | 0,7809 | 0,2464 |  |
| SURF128 | 2364 | 2511 | 533 | 423 | 0,0098 | 0,0105 | 99,9112 | 57,995 | 2364 | 1892 | 533 | 0,0099 | 0,0136 | 0,7936 | 0,1789 |  |
| SURF64 | 2364 | 2511 | 664 | 517 | 0,0098 | 0,0105 | 99,9129 | 57,9462 | 2364 | 1890 | 664 | 0,0099 | 0,0136 | 0,7786 | 0,2187 |  |
| ORB | 5882 | 6798 | 1280 | 906 | 0,0245 | 0,0283 | 99,895 | 58,1842 | 5882 | 5965 | 1280 | 0,0245 | 0,0427 | 0,7078 | 0,154 |  |
| ORB1000 | 1000 | 1000 | 267 | 226 | 0,0042 | 0,0042 | 99,8854 | 57,88 | 1000 | 849 | 267 | 0,0042 | 0,0061 | 0,8464 | 0,226 |  |
| BRISK | 2478 | 2899 | 565 | 494 | 0,0103 | 0,0121 | 99,91 | 57,9496 | 2478 | 2397 | 565 | 0,0103 | 0,0172 | 0,8743 | 0,1994 |  |
| KAZE | 1202 | 1188 | 325 | 300 | 0,005 | 0,005 | 99,9129 | 58,0671 | 1202 | 928 | 325 | 0,005 | 0,0067 | 0,9231 | 0,2496 |  |
| AKAZE | 1006 | 1097 | 260 | 231 | 0,0042 | 0,0046 | 99,8975 | 57,9363 | 1006 | 923 | 260 | 0,0042 | 0,0066 | 0,8885 | 0,2296 |  |

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 | 2025 | 1750 | 0,052968 | 0,047003 | 0,028086 | 0,000705 | 0,026507 | 0,043952 | 0,001411 | 0,128761 |
| SURF128 | 2364 | 2511 | 0,070176 | 0,077039 | 0,046444 | 0,000713 | 0,030182 | 0,087136 | 0,001685 | 0,194372 |
| SURF64 | 2364 | 2511 | 0,070232 | 0,076033 | 0,024892 | 0,000725 | 0,029993 | 0,037488 | 0,001402 | 0,171882 |
| ORB | 5882 | 6798 | 0,016116 | 0,017096 | 0,095627 | 0,001074 | 0,002626 | 0,074708 | 0,001185 | 0,129913 |
| ORB1000 | 1000 | 1000 | 0,009672 | 0,009407 | 0,003531 | 0,000451 | 0,009539 | 0,013225 | 0,001995 | 0,023061 |
| BRISK | 2478 | 2899 | 0,038276 | 0,041423 | 0,018911 | 0,000634 | 0,014867 | 0,03347 | 0,001283 | 0,099244 |
| KAZE | 1202 | 1188 | 0,18373 | 0,126741 | 0,011976 | 0,000552 | 0,129768 | 0,03685 | 0,00184 | 0,322999 |
| AKAZE | 1006 | 1097 | 0,017968 | 0,014119 | 0,004254 | 0,000436 | 0,015365 | 0,016361 | 0,001888 | 0,036777 |

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.