**Normalization results for pairs 6\_0.png\_6\_1.png from subset png\graffiti\_picture\_outside**

**6\_0.png: 6\_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 | 0,809 | -0,016 | 111,124 | 0,078 | 0,742 | 66,782 | 0 | -0 | 1 | 1,084 | 3,132 |  |
| SURF128 | 0,837 | -0,039 | 109,304 | 0,094 | 0,727 | 66,271 | 0 | -0 | 1 | 1,118 | 3,367 |  |
| SURF64 | 0,831 | 0,025 | 105,877 | 0,083 | 0,786 | 63,444 | 0 | 0 | 1 | 1,054 | 2,806 |  |
| ORB | 0,902 | 0,036 | 96,513 | 0,108 | 0,827 | 56,881 | 0 | 0 | 1 | 1,137 | 2,991 |  |
| ORB1000 | 1,135 | 0,016 | 68,433 | 0,196 | 0,895 | 42,598 | 0,001 | 0 | 1 | 1,174 | 2,768 |  |
| BRISK | 0,836 | 0,016 | 106,09 | 0,083 | 0,786 | 63,254 | 0 | 0 | 1 | 1,186 | 2,778 |  |
| KAZE | 0,903 | -0,051 | 103,203 | 0,123 | 0,744 | 61,49 | 0,001 | -0 | 1 | 1,084 | 2,946 |  |
| AKAZE | 0,92 | 0,012 | 96,141 | 0,12 | 0,817 | 55,552 | 0 | 0 | 1 | 1,022 | 2,738 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 1984 | 2912 | 299 | 239 | 0,0083 | 0,0121 | 100 | 47,1621 | 1984 | 2342 | 299 | 0,0083 | 0,0207 | 0,7993 | 0,1205 |  |
| SURF128 | 3200 | 3160 | 179 | 103 | 0,0133 | 0,0132 | 100 | 47,4875 | 3200 | 2224 | 179 | 0,0133 | 0,0195 | 0,5754 | 0,0322 |  |
| SURF64 | 3200 | 3160 | 202 | 116 | 0,0133 | 0,0132 | 100 | 46,7279 | 3200 | 2220 | 202 | 0,0133 | 0,0198 | 0,5743 | 0,0362 |  |
| ORB | 5475 | 9239 | 434 | 305 | 0,0228 | 0,0385 | 100 | 47,9442 | 5475 | 8076 | 434 | 0,0228 | 0,0702 | 0,7028 | 0,0557 |  |
| ORB1000 | 1000 | 1000 | 135 | 99 | 0,0042 | 0,0042 | 100 | 52,1437 | 1000 | 799 | 135 | 0,0042 | 0,0064 | 0,7333 | 0,099 |  |
| BRISK | 1766 | 3095 | 143 | 102 | 0,0074 | 0,0129 | 100 | 47,2129 | 1766 | 2539 | 143 | 0,0074 | 0,0224 | 0,7133 | 0,0578 |  |
| KAZE | 549 | 673 | 90 | 57 | 0,0023 | 0,0028 | 100 | 48,395 | 549 | 365 | 90 | 0,0023 | 0,0031 | 0,6333 | 0,1038 |  |
| AKAZE | 478 | 537 | 100 | 76 | 0,002 | 0,0022 | 100 | 48,5671 | 478 | 380 | 100 | 0,002 | 0,0033 | 0,76 | 0,159 |  |

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 | 1984 | 2912 | 0,052908 | 0,052574 | 0,044188 | 0,000742 | 0,02236 | 0,147787 | 0,003103 | 0,150412 |
| SURF128 | 3200 | 3160 | 0,074229 | 0,070391 | 0,077401 | 0,00138 | 0,022735 | 0,43241 | 0,013394 | 0,223402 |
| SURF64 | 3200 | 3160 | 0,072557 | 0,068636 | 0,042831 | 0,001418 | 0,022196 | 0,212032 | 0,012226 | 0,185442 |
| ORB | 5475 | 9239 | 0,0153 | 0,020545 | 0,121875 | 0,00086 | 0,002508 | 0,280818 | 0,00282 | 0,15858 |
| ORB1000 | 1000 | 1000 | 0,009073 | 0,009229 | 0,003201 | 0,000646 | 0,00915 | 0,023711 | 0,00653 | 0,022149 |
| BRISK | 1766 | 3095 | 0,02694 | 0,041858 | 0,014182 | 0,000745 | 0,014389 | 0,099172 | 0,007305 | 0,083725 |
| KAZE | 549 | 673 | 0,113371 | 0,106859 | 0,003881 | 0,000925 | 0,182642 | 0,043125 | 0,016222 | 0,225036 |
| AKAZE | 478 | 537 | 0,012397 | 0,015713 | 0,001184 | 0,0007 | 0,027597 | 0,01184 | 0,009216 | 0,029995 |

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.