**Normalization results for pairs 10\_0.png\_10\_1.png from subset png\graffiti\_picture\_outside**

**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 ErrIM (pixel) | max ErrIM | Expert rate |
| SIFT | 1,341 | 0,051 | 14,164 | 0,147 | 1,1 | 10,274 | 0,001 | 0 | 1 | 0,783 | 3,15 |  |
| SURF128 | 1,345 | 0,061 | 12,357 | 0,147 | 1,112 | 9,047 | 0,001 | 0 | 1 | 1,07 | 3,712 |  |
| SURF64 | 1,326 | 0,055 | 15,528 | 0,142 | 1,097 | 11,01 | 0,001 | 0 | 1 | 1,193 | 3,723 |  |
| ORB | 1,304 | 0,053 | 16,538 | 0,133 | 1,087 | 11,829 | 0,001 | 0 | 1 | 1,001 | 4,106 |  |
| ORB1000 | 1,315 | 0,039 | 16,193 | 0,14 | 1,077 | 11,66 | 0,001 | -0 | 1 | 0,934 | 3,16 |  |
| BRISK | 1,314 | 0,052 | 16,315 | 0,14 | 1,089 | 11,349 | 0,001 | 0 | 1 | 1,026 | 4,137 |  |
| KAZE | 1,31 | 0,053 | 15,977 | 0,131 | 1,092 | 11,923 | 0,001 | 0 | 1 | 0,89 | 3,558 |  |
| AKAZE | 1,342 | 0,044 | 13,913 | 0,145 | 1,098 | 10,315 | 0,001 | 0 | 1 | 0,757 | 2,862 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 2929 | 2301 | 870 | 785 | 0,0122 | 0,0096 | 98,8421 | 65,8542 | 2920 | 1791 | 870 | 0,0123 | 0,0113 | 0,9023 | 0,2688 |  |
| SURF128 | 2876 | 2559 | 640 | 529 | 0,012 | 0,0107 | 98,8933 | 66,0487 | 2865 | 2022 | 640 | 0,0121 | 0,0128 | 0,8266 | 0,1846 |  |
| SURF64 | 2876 | 2559 | 800 | 702 | 0,012 | 0,0107 | 98,9342 | 65,5921 | 2866 | 2017 | 800 | 0,0121 | 0,0128 | 0,8775 | 0,2449 |  |
| ORB | 9998 | 8860 | 2237 | 2062 | 0,0417 | 0,0369 | 98,8929 | 66,1654 | 9998 | 7912 | 2237 | 0,0421 | 0,0498 | 0,9218 | 0,2062 |  |
| ORB1000 | 1000 | 1000 | 458 | 400 | 0,0042 | 0,0042 | 98,7742 | 66,5312 | 1000 | 985 | 458 | 0,0042 | 0,0062 | 0,8734 | 0,4 |  |
| BRISK | 3571 | 3131 | 754 | 689 | 0,0149 | 0,013 | 98,885 | 65,7879 | 3568 | 2662 | 754 | 0,015 | 0,0169 | 0,9138 | 0,1931 |  |
| KAZE | 1113 | 853 | 354 | 291 | 0,0046 | 0,0036 | 98,92 | 66,2404 | 1110 | 758 | 354 | 0,0047 | 0,0048 | 0,822 | 0,2622 |  |
| AKAZE | 1089 | 864 | 316 | 260 | 0,0045 | 0,0036 | 98,7437 | 66,3883 | 1089 | 807 | 316 | 0,0046 | 0,0051 | 0,8228 | 0,2388 |  |

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 | 2929 | 2301 | 0,072567 | 0,059002 | 0,136699 | 0,005511 | 0,025208 | 0,157125 | 0,00702 | 0,273779 |
| SURF128 | 2876 | 2559 | 0,748808 | 0,072165 | 0,058059 | 0,000788 | 0,144282 | 0,090717 | 0,001489 | 0,87982 |
| SURF64 | 2876 | 2559 | 0,077462 | 0,065116 | 0,031995 | 0,000866 | 0,026189 | 0,039994 | 0,001233 | 0,175439 |
| ORB | 9998 | 8860 | 0,022786 | 0,020595 | 0,199186 | 0,001669 | 0,002301 | 0,089041 | 0,000809 | 0,244237 |
| ORB1000 | 1000 | 1000 | 0,023769 | 0,009986 | 0,003458 | 0,000501 | 0,016877 | 0,00755 | 0,001251 | 0,037714 |
| BRISK | 3571 | 3131 | 0,05246 | 0,044349 | 0,033102 | 0,00089 | 0,014427 | 0,043902 | 0,001291 | 0,1308 |
| KAZE | 1113 | 853 | 0,183466 | 0,118759 | 0,008297 | 0,000567 | 0,152031 | 0,023439 | 0,001949 | 0,31109 |
| AKAZE | 1089 | 864 | 0,019863 | 0,019015 | 0,004297 | 0,000592 | 0,020123 | 0,013598 | 0,002275 | 0,043766 |

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.