**Normalization results for pairs 16\_0.png\_16\_1.png from subset png\graffiti\_picture\_outside**

**16\_0.png: 16\_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 | 0,165 | -0,028 | 158,561 | 0,004 | 0,137 | 106,194 | 0 | -0 | 1 | 0,065 | 0,213 |  |
| SURF128 | 0,175 | 0,001 | 154,738 | 0,004 | 0,158 | 104,978 | 0 | -0 | 1 | 0,724 | 1,602 |  |
| SURF64 | 0,064 | -0,083 | 165,682 | -0,045 | 0,079 | 109,39 | -0 | -0 | 1 | 0,949 | 2,077 |  |
| ORB | 0,065 | -3,768 | 586,267 | 0,676 | -2,171 | 186,762 | 0,001 | -0,008 | 1 | 0,53 | 1,306 |  |
| ORB1000 | -0,686 | -0,276 | 355,472 | -0,377 | -0,19 | 207,793 | -0,002 | -0,001 | 1 | 0 | 0 |  |
| BRISK | 0,126 | -0,758 | 181,388 | 0,032 | -0,429 | 121,39 | 0 | -0,004 | 1 | 0,541 | 1,121 |  |
| KAZE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | ~ |  |
| AKAZE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | ~ |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 823 | 1186 | 25 | 12 | 0,0034 | 0,0049 | 100 | 2,5958 | 823 | 28 | 25 | 0,0034 | 0,0045 | 0,48 | 0,0146 |  |
| SURF128 | 866 | 2221 | 17 | 12 | 0,0036 | 0,0093 | 100 | 2,6821 | 866 | 44 | 17 | 0,0036 | 0,0068 | 0,7059 | 0,0139 |  |
| SURF64 | 866 | 2221 | 30 | 14 | 0,0036 | 0,0093 | 100 | 2,8458 | 866 | 49 | 30 | 0,0036 | 0,0072 | 0,4667 | 0,0162 |  |
| ORB | 5185 | 4692 | 16 | 5 | 0,0216 | 0,0196 | 62,8962 | 97,3792 | 3360 | 4464 | 12 | 0,0223 | 0,0191 | 0,3125 | 0,0015 |  |
| ORB1000 | 1000 | 1000 | 6 | 4 | 0,0042 | 0,0042 | 94,1262 | 99,2354 | 946 | 987 | 6 | 0,0042 | 0,0041 | 0,6667 | 0,0042 |  |
| BRISK | 2212 | 2054 | 12 | 6 | 0,0092 | 0,0086 | 92,1346 | 70,3958 | 2032 | 1534 | 12 | 0,0092 | 0,0091 | 0,5 | 0,003 |  |
| KAZE | 270 | 836 | 3 | 0 | 0,0011 | 0,0035 | 0 | 0 | 0 | 0 | 0 | � | � | 0 | � |  |
| AKAZE | 496 | 670 | 3 | 0 | 0,0021 | 0,0028 | 0 | 0 | 0 | 0 | 0 | � | � | 0 | � |  |

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 | 823 | 1186 | 0,041449 | 0,043817 | 0,008008 | 0,002596 | 0,043653 | 0,320307 | 0,216348 | 0,09587 |
| SURF128 | 866 | 2221 | 0,042649 | 0,061685 | 0,014941 | 0,000667 | 0,03851 | 0,878893 | 0,055608 | 0,119943 |
| SURF64 | 866 | 2221 | 0,035686 | 0,061726 | 0,008286 | 0,002905 | 0,034499 | 0,276195 | 0,20753 | 0,108604 |
| ORB | 5185 | 4692 | 0,01408 | 0,013857 | 0,058725 | 0,013833 | 0,002834 | 3,670293 | 2,766643 | 0,100495 |
| ORB1000 | 1000 | 1000 | 0,008692 | 0,008953 | 0,003303 | 0,000572 | 0,008822 | 0,550513 | 0,142933 | 0,02152 |
| BRISK | 2212 | 2054 | 0,028674 | 0,031745 | 0,012095 | 0,002362 | 0,014208 | 1,0079 | 0,393614 | 0,074876 |
| KAZE | 270 | 836 | 0,17224 | 0,11137 | 0,00211 | 0 | 0,385571 | 0,70326 | 0 | 0,28572 |
| AKAZE | 496 | 670 | 0,017012 | 0,013298 | 0,002013 | 0 | 0,027072 | 0,670947 | 0 | 0,032323 |

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.