**Normalization results for pairs 1\_0.png\_1\_1.png from subset 07\_27\graffiti\_picture\_outside\retest**

**1\_0.png: 1\_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 | 0,317 | 0,02 | 118,888 | -0,057 | 0,391 | 149,901 | -0 | 0 | 1 | 0,318 | 2,595 |  |
| SURF128 | 0,313 | 0,022 | 118,9 | -0,061 | 0,392 | 150,233 | -0 | 0 | 1 | 0,719 | 2,78 |  |
| SURF64 | 0,33 | 0,016 | 118,434 | -0,045 | 0,388 | 149,542 | -0 | 0 | 1 | 0,809 | 3,497 |  |
| ORB | 0,309 | 0,018 | 119,704 | -0,065 | 0,386 | 151,161 | -0 | 0 | 1 | 0,696 | 3,222 |  |
| ORB1000 | 0,331 | 0,007 | 119,056 | -0,044 | 0,375 | 151,275 | -0 | 0 | 1 | 0,815 | 3,082 |  |
| BRISK | 0,321 | 0,02 | 118,432 | -0,056 | 0,391 | 149,676 | -0 | 0 | 1 | 0,653 | 3,305 |  |
| KAZE | 0,312 | 0,026 | 118,105 | -0,06 | 0,395 | 149,308 | -0 | 0 | 1 | 0,844 | 3,172 |  |
| AKAZE | 0,312 | 0,019 | 118,779 | -0,062 | 0,385 | 150,569 | -0 | 0 | 1 | 0,482 | 1,307 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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 | 1744 | 943 | 224 | 191 | 0,0073 | 0,0039 | 100 | 13,0925 | 1744 | 445 | 224 | 0,0073 | 0,0142 | 0,8527 | 0,1095 |  |
| SURF128 | 2384 | 1391 | 163 | 128 | 0,0099 | 0,0058 | 100 | 13,0542 | 2384 | 470 | 163 | 0,0099 | 0,015 | 0,7853 | 0,0537 |  |
| SURF64 | 2384 | 1391 | 180 | 135 | 0,0099 | 0,0058 | 100 | 13,0946 | 2384 | 471 | 180 | 0,0099 | 0,015 | 0,75 | 0,0566 |  |
| ORB | 7567 | 4610 | 274 | 217 | 0,0315 | 0,0192 | 100 | 13,0671 | 7567 | 2634 | 274 | 0,0315 | 0,084 | 0,792 | 0,0287 |  |
| ORB1000 | 1000 | 1000 | 65 | 51 | 0,0042 | 0,0042 | 100 | 13,1408 | 1000 | 619 | 65 | 0,0042 | 0,0196 | 0,7846 | 0,051 |  |
| BRISK | 2891 | 1743 | 230 | 198 | 0,012 | 0,0073 | 100 | 13,1579 | 2891 | 967 | 230 | 0,012 | 0,0306 | 0,8609 | 0,0685 |  |
| KAZE | 934 | 595 | 43 | 32 | 0,0039 | 0,0025 | 100 | 13,0237 | 934 | 297 | 43 | 0,0039 | 0,0095 | 0,7442 | 0,0343 |  |
| AKAZE | 813 | 512 | 49 | 35 | 0,0034 | 0,0021 | 100 | 13,1558 | 813 | 295 | 49 | 0,0034 | 0,0093 | 0,7143 | 0,0431 |  |

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 | 1744 | 943 | 0,075503 | 0,057367 | 0,071951 | 0,004497 | 0,052064 | 0,321211 | 0,023543 | 0,209319 |
| SURF128 | 2384 | 1391 | 0,288608 | 0,051679 | 0,029824 | 0,000498 | 0,079106 | 0,182971 | 0,00389 | 0,370609 |
| SURF64 | 2384 | 1391 | 0,065778 | 0,050341 | 0,01607 | 0,000567 | 0,03189 | 0,089279 | 0,004197 | 0,132757 |
| ORB | 7567 | 4610 | 0,019473 | 0,013869 | 0,083415 | 0,001168 | 0,00279 | 0,304434 | 0,005384 | 0,117925 |
| ORB1000 | 1000 | 1000 | 0,010827 | 0,008844 | 0,003503 | 0,000502 | 0,009834 | 0,053899 | 0,009845 | 0,023676 |
| BRISK | 2891 | 1743 | 0,044252 | 0,024857 | 0,014408 | 0,000416 | 0,014783 | 0,062642 | 0,002101 | 0,083933 |
| KAZE | 934 | 595 | 0,135065 | 0,139822 | 0,006835 | 0,00054 | 0,189801 | 0,158957 | 0,016874 | 0,282262 |
| AKAZE | 813 | 512 | 0,02112 | 0,021056 | 0,002337 | 0,000631 | 0,033551 | 0,047689 | 0,018041 | 0,045144 |

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.