**Normalization results for pairs 1\_0.ppm\_1\_3.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_graffiti**

**1\_0.ppm: 1\_3.ppm: **

**Table 1 - Found homography parameters and normalization accuracy assessment**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 95,375 img2: 49,545 | h11 | h12 | h13 | h21 | h22 | h23 | h31 | h32 | h33 | avg ErrPar (param) | avg ErrIM (pixel) | max ErrIM | avg ErrCPM (corner) | max ErrCPM | Expert rate |
| SIFT | 0,659 | 0,682 | -31,086 | -0,15 | 0,972 | 149,836 | 0 | -0 | 1 | 0,194 | 0,961 | 2,692 | 2,945 | 5,542 |  |
| SURF128 | 0,684 | 0,708 | -40,299 | -0,139 | 0,985 | 147,808 | 0 | 0 | 1 | 0,245 | 1,35 | 2,712 | 6,873 | 10,176 |  |
| SURF64 | 0,665 | 0,685 | -32,887 | -0,149 | 0,958 | 154,684 | 0 | -0 | 1 | 0,247 | 1,392 | 2,281 | 7,187 | 10,715 |  |
| ORB | 0,661 | 0,677 | -30,265 | -0,146 | 0,966 | 149,729 | 0 | -0 | 1 | 0,157 | 1,299 | 2,888 | 1,482 | 2,78 |  |
| ORB1000 | 0,721 | 0,91 | -126,552 | -0,172 | 1,056 | 156,544 | 0 | 0 | 1 | 0,795 | 0,904 | 1,56 | 60,835 | 109,154 |  |
| BRISK | 0,658 | 0,675 | -29,782 | -0,151 | 0,967 | 150,506 | 0 | -0 | 1 | 0,212 | 0,974 | 2,207 | 3,848 | 7,451 |  |
| KAZE | 0,645 | 0,652 | -25,751 | -0,159 | 0,936 | 154,61 | 0 | -0 | 1 | 0,411 | 1,138 | 2,496 | 11,266 | 22,956 |  |
| AKAZE | 0,673 | 0,674 | -32,001 | -0,143 | 0,954 | 153,669 | 0 | -0 | 1 | 0,224 | 1,163 | 2,004 | 5,32 | 8,946 |  |
| Original matrix | 0,666 | 0,678 | -31,246 | -0,143 | 0,969 | 148,92 | 0 | -0 | 0,999 |  |  |  |  |  |  |

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 | 2674 | 3668 | 145 | 62 | 0,0052 | 0,0072 | 95,4215 | 49,7658 | 2470 | 1804 | 136 | 0,0051 | 0,0071 | 0,4276 | 0,0251 |  |
| SURF128 | 4796 | 5315 | 89 | 27 | 0,0094 | 0,0104 | 95,4752 | 49,8975 | 4621 | 2951 | 89 | 0,0095 | 0,0116 | 0,3034 | 0,0058 |  |
| SURF64 | 4796 | 5315 | 115 | 26 | 0,0094 | 0,0104 | 95,6553 | 49,5723 | 4630 | 2935 | 114 | 0,0095 | 0,0116 | 0,2261 | 0,0056 |  |
| ORB | 9147 | 13028 | 151 | 68 | 0,0179 | 0,0254 | 95,3779 | 49,5785 | 9016 | 8299 | 150 | 0,0185 | 0,0327 | 0,4503 | 0,0075 |  |
| ORB1000 | 1000 | 1000 | 31 | 9 | 0,002 | 0,002 | 93,3998 | 54,0186 | 981 | 794 | 29 | 0,0021 | 0,0029 | 0,2903 | 0,0092 |  |
| BRISK | 3523 | 5187 | 88 | 50 | 0,0069 | 0,0101 | 95,4553 | 49,785 | 3421 | 3086 | 87 | 0,007 | 0,0121 | 0,5682 | 0,0146 |  |
| KAZE | 2045 | 2151 | 51 | 31 | 0,004 | 0,0042 | 95,3379 | 50,435 | 1939 | 1189 | 51 | 0,004 | 0,0046 | 0,6078 | 0,016 |  |
| AKAZE | 1755 | 1866 | 47 | 15 | 0,0034 | 0,0036 | 95,44 | 49,518 | 1706 | 1165 | 46 | 0,0035 | 0,0046 | 0,3191 | 0,0088 |  |

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 | 2674 | 3668 | 0,580449 | 0,593787 | 0,302877 | 0,004442 | 0,189477 | 2,088804 | 0,071652 | 1,481556 |
| SURF128 | 4796 | 5315 | 0,440945 | 0,438566 | 0,635658 | 0,027523 | 0,087227 | 7,14222 | 1,019373 | 1,542692 |
| SURF64 | 4796 | 5315 | 0,414003 | 0,404043 | 0,288041 | 0,086777 | 0,08117 | 2,504701 | 3,337584 | 1,192864 |
| ORB | 9147 | 13028 | 0,042463 | 0,051388 | 0,864272 | 0,004078 | 0,004293 | 5,723656 | 0,059974 | 0,962201 |
| ORB1000 | 1000 | 1000 | 0,032556 | 0,053343 | 0,00852 | 0,020904 | 0,042949 | 0,274828 | 2,32266 | 0,115323 |
| BRISK | 3523 | 5187 | 0,111174 | 0,139431 | 0,178816 | 0,001445 | 0,029218 | 2,032 | 0,028904 | 0,430867 |
| KAZE | 2045 | 2151 | 0,822977 | 0,767293 | 0,148357 | 0,001152 | 0,379573 | 2,908963 | 0,037161 | 1,739778 |
| AKAZE | 1755 | 1866 | 0,139268 | 0,179032 | 0,034495 | 0,013964 | 0,087649 | 0,733932 | 0,930907 | 0,366759 |

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.