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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 62,422 img2: 85,033 | 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 | 1,436 | -0,008 | -258,377 | 0,194 | 1,3 | -196,085 | 0,001 | 0 | 1 | 0,18 | 0,448 | 3,731 | 0,386 | 0,474 |  |
| SURF128 | 1,437 | -0,008 | -258,316 | 0,193 | 1,306 | -197,167 | 0,001 | 0 | 1 | 0,342 | 0,748 | 3,563 | 2,086 | 4,073 |  |
| SURF64 | 1,431 | -0,009 | -256,763 | 0,194 | 1,299 | -196,166 | 0,001 | 0 | 1 | 0,249 | 0,845 | 4,463 | 1,111 | 1,612 |  |
| ORB | 1,435 | -0,009 | -257,791 | 0,194 | 1,3 | -196,564 | 0,001 | 0 | 1 | 0,169 | 0,916 | 3,825 | 0,508 | 0,889 |  |
| ORB1000 | 1,45 | -0,005 | -263,57 | 0,199 | 1,314 | -201,106 | 0,001 | 0 | 1 | 0,862 | 0,861 | 2,895 | 2,289 | 4,336 |  |
| BRISK | 1,432 | -0,009 | -256,948 | 0,193 | 1,299 | -195,872 | 0,001 | 0 | 1 | 0,254 | 0,793 | 3,809 | 1,222 | 2,117 |  |
| KAZE | 1,436 | -0,01 | -257,871 | 0,195 | 1,301 | -196,803 | 0,001 | 0 | 1 | 0,171 | 0,662 | 3,941 | 0,53 | 0,856 |  |
| AKAZE | 1,434 | -0,009 | -257,543 | 0,194 | 1,3 | -196,095 | 0,001 | 0 | 1 | 0,219 | 0,574 | 4,34 | 0,736 | 1,068 |  |
| Original matrix | 1,435 | -0,009 | -257,96 | 0,195 | 1,299 | -196,36 | 0,001 | 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 | 11196 | 6476 | 3716 | 2915 | 0,0111 | 0,0101 | 62,4257 | 85,05 | 8768 | 6299 | 3651 | 0,014 | 0,0115 | 0,7844 | 0,3325 |  |
| SURF128 | 16204 | 10218 | 2930 | 2015 | 0,0161 | 0,0159 | 62,462 | 84,9436 | 13288 | 9670 | 2893 | 0,0212 | 0,0177 | 0,6877 | 0,1516 |  |
| SURF64 | 16204 | 10218 | 3729 | 3109 | 0,0161 | 0,0159 | 62,4496 | 85,077 | 13294 | 9677 | 3677 | 0,0212 | 0,0177 | 0,8337 | 0,2339 |  |
| ORB | 64719 | 40707 | 12279 | 11434 | 0,0644 | 0,0632 | 62,4326 | 85,0548 | 56839 | 39955 | 12235 | 0,0906 | 0,073 | 0,9312 | 0,2012 |  |
| ORB1000 | 1000 | 1000 | 325 | 240 | 0,001 | 0,0016 | 62,2077 | 84,9018 | 929 | 1000 | 325 | 0,0015 | 0,0018 | 0,7385 | 0,2583 |  |
| BRISK | 27371 | 17492 | 4502 | 3880 | 0,0272 | 0,0272 | 62,4441 | 85,1099 | 23652 | 17190 | 4474 | 0,0377 | 0,0314 | 0,8618 | 0,164 |  |
| KAZE | 6700 | 3965 | 2288 | 2043 | 0,0067 | 0,0062 | 62,4172 | 85,0363 | 5287 | 3937 | 2276 | 0,0084 | 0,0072 | 0,8929 | 0,3864 |  |
| AKAZE | 7407 | 4236 | 1887 | 1505 | 0,0074 | 0,0066 | 62,4445 | 85,029 | 6242 | 4208 | 1874 | 0,0099 | 0,0077 | 0,7976 | 0,2411 |  |

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 | 11196 | 6476 | 0,384967 | 0,17258 | 0,821162 | 0,00255 | 0,030516 | 0,22098 | 0,000874 | 1,381259 |
| SURF128 | 16204 | 10218 | 0,971105 | 0,699973 | 3,006874 | 0,002417 | 0,064216 | 1,026237 | 0,001199 | 4,68037 |
| SURF64 | 16204 | 10218 | 0,616599 | 0,350412 | 0,991037 | 0,002672 | 0,036172 | 0,265764 | 0,000859 | 1,96072 |
| ORB | 64719 | 40707 | 0,138229 | 0,086541 | 8,336638 | 0,006956 | 0,00213 | 0,678934 | 0,000608 | 8,568364 |
| ORB1000 | 1000 | 1000 | 0,043092 | 0,027944 | 0,00408 | 0,000714 | 0,035517 | 0,012552 | 0,002975 | 0,075829 |
| BRISK | 27371 | 17492 | 0,478136 | 0,291568 | 1,753238 | 0,002834 | 0,017068 | 0,389435 | 0,00073 | 2,525777 |
| KAZE | 6700 | 3965 | 0,651079 | 0,420156 | 0,289401 | 0,001488 | 0,10157 | 0,126486 | 0,000728 | 1,362123 |
| AKAZE | 7407 | 4236 | 0,136373 | 0,094422 | 0,15229 | 0,00123 | 0,02035 | 0,080704 | 0,000817 | 0,384315 |

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.