**Normalization results for pairs 1\_0.ppm\_1\_4.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_cartooncity**

**1\_0.ppm: 1\_4.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 88,609 img2: 57,585 | 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 | 1,535 | 0,025 | 248,828 | 0,313 | 1,494 | -227,722 | 0,001 | 0 | 1 | 0,614 | 0,789 | 3,113 | 7,996 | 11,839 |  |
| SURF128 | 1,526 | 0,019 | 250,098 | 0,311 | 1,484 | -225,83 | 0,001 | 0 | 1 | 0,512 | 1,251 | 3,04 | 12,693 | 24,452 |  |
| SURF64 | 1,534 | 0,024 | 249,159 | 0,31 | 1,495 | -227,934 | 0,001 | 0 | 1 | 0,583 | 1,305 | 3,492 | 6,946 | 11,54 |  |
| ORB | 1,542 | 0,024 | 248,771 | 0,317 | 1,493 | -228,09 | 0,001 | 0 | 1 | 0,657 | 1,041 | 3,378 | 11,018 | 18,109 |  |
| ORB1000 | 1,496 | -0,002 | 255,839 | 0,302 | 1,44 | -215,291 | 0,001 | 0 | 1 | 0,526 | 1,074 | 1,807 | 13,894 | 30,849 |  |
| BRISK | 1,533 | 0,023 | 249,006 | 0,311 | 1,49 | -226,92 | 0,001 | 0 | 1 | 0,561 | 0,868 | 4,214 | 8,77 | 12,893 |  |
| KAZE | 1,528 | 0,023 | 249,464 | 0,312 | 1,489 | -226,723 | 0,001 | 0 | 1 | 0,54 | 1,083 | 2,866 | 10,126 | 17,791 |  |
| AKAZE | 1,539 | 0,023 | 249,053 | 0,315 | 1,493 | -227,308 | 0,001 | 0 | 1 | 0,622 | 0,907 | 2,46 | 15,065 | 25,66 |  |
| Original matrix | 1,485 | 0,02 | 254,94 | 0,298 | 1,475 | -221,33 | 0,001 | 0 | 1,002 |  |  |  |  |  |  |

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 | 5614 | 726 | 476 | 0,0111 | 0,0087 | 88,6842 | 57,7051 | 10247 | 4473 | 696 | 0,0115 | 0,012 | 0,6556 | 0,0465 |  |
| SURF128 | 16204 | 8607 | 341 | 227 | 0,0161 | 0,0134 | 88,6306 | 57,5352 | 15124 | 6843 | 331 | 0,017 | 0,0185 | 0,6657 | 0,015 |  |
| SURF64 | 16204 | 8607 | 460 | 314 | 0,0161 | 0,0134 | 88,611 | 57,7427 | 15118 | 6871 | 445 | 0,017 | 0,0185 | 0,6826 | 0,0208 |  |
| ORB | 64719 | 35861 | 791 | 503 | 0,0644 | 0,0557 | 88,7304 | 57,6466 | 62808 | 31295 | 786 | 0,0704 | 0,0843 | 0,6359 | 0,008 |  |
| ORB1000 | 1000 | 1000 | 32 | 15 | 0,001 | 0,0016 | 88,7596 | 57,4782 | 990 | 946 | 32 | 0,0011 | 0,0026 | 0,4688 | 0,0152 |  |
| BRISK | 27371 | 15585 | 453 | 364 | 0,0272 | 0,0242 | 88,6758 | 57,6784 | 26268 | 13699 | 452 | 0,0295 | 0,0369 | 0,8035 | 0,0139 |  |
| KAZE | 6700 | 3869 | 315 | 250 | 0,0067 | 0,006 | 88,6573 | 57,6091 | 6129 | 3317 | 314 | 0,0069 | 0,0089 | 0,7937 | 0,0408 |  |
| AKAZE | 7407 | 4182 | 206 | 136 | 0,0074 | 0,0065 | 88,735 | 57,4518 | 7041 | 3592 | 200 | 0,0079 | 0,0097 | 0,6602 | 0,0193 |  |

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 | 5614 | 0,305903 | 0,167972 | 0,707804 | 0,001151 | 0,028621 | 0,974936 | 0,002417 | 1,182828 |
| SURF128 | 16204 | 8607 | 0,553991 | 0,300877 | 1,619455 | 0,00101 | 0,034572 | 4,749135 | 0,004449 | 2,475333 |
| SURF64 | 16204 | 8607 | 0,504285 | 0,288975 | 0,750785 | 0,001051 | 0,032347 | 1,632142 | 0,003347 | 1,545097 |
| ORB | 64719 | 35861 | 0,133001 | 0,074985 | 6,618062 | 0,001514 | 0,002072 | 8,366702 | 0,00301 | 6,827562 |
| ORB1000 | 1000 | 1000 | 0,040047 | 0,025457 | 0,003799 | 0,002829 | 0,032751 | 0,11873 | 0,18862 | 0,072133 |
| BRISK | 27371 | 15585 | 0,44392 | 0,239993 | 1,197594 | 0,000892 | 0,015808 | 2,643695 | 0,00245 | 1,882399 |
| KAZE | 6700 | 3869 | 0,596356 | 0,374384 | 0,229788 | 0,00058 | 0,092886 | 0,729485 | 0,002318 | 1,201107 |
| AKAZE | 7407 | 4182 | 0,116455 | 0,071154 | 0,104317 | 0,000914 | 0,016368 | 0,506394 | 0,006721 | 0,29284 |

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.