**Normalization results for pairs 1\_0.ppm\_1\_5.ppm from subset HPatches\_mikolajczyk\_set10\_Pairs50\v\_cartooncity**

**1\_0.ppm: 1\_5.ppm: **

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 90,911 img2: 59,579 | 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 | 0,029 | 0,014 | 198,084 | -0,162 | 0,446 | 114,707 | -0,001 | 0 | 1 | 0,314 | 0,653 | 3,93 | 5,729 | 15,619 |  |
| SURF128 | 0,026 | 0,009 | 201,074 | -0,162 | 0,441 | 114,672 | -0,001 | -0 | 1 | 0,389 | 1,057 | 3,077 | 12,896 | 22,088 |  |
| SURF64 | 0,026 | 0,01 | 201,032 | -0,162 | 0,44 | 115,807 | -0,001 | -0 | 1 | 0,439 | 1,015 | 4,418 | 12,561 | 22,456 |  |
| ORB | 0,031 | 0,016 | 196,049 | -0,163 | 0,447 | 115,129 | -0,001 | 0 | 1 | 0,392 | 1,066 | 4,048 | 6,773 | 13,316 |  |
| ORB1000 | 0,038 | 0,006 | 194,35 | -0,158 | 0,447 | 110,806 | -0,001 | -0 | 1 | 0,553 | 1,021 | 2,726 | 19,664 | 42,426 |  |
| BRISK | 0,029 | 0,012 | 199,381 | -0,162 | 0,445 | 114,805 | -0,001 | 0 | 1 | 0,288 | 0,956 | 3,637 | 7,94 | 15,231 |  |
| KAZE | 0,027 | 0,013 | 199,334 | -0,162 | 0,443 | 115,251 | -0,001 | 0 | 1 | 0,386 | 0,865 | 4,068 | 9,646 | 20,773 |  |
| AKAZE | 0,03 | 0,013 | 197,639 | -0,161 | 0,446 | 113,52 | -0,001 | 0 | 1 | 0,259 | 0,786 | 3,49 | 4,495 | 9,232 |  |
| Original matrix | 0,033 | 0,011 | 198,34 | -0,161 | 0,447 | 114,31 | -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 | 6069 | 1049 | 739 | 0,0111 | 0,0094 | 90,8483 | 59,7719 | 10148 | 4719 | 1013 | 0,0111 | 0,0123 | 0,7045 | 0,0728 |  |
| SURF128 | 16204 | 8374 | 426 | 269 | 0,0161 | 0,013 | 90,7639 | 59,7918 | 15343 | 6610 | 412 | 0,0168 | 0,0172 | 0,6315 | 0,0175 |  |
| SURF64 | 16204 | 8374 | 649 | 391 | 0,0161 | 0,013 | 90,8597 | 59,6942 | 15349 | 6605 | 643 | 0,0168 | 0,0172 | 0,6025 | 0,0255 |  |
| ORB | 64719 | 35933 | 1326 | 962 | 0,0644 | 0,0558 | 90,8495 | 59,9819 | 61594 | 31091 | 1311 | 0,0674 | 0,0805 | 0,7255 | 0,0156 |  |
| ORB1000 | 1000 | 1000 | 24 | 17 | 0,001 | 0,0016 | 90,68 | 60,2249 | 989 | 993 | 24 | 0,0011 | 0,0026 | 0,7083 | 0,0172 |  |
| BRISK | 27371 | 14922 | 689 | 532 | 0,0272 | 0,0232 | 90,8143 | 59,6838 | 25681 | 13032 | 683 | 0,0281 | 0,0339 | 0,7721 | 0,0207 |  |
| KAZE | 6700 | 3371 | 457 | 384 | 0,0067 | 0,0052 | 90,8503 | 59,7601 | 6181 | 2863 | 453 | 0,0068 | 0,0074 | 0,8403 | 0,0621 |  |
| AKAZE | 7407 | 3759 | 384 | 306 | 0,0074 | 0,0058 | 90,8089 | 59,8383 | 6983 | 3306 | 379 | 0,0076 | 0,0086 | 0,7969 | 0,0438 |  |

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 | 6069 | 0,254816 | 0,162997 | 0,599083 | 0,001068 | 0,024808 | 0,571098 | 0,001445 | 1,017964 |
| SURF128 | 16204 | 8374 | 0,491169 | 0,254442 | 1,195405 | 0,001127 | 0,030347 | 2,806115 | 0,004188 | 1,942143 |
| SURF64 | 16204 | 8374 | 0,506341 | 0,234539 | 0,675351 | 0,001374 | 0,029627 | 1,040601 | 0,003512 | 1,417604 |
| ORB | 64719 | 35933 | 0,134565 | 0,074528 | 5,053672 | 0,001104 | 0,002076 | 3,811215 | 0,001147 | 5,263868 |
| ORB1000 | 1000 | 1000 | 0,040084 | 0,024414 | 0,003257 | 0,000746 | 0,032249 | 0,135722 | 0,043911 | 0,068503 |
| BRISK | 27371 | 14922 | 0,443384 | 0,221251 | 0,968348 | 0,000758 | 0,015513 | 1,40544 | 0,001425 | 1,633741 |
| KAZE | 6700 | 3371 | 0,578863 | 0,336604 | 0,208657 | 0,000566 | 0,093124 | 0,456579 | 0,001473 | 1,12469 |
| AKAZE | 7407 | 3759 | 0,127314 | 0,073219 | 0,083325 | 0,000855 | 0,018333 | 0,216991 | 0,002793 | 0,284712 |

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.