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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 100 img2: 23,466 | 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 | 0,388 | 0,285 | 169,711 | -0,286 | 0,393 | 340,287 | -0 | 0 | 1 | 0,103 | 0,422 | 2,666 | 0,67 | 1,574 |  |
| SURF128 | 0,388 | 0,284 | 169,81 | -0,286 | 0,393 | 339,987 | -0 | 0 | 1 | 0,102 | 0,923 | 3,128 | 0,908 | 1,716 |  |
| SURF64 | 0,391 | 0,28 | 169,866 | -0,284 | 0,39 | 340,179 | -0 | -0 | 1 | 0,267 | 1,059 | 4,102 | 1,722 | 3,252 |  |
| ORB | 0,39 | 0,284 | 169,568 | -0,284 | 0,392 | 340,174 | -0 | 0 | 1 | 0,129 | 0,826 | 3,446 | 1,012 | 1,826 |  |
| ORB1000 | 0,383 | 0,289 | 169,94 | -0,29 | 0,399 | 339,645 | -0 | 0 | 1 | 0,546 | 0,814 | 2,283 | 3,51 | 7,296 |  |
| BRISK | 0,39 | 0,286 | 169,173 | -0,285 | 0,393 | 339,9 | -0 | 0 | 1 | 0,096 | 0,784 | 3,661 | 0,494 | 0,809 |  |
| KAZE | 0,391 | 0,284 | 169,216 | -0,284 | 0,393 | 339,911 | -0 | 0 | 1 | 0,146 | 0,937 | 2,933 | 0,78 | 1,109 |  |
| AKAZE | 0,391 | 0,289 | 168,352 | -0,286 | 0,397 | 340,17 | -0 | 0 | 1 | 0,257 | 0,632 | 3,083 | 1,095 | 2,388 |  |
| Original matrix | 0,389 | 0,285 | 169,51 | -0,285 | 0,393 | 340,1 | -0 | 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 | 10261 | 7040 | 1013 | 838 | 0,0178 | 0,0122 | 100 | 23,4875 | 10261 | 2251 | 1013 | 0,0178 | 0,0166 | 0,8272 | 0,0817 |  |
| SURF128 | 6299 | 5170 | 282 | 227 | 0,0109 | 0,0089 | 100 | 23,4846 | 6299 | 1577 | 282 | 0,0109 | 0,0116 | 0,805 | 0,036 |  |
| SURF64 | 6299 | 5170 | 436 | 337 | 0,0109 | 0,0089 | 100 | 23,4891 | 6299 | 1579 | 436 | 0,0109 | 0,0116 | 0,7729 | 0,0535 |  |
| ORB | 37625 | 29914 | 3909 | 3528 | 0,0651 | 0,0518 | 100 | 23,4654 | 37625 | 10669 | 3909 | 0,0651 | 0,0787 | 0,9025 | 0,0938 |  |
| ORB1000 | 1000 | 1000 | 80 | 61 | 0,0017 | 0,0017 | 100 | 23,5901 | 1000 | 278 | 80 | 0,0017 | 0,002 | 0,7625 | 0,061 |  |
| BRISK | 14959 | 11051 | 1347 | 1277 | 0,0259 | 0,0191 | 100 | 23,4908 | 14959 | 3924 | 1347 | 0,0259 | 0,0289 | 0,948 | 0,0854 |  |
| KAZE | 2922 | 2096 | 233 | 208 | 0,0051 | 0,0036 | 100 | 23,4929 | 2922 | 767 | 233 | 0,0051 | 0,0056 | 0,8927 | 0,0712 |  |
| AKAZE | 3255 | 2262 | 308 | 256 | 0,0056 | 0,0039 | 100 | 23,5194 | 3255 | 907 | 308 | 0,0056 | 0,0067 | 0,8312 | 0,0786 |  |

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 | 10261 | 7040 | 0,218011 | 0,294251 | 1,4467 | 0,000763 | 0,031521 | 1,428134 | 0,00091 | 1,959726 |
| SURF128 | 6299 | 5170 | 0,277005 | 0,227115 | 0,434912 | 0,000574 | 0,043952 | 1,542239 | 0,002529 | 0,939605 |
| SURF64 | 6299 | 5170 | 0,300776 | 0,284538 | 0,246975 | 0,000663 | 0,051392 | 0,566456 | 0,001967 | 0,832952 |
| ORB | 37625 | 29914 | 0,081426 | 0,072491 | 4,00751 | 0,002971 | 0,002293 | 1,0252 | 0,000842 | 4,164398 |
| ORB1000 | 1000 | 1000 | 0,026184 | 0,023546 | 0,003617 | 0,000646 | 0,024865 | 0,045218 | 0,010592 | 0,053994 |
| BRISK | 14959 | 11051 | 0,250088 | 0,169579 | 0,614197 | 0,000955 | 0,016031 | 0,455974 | 0,000747 | 1,034819 |
| KAZE | 2922 | 2096 | 0,431717 | 0,411493 | 0,063242 | 0,000392 | 0,172034 | 0,271423 | 0,001883 | 0,906843 |
| AKAZE | 3255 | 2262 | 0,078319 | 0,085941 | 0,042737 | 0,000546 | 0,031027 | 0,138755 | 0,002132 | 0,207542 |

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.