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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 98,073 img2: 61,837 | 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 | 0,516 | 0,019 | 40,567 | -0,146 | 0,749 | 100,695 | -0 | 0 | 1 | 0,504 | 0,753 | 3,402 | 0,458 | 0,993 |  |
| SURF128 | 0,52 | 0,02 | 38,551 | -0,145 | 0,751 | 99,952 | -0 | 0 | 1 | 0,674 | 0,967 | 4,155 | 2,038 | 4,275 |  |
| SURF64 | 0,518 | 0,019 | 39,912 | -0,145 | 0,749 | 100,041 | -0 | 0 | 1 | 0,609 | 1,016 | 4,13 | 0,974 | 1,877 |  |
| ORB | 0,52 | 0,021 | 39,046 | -0,145 | 0,752 | 99,787 | -0 | 0 | 1 | 0,69 | 0,968 | 3,734 | 1,612 | 3,497 |  |
| ORB1000 | 0,519 | 0,018 | 39,698 | -0,146 | 0,749 | 100,53 | -0 | 0 | 1 | 0,629 | 0,956 | 3,191 | 2,198 | 3,762 |  |
| BRISK | 0,517 | 0,02 | 40,027 | -0,146 | 0,749 | 100,619 | -0 | 0 | 1 | 0,578 | 0,849 | 4,061 | 0,662 | 1,239 |  |
| KAZE | 0,517 | 0,018 | 40,16 | -0,146 | 0,748 | 100,552 | -0 | 0 | 1 | 0,605 | 0,876 | 3,327 | 1,121 | 2,074 |  |
| AKAZE | 0,52 | 0,02 | 39,135 | -0,145 | 0,752 | 99,311 | -0 | 0 | 1 | 0,656 | 0,736 | 3,014 | 1,867 | 3,728 |  |
| Original matrix | 0,521 | 0,019 | 41,006 | -0,148 | 0,755 | 101,84 | -0 | 0 | 1,009 |  |  |  |  |  |  |

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 | 13974 | 11216 | 4088 | 3970 | 0,0147 | 0,0118 | 98,0528 | 61,9117 | 13638 | 9223 | 4087 | 0,0146 | 0,0157 | 0,9711 | 0,2911 |  |
| SURF128 | 14804 | 11343 | 2028 | 1669 | 0,0156 | 0,0119 | 98,0652 | 61,9901 | 14628 | 8553 | 2028 | 0,0157 | 0,0145 | 0,823 | 0,1141 |  |
| SURF64 | 14804 | 11343 | 2951 | 2535 | 0,0156 | 0,0119 | 98,0776 | 61,9279 | 14629 | 8550 | 2951 | 0,0157 | 0,0145 | 0,859 | 0,1733 |  |
| ORB | 64986 | 44613 | 10693 | 9509 | 0,0683 | 0,0469 | 98,0583 | 61,9378 | 64645 | 38676 | 10693 | 0,0693 | 0,0656 | 0,8893 | 0,1471 |  |
| ORB1000 | 1000 | 1000 | 193 | 175 | 0,0011 | 0,0011 | 98,0803 | 61,9042 | 1000 | 902 | 193 | 0,0011 | 0,0015 | 0,9067 | 0,175 |  |
| BRISK | 27221 | 14761 | 3775 | 3391 | 0,0286 | 0,0155 | 98,0514 | 61,9122 | 26914 | 12885 | 3775 | 0,0288 | 0,0219 | 0,8983 | 0,126 |  |
| KAZE | 4180 | 2423 | 1105 | 1014 | 0,0044 | 0,0025 | 98,0631 | 61,9755 | 4090 | 1983 | 1105 | 0,0044 | 0,0034 | 0,9176 | 0,2479 |  |
| AKAZE | 5089 | 2761 | 854 | 725 | 0,0053 | 0,0029 | 98,0546 | 61,9993 | 5052 | 2321 | 854 | 0,0054 | 0,0039 | 0,8489 | 0,1435 |  |

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 | 13974 | 11216 | 0,345249 | 0,288604 | 2,078044 | 0,003206 | 0,025218 | 0,508327 | 0,000807 | 2,715103 |
| SURF128 | 14804 | 11343 | 0,567218 | 0,543639 | 2,208045 | 0,00117 | 0,043121 | 1,088779 | 0,000701 | 3,320072 |
| SURF64 | 14804 | 11343 | 0,587397 | 0,521073 | 1,138498 | 0,001578 | 0,042807 | 0,3858 | 0,000622 | 2,248546 |
| ORB | 64986 | 44613 | 0,148367 | 0,100897 | 9,896901 | 0,007263 | 0,002272 | 0,925549 | 0,000763 | 10,153429 |
| ORB1000 | 1000 | 1000 | 0,040188 | 0,034597 | 0,003857 | 0,000392 | 0,037391 | 0,019984 | 0,002239 | 0,079034 |
| BRISK | 27221 | 14761 | 0,466911 | 0,228451 | 1,280321 | 0,002376 | 0,016314 | 0,339157 | 0,0007 | 1,978059 |
| KAZE | 4180 | 2423 | 0,592301 | 0,553442 | 0,113652 | 0,000719 | 0,185054 | 0,102852 | 0,000708 | 1,260114 |
| AKAZE | 5089 | 2761 | 0,116008 | 0,103347 | 0,057899 | 0,000636 | 0,030113 | 0,067797 | 0,000876 | 0,27789 |

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.