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

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

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 79,654 img2: 67,371 | 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 | 0,186 | 0,032 | 172,098 | -0,086 | 0,482 | 115,159 | -0 | 0 | 1 | 0,48 | 0,606 | 3,609 | 4,075 | 8,217 |  |
| SURF128 | 0,19 | 0,033 | 168,811 | -0,085 | 0,485 | 113,754 | -0 | 0 | 1 | 0,817 | 0,882 | 3,458 | 11,122 | 21,25 |  |
| SURF64 | 0,185 | 0,03 | 172,658 | -0,086 | 0,48 | 115,072 | -0 | 0 | 1 | 0,332 | 0,944 | 4,55 | 3,001 | 6,206 |  |
| ORB | 0,19 | 0,032 | 168,664 | -0,086 | 0,485 | 114,282 | -0 | 0 | 1 | 0,784 | 0,871 | 3,837 | 12,175 | 21,559 |  |
| ORB1000 | 0,183 | 0,026 | 174,213 | -0,086 | 0,478 | 115,424 | -0 | 0 | 1 | 0,393 | 0,906 | 2,666 | 4,474 | 7,661 |  |
| BRISK | 0,188 | 0,032 | 170,317 | -0,086 | 0,483 | 114,473 | -0 | 0 | 1 | 0,63 | 0,8 | 3,757 | 7,88 | 15,303 |  |
| KAZE | 0,187 | 0,032 | 170,747 | -0,086 | 0,483 | 114,599 | -0 | 0 | 1 | 0,592 | 0,825 | 3,113 | 7,524 | 13,621 |  |
| AKAZE | 0,19 | 0,033 | 168,806 | -0,086 | 0,485 | 114,415 | -0 | 0 | 1 | 0,768 | 0,733 | 3,416 | 11,769 | 20,989 |  |
| Original matrix | 0,183 | 0,029 | 174,4 | -0,087 | 0,48 | 116,36 | -0 | 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 | 17804 | 6767 | 3057 | 2715 | 0,0128 | 0,0105 | 79,6996 | 67,4337 | 13164 | 5844 | 3038 | 0,0119 | 0,0135 | 0,8881 | 0,2062 |  |
| SURF128 | 18208 | 7976 | 1657 | 1410 | 0,0131 | 0,0124 | 79,7009 | 67,7406 | 14779 | 6340 | 1655 | 0,0134 | 0,0145 | 0,8509 | 0,0954 |  |
| SURF64 | 18208 | 7976 | 2240 | 1879 | 0,0131 | 0,0124 | 79,6311 | 67,4886 | 14769 | 6316 | 2234 | 0,0134 | 0,0145 | 0,8388 | 0,1272 |  |
| ORB | 63449 | 24846 | 6424 | 5925 | 0,0457 | 0,0386 | 79,6836 | 67,8089 | 49400 | 22522 | 6388 | 0,0446 | 0,0516 | 0,9223 | 0,1199 |  |
| ORB1000 | 1000 | 1000 | 185 | 143 | 0,0007 | 0,0016 | 79,4963 | 67,5939 | 898 | 729 | 185 | 0,0008 | 0,0017 | 0,773 | 0,1592 |  |
| BRISK | 18557 | 7795 | 2073 | 1932 | 0,0134 | 0,0121 | 79,6959 | 67,6217 | 14404 | 6863 | 2065 | 0,013 | 0,0158 | 0,932 | 0,1341 |  |
| KAZE | 4397 | 2014 | 757 | 684 | 0,0032 | 0,0031 | 79,6965 | 67,6045 | 3522 | 1516 | 756 | 0,0032 | 0,0035 | 0,9036 | 0,1942 |  |
| AKAZE | 4765 | 1898 | 671 | 595 | 0,0034 | 0,0029 | 79,7058 | 67,7752 | 3804 | 1617 | 669 | 0,0034 | 0,0037 | 0,8867 | 0,1564 |  |

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 | 17804 | 6767 | 0,451107 | 0,191207 | 1,560432 | 0,001963 | 0,026796 | 0,510445 | 0,000722 | 2,204708 |
| SURF128 | 18208 | 7976 | 1,179484 | 0,537617 | 1,86951 | 0,001186 | 0,066091 | 1,128249 | 0,000841 | 3,587797 |
| SURF64 | 18208 | 7976 | 0,795069 | 0,344233 | 1,118984 | 0,001447 | 0,043411 | 0,499546 | 0,00077 | 2,259733 |
| ORB | 63449 | 24846 | 0,15268 | 0,059619 | 5,531162 | 0,00425 | 0,002402 | 0,861015 | 0,000717 | 5,747712 |
| ORB1000 | 1000 | 1000 | 0,048353 | 0,02263 | 0,003899 | 0,000538 | 0,035491 | 0,021074 | 0,003759 | 0,07542 |
| BRISK | 18557 | 7795 | 0,296519 | 0,119588 | 0,493854 | 0,001366 | 0,015659 | 0,238231 | 0,000706 | 0,911327 |
| KAZE | 4397 | 2014 | 0,798965 | 0,368418 | 0,100042 | 0,000604 | 0,182317 | 0,132155 | 0,000883 | 1,268029 |
| AKAZE | 4765 | 1898 | 0,158274 | 0,071592 | 0,036955 | 0,00067 | 0,035467 | 0,055074 | 0,001125 | 0,267491 |

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.