

## ORB (Oriented FAST and Rotated BRIEF)

### Goal

In this chapter,

- We will see the basics of ORB

### Theory

As an OpenCV enthusiast, the most important thing about the ORB is that it came from "OpenCV Labs". This algorithm was brought up by Ethan Rublee, Vincent Rabaud, Kurt Konolige and Gary R. Bradski in their paper **ORB: An efficient alternative to SIFT or SURF** in 2011. As the title says, it is a good alternative to SIFT and SURF in computation cost, matching performance and mainly the patents. Yes, SIFT and SURF are patented and you are supposed to pay them for its use. But ORB is not !!!

ORB is basically a fusion of FAST keypoint detector and BRIEF descriptor with many modifications to enhance the performance. First it use FAST to find keypoints, then apply Harris corner measure to find top N points among them. It also use pyramid to produce multiscale-features. But one problem is that, FAST doesn't compute the orientation. So what about rotation invariance? Authors came up with following modification.

It computes the intensity weighted centroid of the patch with located corner at center. The direction of the vector from this corner point to centroid gives the orientation. To improve the rotation invariance, moments are computed with x and y which should be in a circular region of radius  $r$ , where  $r$  is the size of the patch.

Now for descriptors, ORB use BRIEF descriptors. But we have already seen that BRIEF performs poorly with rotation. So what ORB does is to "steer" BRIEF according to the orientation of keypoints. For any feature set of  $n$  binary tests at location  $(x_i, y_i)$ , define a  $2 \times n$  matrix,  $S$  which contains the coordinates of these pixels. Then using the orientation of patch,  $\theta$ , its rotation matrix is found and rotates the  $S$  to get steered(rotated) version  $S_\theta$ .

ORB discretize the angle to increments of  $2\pi/30$  (12 degrees), and construct a lookup table of precomputed BRIEF patterns. As long as the keypoint orientation  $\theta$  is consistent across views, the correct set of points  $S_\theta$  will be used to compute its descriptor.

BRIEF has an important property that each bit feature has a large variance and a mean near 0.5. But once it is oriented along keypoint direction, it loses this property and become more distributed. High variance makes a feature more discriminative, since it responds differentially to inputs. Another desirable property is to have the tests uncorrelated, since then each test will contribute to the result. To resolve all these, ORB runs a greedy search among all possible binary tests to find the ones that have both high variance and means close to 0.5, as well as being uncorrelated. The result is called **rBRIEF**.