

CSDD Features: Center-Surround Distribution Distance for Feature Extraction and Matching

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Introduction

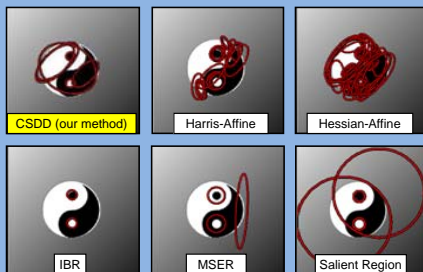
A new interest region operator and feature descriptor called Center-Surround Distribution Distance (CSDD) is based on comparing feature distributions between a central foreground region and a surrounding ring of background pixels. In addition to finding light/dark blobs surrounded by a dark(light) background, CSDD also detects blobs with arbitrary color distribution that "stand out" perceptually because they look different from the background. CSDD detection repeatability is evaluated and compared with other state-of-the-art approaches using a standard dataset, while use of CSDD features for image registration is demonstrated using a RANSAC procedure for affine image matching.



Sample regions extracted as local maxima of the CSDD interest operator at one scale level. Left: Original image. Middle: CSDD interest score for each pixel. Overlaid are the 30 most dominant peaks at this scale. Right: Corresponding interest regions.

Motivation

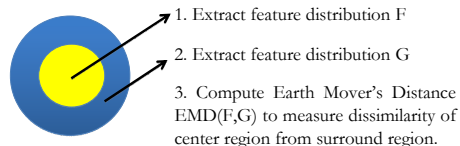
Our work is motivated by the goal of finding larger interest regions that are more complex in appearance and more discriminative than those found by current interest operators.



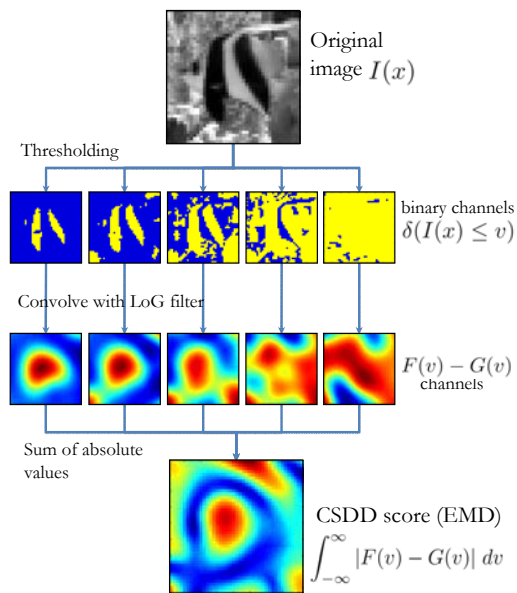
Example: Yin-yang symbol superimposed on an intensity gradient. Of the six interest region detectors compared, only the CSDD detector captures the natural location and scale of the symbol.

Computing CSDD Scores

Intuition: consider a center-surround region of a given scale, centered at a given pixel



How to do this efficiently for all pixels?



Implementation Details

- This method of EMD computation only works for 1D distributions. For n-D distributions, we concatenate the n 1D marginals to get a 1D distribution.
- Fast LoG filtering at every scale is performed using a fourth-order IIR filter (aka Deriche-filtering).
- We form a scale space of CSDD score images indexed by the scale of the LoG filter. CSDD features are then found as extrema in both scale and space.

Experimental Results

We have evaluated CSDD performance with respect to detection repeatability and matching utility. Details of the experiments and a complete set of results can be found on our website:

<http://vision.cse.psu.edu/projects/csdd/csdd.html>

• Matching Results

Circular CSDD features were used within a RANSAC procedure to find correspondences for 6-parameter affine image registration.



Row 1: four frames from a parking lot video sequence, showing affine alignment of bottom frame overlaid on top frame.

Row 2: left to right: shout3 to shout4; shout2 to was2 (images courtesy of Tinne Tuytelaars); stop sign; snowy stop sign.

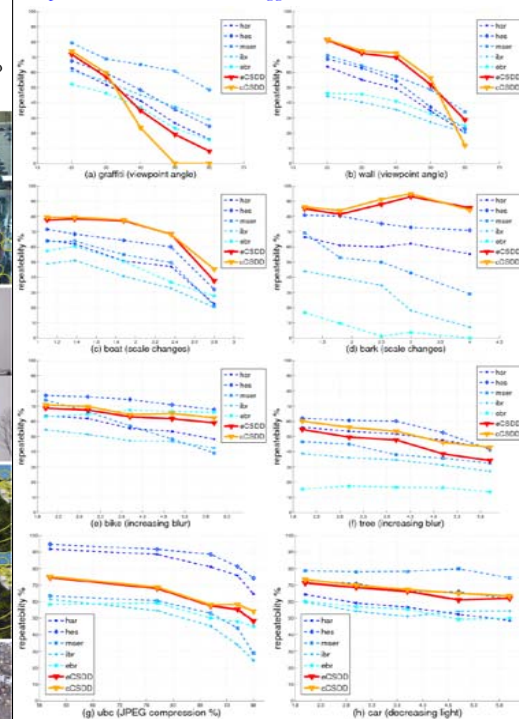
Row 3: kampa1 to kampa4 (images courtesy of Jiri Matas); bike1 to bike6; trees1 to trees5; ubc1 to ubc6.

Row 4: natural textures: asphalt; grass; gravel; stones.

• Detection Results

We compared repeatability scores between the circular cCSDD detector, an elliptical eCSDD detector, and five other state-of-the-art detectors (Harris- and Hessian-affine, MSER, edge-based (EBR), and intensity extrema-based (IBR)) for the eight image sequences from the standard affine covariant region detector evaluation dataset, available at

<http://www.robots.ox.ac.uk/~vgg/research/affine/>



Conclusions

- The new CSDD feature detector outperforms current state-of-the-art detectors on 3 out of 8 standard testsets used to evaluate affine covariant region detector repeatability.
- Image-to-image matching based on circular CSDD features performs well, particularly when there are large changes of scale and in-plane rotation.