Robust Shape Regularity Criteria for Superpixel Evaluation

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Available code at
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Abstract

Regular decompositions are necessary for most superpixel-based object recognition or tracking applications. So far in the literature, the regularity or compactness of a superpixel shape is mainly measured by its circularity. In this work, we demonstrate that such measure is not adapted for superpixel evaluation, since it does not directly express regularity but circular appearance. We propose a new metric, the Shape Regularity Criteria (SRC), that considers several shape regularity aspects: convexity, balanced repartition, and contour smoothness. Finally, we demonstrate that our measure is robust to scale and noise to more relevantly compare superpixel methods.

The Proposed Shape Regularity Criteria

• Shape Regularity Criteria (SRC):

Evaluation of convexity, balanced repartition and contour smoothness of shape S

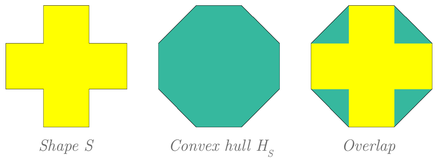
$$\mathrm{SRC}(S) = \mathrm{SO}(S)\mathrm{V_{xy}}(S)\mathrm{CO}(S)$$

• Evaluation of each regularity aspect:

• **Convexity:**

The solidity (SO) evaluates the overlap of a shape S with its convex hull H_S

$$\mathrm{SO}(S) = \frac{|S|}{|H_S|} \leq 1$$



• **Balanced repartition:**

Variance term $\mathrm{V_{xy}}$ to evaluate the repartition of pixel positions (x,y)
The shape is considered as balanced only if the std. dev. $\sigma_x = \sigma_y$

$$\mathrm{V_{xy}}(S) = \frac{|\min(\sigma_x, \sigma_y)|}{|\max(\sigma_x, \sigma_y)|} \leq 1$$

• **Contour smoothness:**

Measure of the shape contour smoothness with the convexity (CO)

$$\mathrm{CO}(S) = \frac{|P(H_S)|}{|P(S)|} \leq 1$$

The Circularity Metric

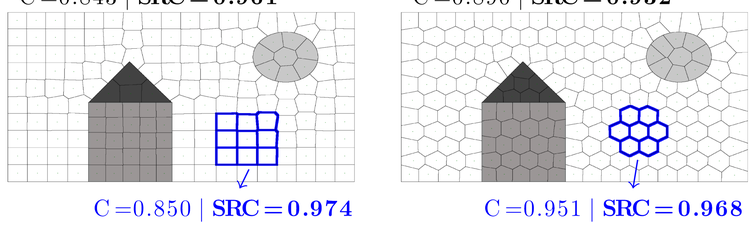
• Definition:

The circularity C [4] is the reference metric to evaluate the compactness of a superpixel S in the superpixel literature

$$C(S) = \frac{4\pi|S|}{|P(S)|} \qquad \text{with } P(S) \text{ the perimeter}$$

• Limitations:

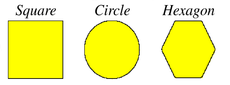
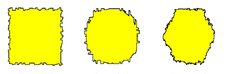
→ Too sensitive to contour smoothness, non-robust to scale and noise
→ Only considers circular shapes, circles and hexagons get higher measures



Regularity Evaluation

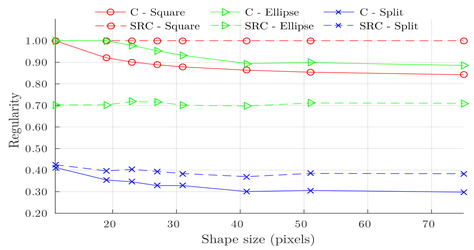
• Comparison on smooth and noisy synthetic shapes:

→ SRC gives the highest measure for squares, circles and hexagons
→ Less sensitivity to contour smoothness
→ Better differentiation of shape groups with SRC

	Regular shapes			Standard shapes			Irregular shapes		
	Square	*Circle*	*Hexagon*	*Ellipse*	*Cross*	*Bean*	*W*	*Split*	*U*
Smooth									
C	**0.830**	**1.000**	**0.940**	**0.870**	**0.530**	**0.580**	**0.150**	**0.280**	**0.150**
SRC	**1.000**	**0.989**	**0.987**	**0.712**	**0.650**	**0.564**	**0.387**	**0.369**	**0.233**
SO	1.000	0.989	0.989	0.988	0.781	0.800	0.841	0.530	0.357
$\mathrm{V_{xy}}$	1.000	1.000	0.997	0.718	1.000	0.811	0.990	0.888	0.942
CO	1.000	1.000	1.000	0.997	0.833	0.868	0.465	0.783	0.694
Noisy									
C	**0.480**	**0.430**	**0.420**	**0.440**	**0.360**	**0.450**	**0.100**	**0.210**	**0.070**
SRC	**0.716**	**0.633**	**0.625**	**0.498**	**0.522**	**0.496**	**0.296**	**0.307**	**0.137**
SO	0.925	0.923	0.917	0.931	0.743	0.797	0.763	0.542	0.234
$\mathrm{V_{xy}}$	0.999	1.000	0.997	0.717	0.996	0.802	0.988	0.855	0.939
CO	0.774	0.685	0.683	0.997	0.705	0.777	0.392	0.662	0.622

Robustness

• Robustness to scale:



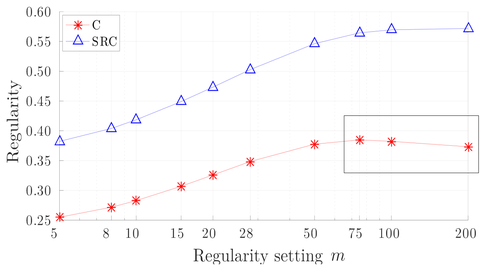
Regularity evaluation for several shape sizes

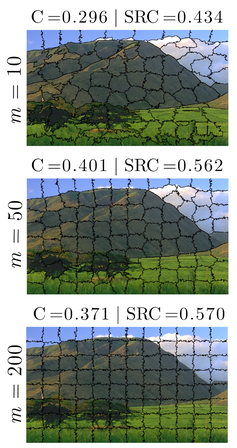
→ SRC is constant with the shape size/superpixel scale

• Robustness to noise:

SLIC [1] superpixels on [3] with noisy boundaries
Evolution of the regularity setting m

→ SRC is better correlated to the regularity setting than C

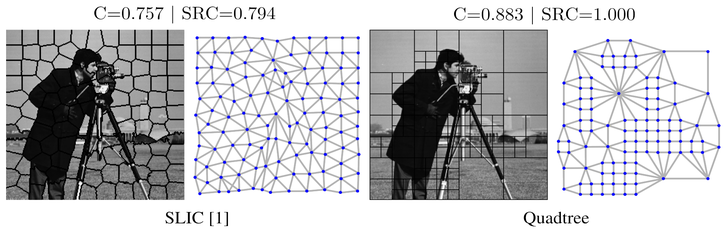




Perspectives

• Global evaluation of regularity:

No consideration of size regularity with local measures



→ Global regularity evaluation using SRC and a shape consistency measure [2]

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