WαSH: Weighted α-Shapes for Local Feature Detection

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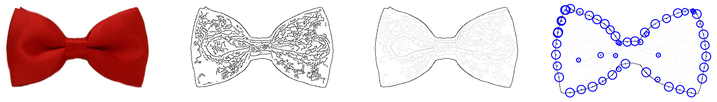
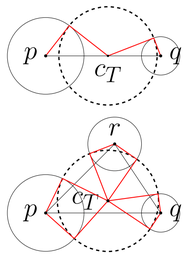
Weighted α-shapes detector

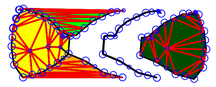
- **Image representation:** We sample the binary edges using a fixed *sampling interval* s, and define a *weight* $w(p) = g(p)\left(\frac{s}{2}\right)^2$ for each point p, with $g(p)$ being the gradient magnitude of the image.



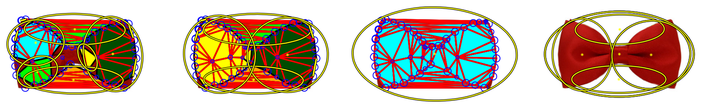
- **Triangulation:** We use a regular triangulation of the sampled points p. A regular triangulation is similar to a Delaunay triangulation, but each point p is assigned a weight $w(p)$, and Euclidean distances are replaced by power distances.



- **Neighboring simplices:** Each triangle has its edges as neighbors. Each edge has as neighbors the triangles it belongs to.



- **Component tree:** Stores all connected components κ_i of the α-filtration for different values of α.

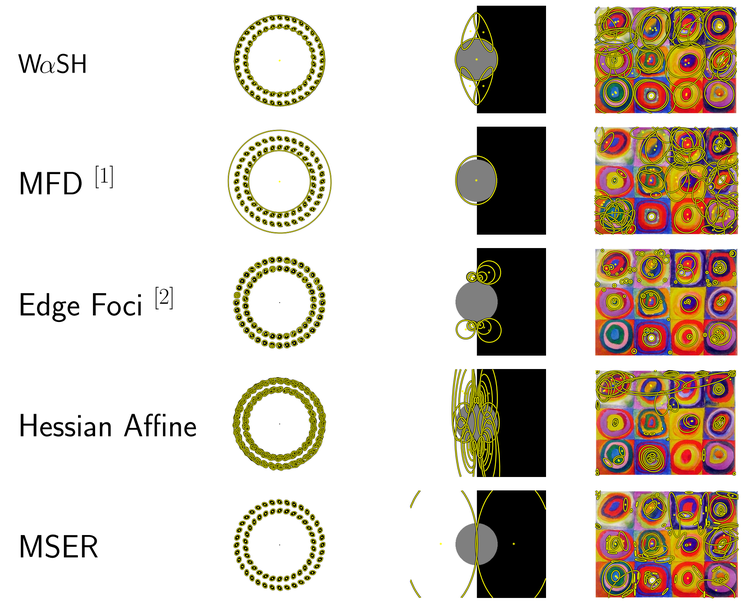


$K_1 \subseteq K_2 \subseteq K_3$ detected regions

- **Component selection criterion:** $s(\kappa_U) = \frac{a(\kappa_U)}{\rho_T}$, where $a(\kappa_U)$ is the total area of the component κ_U and ρ_T is the size of the boundary edge σ_T responsible for merging the component with another one.

Examples on real images

Qualitative comparison



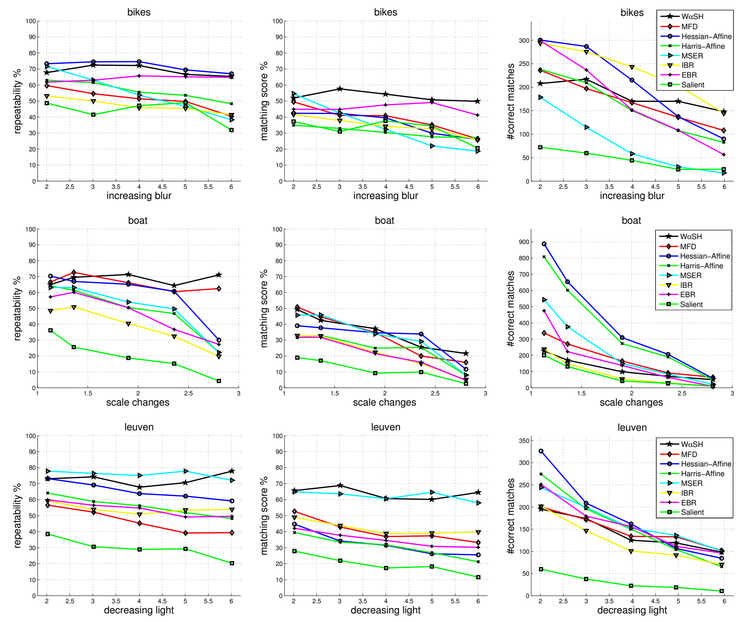
Algorithm

Algorithm 1: WαSH Feature Detection

input : grayscale image f
output: local feature set F

$g \leftarrow \|\nabla f\| / \max\{\|\nabla f\|\}$ *// normalized gradient*
$E \leftarrow \textsc{Canny}(g)$ *// edge detection*
$P \leftarrow \textsc{Sample}(E)$ *// edge sampling*
$\mathcal{R} \leftarrow \textsc{Regular}(P)$ *// regular triangulation*
$(\mathcal{K}, \rho) \leftarrow \textsc{Complex}(\mathcal{R})$ *// simplicial complex + sizes*
$N \leftarrow \textsc{Neighbor}(\mathcal{K}')$ *// neighborhood system*
$F \leftarrow \emptyset$
foreach $\sigma_T \in \mathcal{K}'$ **do** *// initialize each simplex*
  $\textsc{MakeSet}(\sigma_T)$ *// as an individual component*
  $\sigma_T.area \leftarrow \textsc{Area}(T)$ *// with its own area*
  $\sigma_T.root \leftarrow \sigma_T$
foreach $\sigma_T \in \mathcal{K}'$ *in descending order of* ρ_T **do** *// current simplex*
  $\kappa_T \leftarrow \textsc{Find}(\sigma_T)$ *// current component* κ_T
  $r_T \leftarrow \kappa_T.root$
  foreach $\sigma_U \in N(\sigma_T)$ *such that* $\rho_U \geq \rho_T$ **do** *// adjacent, processed simplex*
    $\kappa_U \leftarrow \textsc{Find}(\sigma_U)$ *// adjacent component* κ_U
    $r_U \leftarrow \kappa_U.root$
    if $\kappa_T \neq \kappa_U$ **then** *// if different components*
      if $|U| = 3 \wedge r_U.area/\rho_T > \tau$ **then** *// if* κ_U *is triangle & strong*
        $F \leftarrow F \cup r_U$ *// select it*
      $r_T.\textsc{AddChild}(r_U)$ *// add it below* κ_T
      $r_T.area \leftarrow r_T.area + r_U.area$ *// merge areas*
      $\kappa_T \leftarrow \textsc{Union}(\kappa_T, \kappa_U)$ *// and disjoint sets*
      $\kappa_T.root \leftarrow r_T$

Repeatability & matching score



repeatability matching score correct matches

Large scale image retrieval

- Oxford Buildings dataset, with 50K and 200K visual words, BoW and Fast Spatial Matching.

Detector		**WαSH**	MFD	EF	HessAff	MSER	SIFT	SURF
Features ($\times 10^6$)		**7.19**	7.64	19.72	29.02	13.33	11.13	6.84
Detection time (s)		**1.32**	2.35	13.51	6.67	4.48	5.29	0.42
Inverted file (MB)	50K	**44.1**	51.9	132.1	116.2	71.2	75.9	47.8
	200K	**49.1**	58.4	146.2	128.8	78.8	84.0	53.5
BoW query (ms)	50K	**0.92**	0.94	3.11	2.71	1.32	1.51	0.88
	200K	**0.75**	0.68	1.81	1.61	0.88	0.95	0.64
FastSM query (s)	50K	**1.43**	2.45	26.01	25.17	6.57	8.35	3.75
	200K	**1.35**	0.93	4.69	6.10	2.20	5.29	3.45
BoW (mAP)	50K	**0.529**	0.531	0.455	0.489	0.489	0.422	0.466
	200K	**0.592**	0.600	0.528	0.578	0.568	0.494	0.575
FastSM (mAP)	50K	**0.541**	0.540	0.500	0.516	0.524	0.446	0.497
	200K	**0.588**	0.600	0.566	0.608	0.593	0.516	0.591

[1] Y. Avrithis and K. Rapantzikos, The medial feature detector: Stable regions from image boundaries, ICCV, 2011
[2] C.L. Zitnick and K. Ramnath, Edge foci interest points, ICCV, 2011

Binaries available at: http://image.ntua.gr/iva/research/wash/

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