Augmented Reality & Video Service Emerging Technologies

SIFT SURF FAST BRIEF ORB BRISK

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AR Feature Detection & Description Method Comparison

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	SIFT	SURF	FAST	BRIEF	ORB	BRISK
Year	1999	2006	2006	2010	2011	2011
Feature Detector	Difference of Gaussian	Fast Hessian	Binary comparison	N/A	FAST	FAST or AGAST
Spectra	Local gradient magnitude	Integral box filter	N/A	Local binary	Local binary	Local binary
Orientation	Yes	Yes	N/A	No	Yes	Yes
Feature Shape	Square	HAAR rectangles	N/A	Square	Square	Square
Feature Pattern	Square	Dense	N/A	Random point-pair pixel compares	Trained point-pair pixel compares	Trained point-pair pixel compares

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AR Feature Detection & Description Method Comparison

	SIFT	SURF	FAST	BRIEF	ORB	BRISK
Distance Function	Euclidean	Euclidean	N/A	Hamming	Hamming	Hamming
Robustness	6 Brightness, rotation, contrast, affine transforms, scale, noise	4 Scale, rotation, illumination, noise	N/A	2 Brightness, contrast	3 Brightness, contrast, rotation, limited scale	4 Brightness, contrast, rotation, scale
Pros	Accurate	Accurate	Fast, real-time applicable	Fast, real-time applicable	Fast, real-time applicable	Fast, real-time applicable
Cons	Slow, compute-intensive, patented	Slow, patented	Large number of interest points	Scale and rotation invariant	Less scale invariant	Less scale invariant

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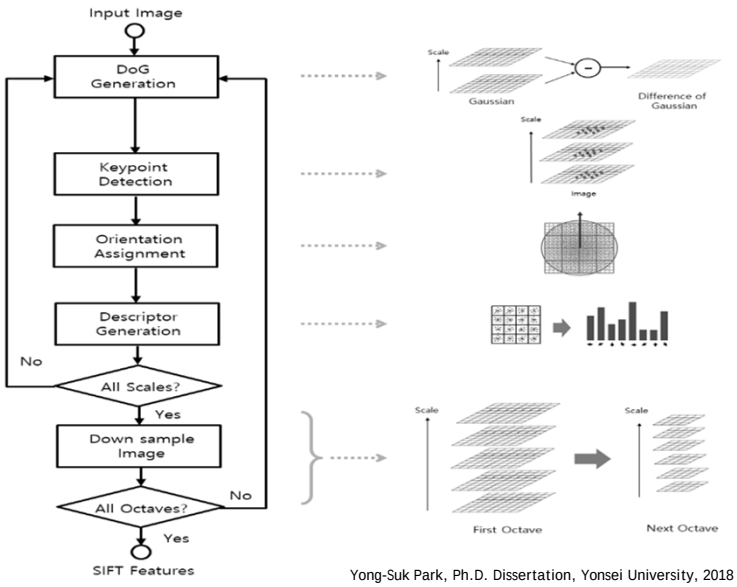
SIFT

SIFT

❖ **SIFT: Scale Invariant Feature Transform**

- One of the first feature detectors scheme proposed
- Uses image transformations in the feature detection matching process
- SIFT Characteristics
  - Highly accurate
  - However, large computational complexity limits use in real-time applications

SIFT Feature Extraction Process



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SIFT

❖ SIFT Processing Steps

- DoG (Difference of Gaussian) Generation
  - Build a scale space using an approximation based on DoG techniques
  - Local extrema of the DoG images (at varying scales) are the selected interest points
  - DoG images are produced by image convolving or blurring with Gaussians at each octave of the scale space in the Gaussian Pyramid
  - Gaussian image (based on set number of octaves) is down-sampled after each iteration of an octave

SIFT

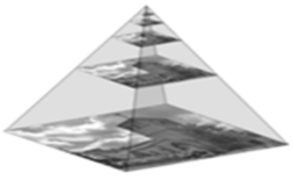
❖ SIFT Processing Steps

- Why use DoG (Difference of Gaussian)?
  - DoG is a LoG (Laplacian of Gaussian) approximation method
  - DoG has low computational complexity compared to LoG
  - DoG does not need partial derivative computations like LoG does
  - DoG obtains local extrema of images with difference of the Gaussians

SIFT

❖ IPD (Interest Point Detection) Classical methods

- LoG (Laplacian of Gaussian) is useful in IPD
  - LoG is scale invariant when applied at multiple image scales
  - Popular approach to improve performance
  - Gaussian scale-space pyramid & kernel techniques are frequently used



SIFT

❖ Classical methods for IPD (Interest Point Detection)

- Approximation of LoG (Laplacian of Gaussian)
  - **Laplacian**
    - Differential operator of a function on Euclidean space
    - Second order Gaussian scale space derivatives are very sensitive to noise and require significant computation

SIFT

❖ SIFT Processing Steps

- Keypoint Detection
  - Keypoint localization process
    - Each pixel in the DoG image is compared to its neighboring pixels
  - Comparison is processed on the current scale and two scales above and below
  - Candidate keypoints are pixels that are local maximums or local minimums (i.e., extrema)
  - Final set of keypoints exclude low contrast points

SIFT

❖ SIFT Processing Steps

- Orientation Assignment
  - Keypoint orientation determination process
  - Orientation of a keypoint is the local image gradient histogram in the neighborhood of the keypoint
  - Peaks in the histogram are selected as the dominant orientations

SIFT

❖ SIFT Descriptor Generation

- Compute the feature descriptor for each keypoint
- Feature descriptor consists of 128 orientation histograms

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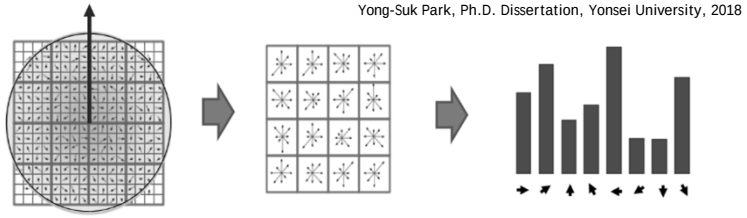

Image gradients
Take 16x16 window around interest point

Keypoint descriptor
Divide into 4x4 grid of cells

128 features for 1 keypoint
Compute histogram of image gradients in each cell

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