BRIEF: Computing a Local Binary Descriptor Very Fast

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Introduction
Method
Conclusion
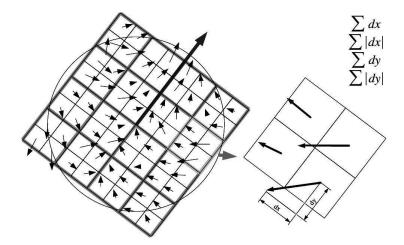
Motivation
Problem Definition
Previous Work
Background

Motivation: A 256-Byte Descriptor?

$$\sum dx$$
$$\sum |dx|$$
$$\sum dy$$
$$\sum |dy|$$

Figure : A SURF descriptor stores 64 orientation values as 4-byte integers.

Introduction
Method
Conclusion

Motivation
Problem Definition
Previous Work
Background

Problem Definition: Make It Smaller, Compute It Faster
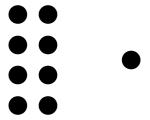
Figure : Reduce the size by a factor of 8.

Introduction
Method
Conclusion

Motivation
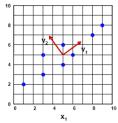Problem Definition
Previous Work
Background

Previous Work: Principal Component Analysis

- $X=(x_1,x_2)=\{(1,2),(3,3),(3,5),(5,4),(5,6),(6,5),(8,7),(9,8)\}$

$$\Sigma_x = \begin{bmatrix} 6.25 & 4.25 \\ 4.25 & 3.5 \end{bmatrix}$$

$$\Sigma_x v = \lambda v \Rightarrow |\Sigma_x - \lambda I| = 0 \Rightarrow \begin{vmatrix} 6.25 - \lambda & 4.25 \\ 4.25 & 3.5 - \lambda \end{vmatrix} = 0 \Rightarrow \lambda_1 = 9.34; \ \lambda_2 = 0.41;$$

$$\begin{bmatrix} 6.25 & 4.25 \\ 4.25 & 3.5 \end{bmatrix} \begin{bmatrix} v_{11} \\ v_{12} \end{bmatrix} = \begin{bmatrix} \lambda_1 v_{11} \\ \lambda_1 v_{12} \end{bmatrix} \Rightarrow \begin{bmatrix} v_{11} \\ v_{12} \end{bmatrix} = \begin{bmatrix} 0.81 \\ 0.59 \end{bmatrix}$$

$$\begin{bmatrix} 6.25 & 4.25 \\ 4.25 & 3.5 \end{bmatrix} \begin{bmatrix} v_{21} \\ v_{22} \end{bmatrix} = \begin{bmatrix} \lambda_2 v_{21} \\ \lambda_2 v_{22} \end{bmatrix} \Rightarrow \begin{bmatrix} v_{21} \\ v_{22} \end{bmatrix} = \begin{bmatrix} -0.59 \\ 0.81 \end{bmatrix}$$

Introduction
Method
Conclusion

Motivation
Problem Definition
Previous Work
Background

Previous Work: Floating-Point Quantization
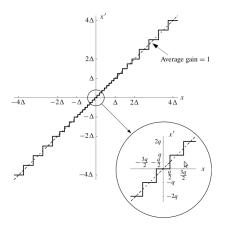
Figure : Quantization with a 3-Bit Mantissa.

Introduction
Method
Conclusion

Motivation
Problem Definition
Previous Work
Background

Background: Hamming Distance

00011101
10010111
─────────
10001010
⬇
Bit count = 3

Introduction
Method
Conclusion

Motivation
Problem Definition
Previous Work
Background

Background: Hamming Distance

00011101
10010111
—————
10001010
⇩
Bit count = 3

XOR EAX, EBX
POPCNT EAX, EAX

01101011101
10010101010
10

10001110101
11000110100
3

11101110111
10101010101
?

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Method: Sampling Distributions

Figure : Sampling distributions.

Introduction
Method
Conclusion

Method
Data
Experimental Setup
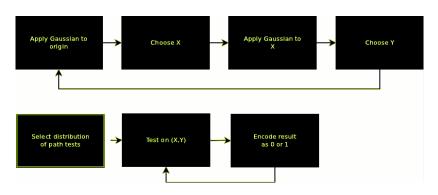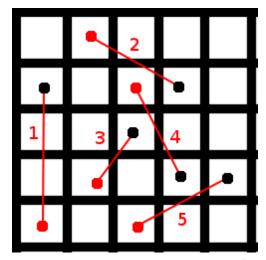
Method: Patch Test

$$\tau(p; \mathbf{x}, y) := \begin{cases} 1 & \text{if } I(\mathbf{p}, \mathbf{x}) < I(\mathbf{p}, \mathbf{y}) \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Method: Descriptor Formula

$$\sum_{l \leq i \leq n_d} 2^{i-1} \tau(p; x_i, y_i) \qquad (2)$$

Introduction
Method
Conclusion

Method
Data
Experimental Setup
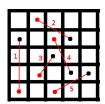
Method: Example of Distribution

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Example of Patch Test on Distribution

$$\begin{bmatrix} 1 & 3 & 5 & 4 & 2 \\ 3 & 2 & 1 & 8 & 7 \\ 9 & 5 & 4 & 6 & 4 \\ 7 & 9 & 5 & 2 & 1 \\ 2 & 3 & 6 & 5 & 4 \end{bmatrix}$$

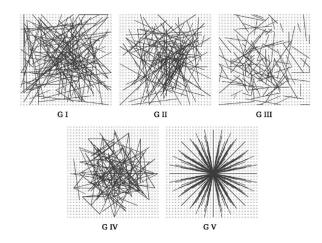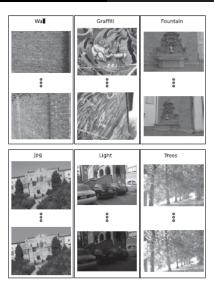| x	y	τ
2	3	1
3	8	1
9	4	0
1	2	1
6	1	0

11010

Figure : Sampling distributions.

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Example of Patch Test on Distribution

$$\begin{bmatrix} 3 & 2 & 1 & 8 & 7 \\ 9 & 5 & 4 & 6 & 4 \\ 7 & 9 & 5 & 2 & 1 \\ 1 & 3 & 5 & 4 & 2 \\ 2 & 3 & 6 & 5 & 4 \end{bmatrix}$$

x	y	τ
2	9	1
2	6	1
3	5	1
4	4	0
6	2	0

11100

Figure : Sampling distributions.

Introduction
Method
Conclusion

Method
Data
Experimental Setup

1	1	0	1	0
1	1	1	0	0
y	y	n	n	y

Hamming distance: 2.

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Method: Sampling

$$X \leftarrow Uniform\left(-\frac{S}{2},\frac{S}{2}\right)$$
$$Y \leftarrow Uniform\left(-\frac{S}{2},\frac{S}{2}\right)$$

(G I)

$$X \leftarrow Gaussian\left(0,\frac{1}{25}S^2\right)$$
$$Y \leftarrow Gaussian\left(0,\frac{1}{25}S^2\right)$$

(G II)

$$X \leftarrow Gaussian\left(0,\frac{1}{25}S^2\right)$$
$$Y \leftarrow Gaussian\left(x_i,\frac{1}{100}S^2\right)$$

(G III)

$$X \leftarrow RandDiscrete(0 < \theta < 360, 0 < r < S/2)$$
$$Y \leftarrow RandDiscrete(0 < \theta < 360, 0 < r < S/2)$$

(G IV)

$$X \leftarrow (0,0)$$
$$Y \leftarrow RandDiscrete(0 < \theta < 360, 0 < r < S/2)$$

(G V)

Introduction
Method
Conclusion

Method
Data
Experimental Setup

Method: Sampling Distributions

G I   G II   G III

G IV   G V

Figure : Sampling distributions.

Introduction
Method
Conclusion

Method
Data
Experimental Setup

(a)

Introduction
Method
Conclusion

Method
Data
Experimental Setup

(b)

Introduction
Method
Conclusion

Method
Data
Experimental Setup
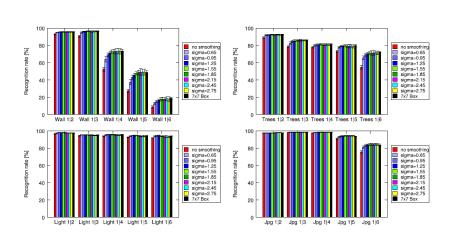
Experimental Setup

- U-BRIEF
- S-BRIEF
- O-BRIEF
- D-BRIEF

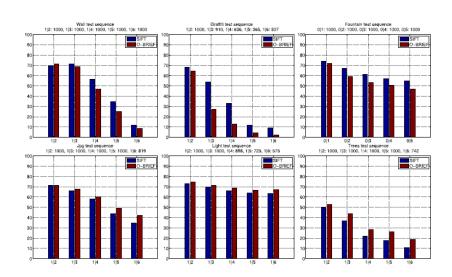Descriptor performance for Liberty dataset (average over three subsets)
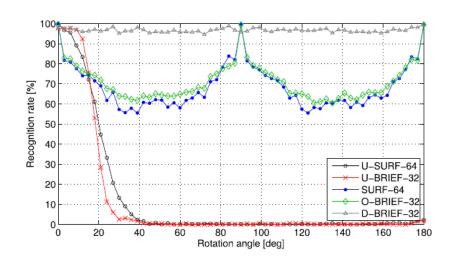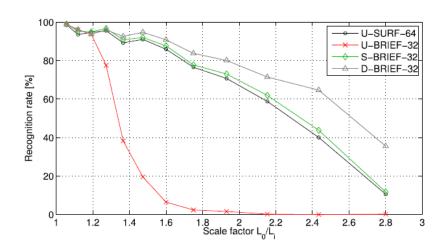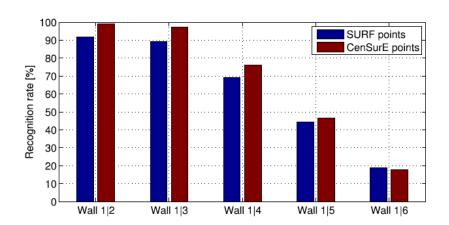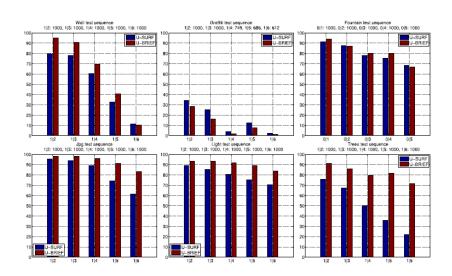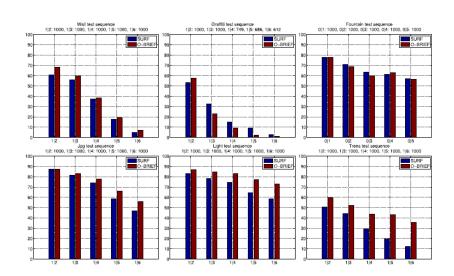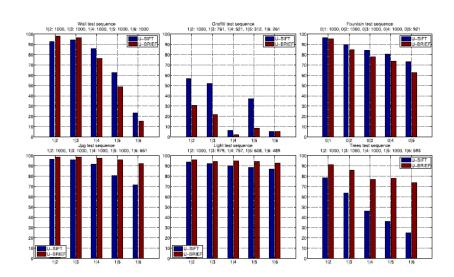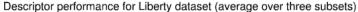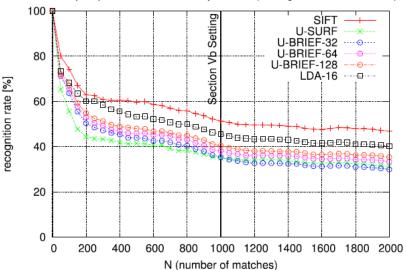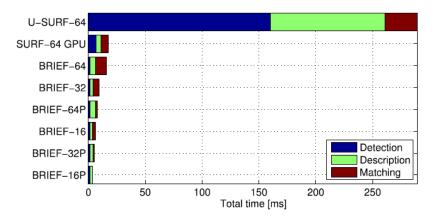
Conclusion

- http://www.embege.com/gauss/
- http://cvlab.epfl.ch/ strecha/multiview/denseMVS.html
- http://www.cs.ubc.ca/ mbrown/patchdata/patchdata.html
- http://www.robots.ox.ac.uk/ vgg/research/affine/
- Dr. Gunturk's "Machine Recognition of Patterns" class notes