BRIEF: Computing a Local Binary Descriptor Very Fast

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October 11, 2012



Motivation: A 256-Byte Descriptor?

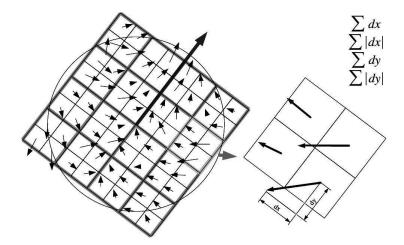


Figure : A SURF descriptor stores 64 orientation values as 4-byte integers.



Problem Definition: Make It Smaller, Compute It Faster

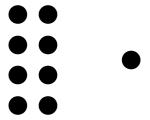


Figure: Reduce the size by a factor of 8.

Previous Work: Principal Component Analysis

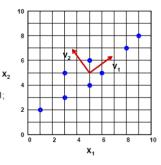
• $X=(\bar{x_1},\bar{x_2})=\{(1,2),(3,3),(3,5),(5,4),(5,6),(6,5),(8,7),(9,8)\}$

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

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

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

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



Previous Work: Floating-Point Quantization

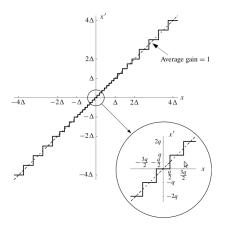


Figure: Quantization with a 3-Bit Mantissa.

Background: Hamming Distance

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00011101 10010111	01101011101 10010101010	10
10001010 Bit count = 3	10001110101 11000110100	3
XOR EAX, EBX POPCNT EAX, EAX	11101110111 10101010101	?

Method: Sampling Distributions

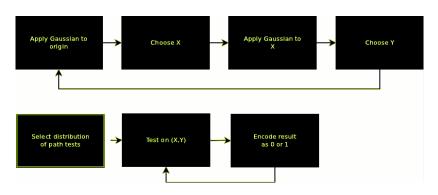


Figure: Sampling distributions.

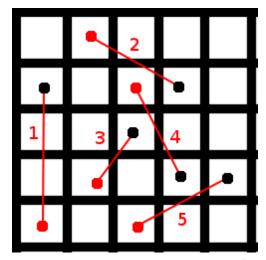
Method: Patch Test

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

Method: Descriptor Formula

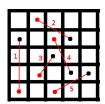
$$\sum_{1 \le i \le n_d} 2^{i-1} \tau(\rho; x_i, y_i) \tag{2}$$

Method: Example of Distribution



Example of Patch Test on Distribution

Γ1	3	5	4	2
3	2 5	1	8	7
9	5	4	6	4
[1 3 9 7 2	9 3	5	2	1
2	3	6	5	2 7 4 1 4



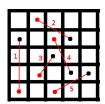
X	у	$\mid au$
2	3	1
3	8	1
9	4	0
1	2	1
6	1	0
11010		

Figure : Sampling distributions.



Example of Patch Test on Distribution

[3	2	1	8	7
9	5	4	6	4
[3 9 7 1 2	2 5 9 3 3	5	6 2	7 4 1 2 4
1	3	5	4 5	2
2	3	6	5	4_



Х	у	au
2	9	1
2	6	1
3	5	1
4	4	0
6	2	0
11100		

Figure: Sampling distributions.



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

Hamming distance: 2.

Method: Sampling

$$\begin{split} &X \leftarrow \textit{Uniform}\left(-\frac{s}{2},\frac{s}{2}\right) \\ &Y \leftarrow \textit{Uniform}\left(-\frac{s}{2},\frac{s}{2}\right) \end{split} \tag{G I}$$

$$\begin{split} X &\leftarrow Gaussian\left(0, \frac{1}{25}S^2\right) \\ Y &\leftarrow Gaussian\left(0, \frac{1}{25}S^2\right) \end{split} \tag{G II)} \end{split}$$

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

 $Y \leftarrow Gaussian\left(x_i, \frac{1}{1100}S^2\right)$ (G III)

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

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

$$\begin{array}{l} X \leftarrow (0,0) \\ Y \leftarrow RandDiscrete(0 < \theta < 360.0 < r < 5/2) \end{array}$$
 (G V)

Method: Sampling Distributions

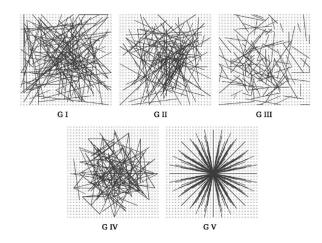
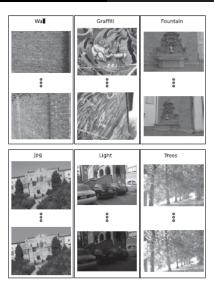


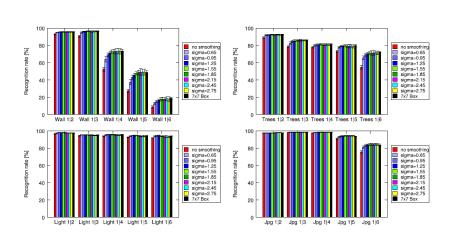
Figure : Sampling distributions.

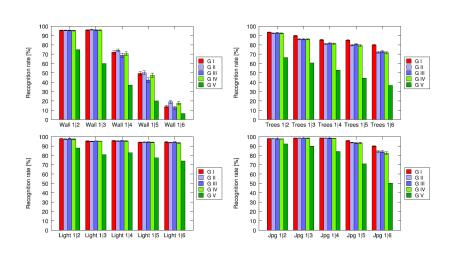


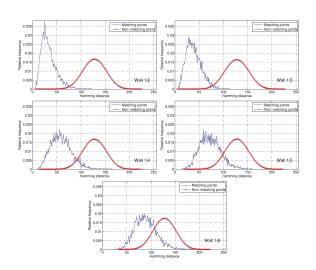


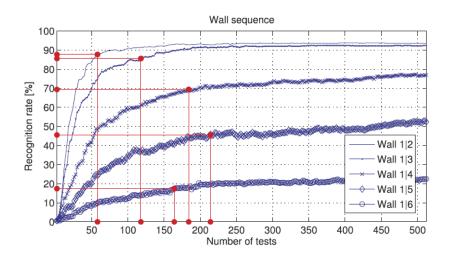
Experimental Setup

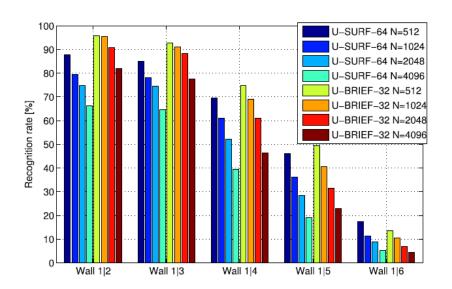
- U-BRIEF
- S-BRIEF
- O-BRIEF
- D-BRIEF

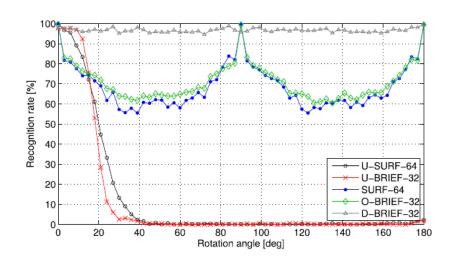


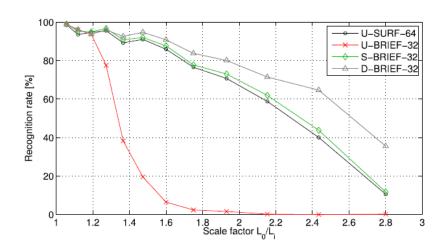


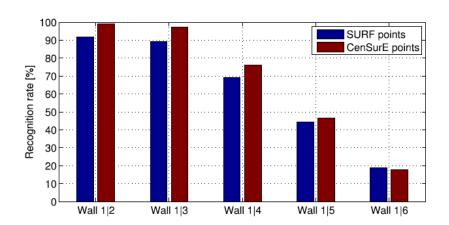


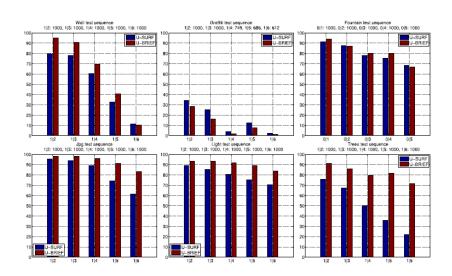


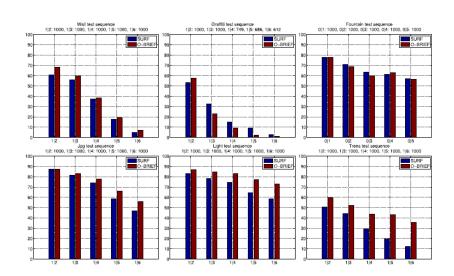


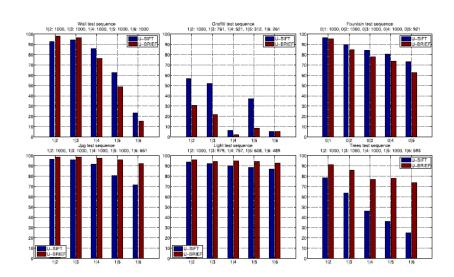


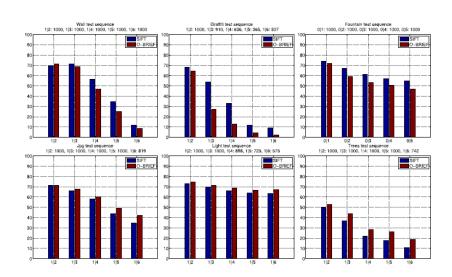


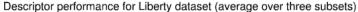


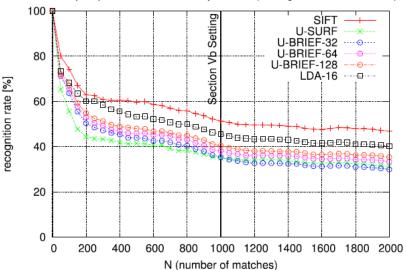


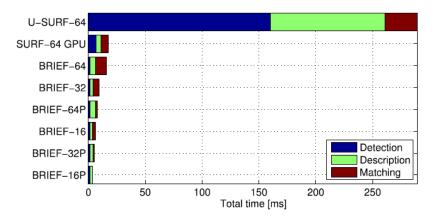














Conclusion



- 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