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QR

SIFT

13%

SIFT

A Proposal of Encoding Marker which is Robust against Blur and easy to Detect

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Abstract We proposed a new encoding Marker which can have flexibility to marker's placement and distance. Our method can detect the marker by using the SIFT-Localization method without dependence on their parameters. Marker's feature is represented by frequency information of color encoded by using ICA and Spread code. In consequence, the proposal method shows a characteristic of robustness against blur. Experimental results showed that the proposed method could boost 13% success rate of decoding.

Keywords Maker color code SIFT low resolution ICA spread code

1.

[5]

Baxter(Rethink Robotics [1]) NEXTAGE([6]
[2]) 1cm 1 3m

[3] [7] [8] OCM[9]

QR [4]

QR 3

1 1

QR

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(1)

(2)

2 (1)

(a) Scale-Invariant Feature Transform [10]

SIFT

SIFT

(b)

(2) (c) 1bit

Decode/Encode (d)

/ (e) Independent Component Analysis [11]

ICA

2 **3**

(1) (2) **4**

2.

2.1.

SIFT

SIFT

SIFT

SIFT

SIFT

SIFT

RGB G 2 RB

G

SIFT

Fig.1( ) σk^4 σk^9

$\sigma=1.2$ $k=2^{1/3}$

2.2.

Fig.1( )

1~4

G RB

5

4 4

$R_h=120$ $B_h=117$ $R_L=B_L=50$

Class-R R R_h B B_h

Class-B R R_h B B_h

Class-R/B R R_h B B_h

Class-N R R_L B B_L

Class-I

16

2 R B R/B N I

5 9 Class-I

16

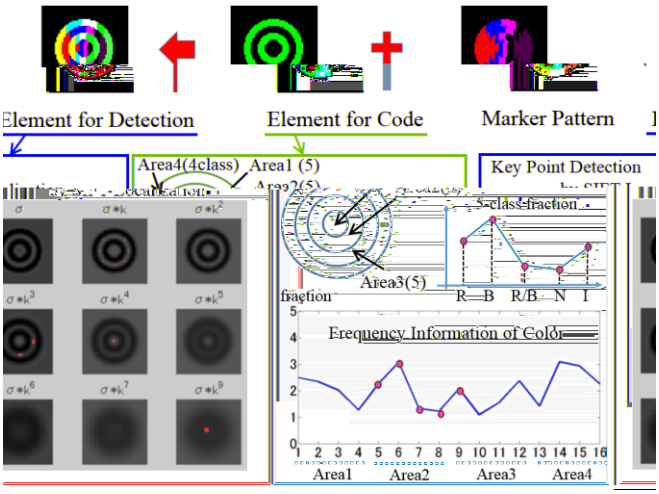


Fig. 1 Structure of Marker and Representation of Code Information

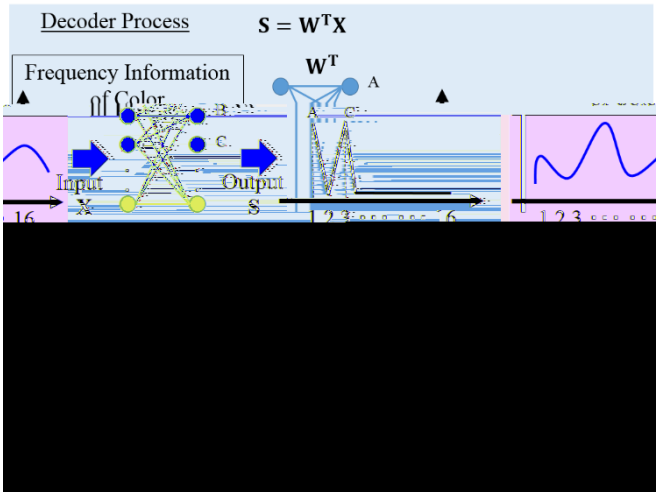


Fig. 2 Decode and Encode Process

2.3. Decode/Encode

Fig.2

n n=16 **X** $\mathbf{W}^T$

$$\mathbf{S}=\mathbf{W}^T\mathbf{X} \quad (1)$$

S_i **S** *i*

i bit 1 *i* bit 0

16 bit

$$\mathbf{X}=\mathbf{W}\mathbf{S} \quad (2)$$

S 0/1

W $\mathbf{W}^T$ 16

bit $\mathbf{X}_i$ (2)

$$\mathbf{X}=\sum_i^n \mathbf{X}_i=\sum_i^n \mathbf{W}_i S_i \quad (3)$$

1bit

1bit

2.4. /

W $\mathbf{W}^T$

W $\mathbf{W}^T$

$\mathbf{X}_i$

M [12]

M **W**

M **P**

W M 4 a^4+a+1

2^4-1 {1, -1} $\mathbf{P}_{*i}$ $\mathbf{P}_{i*}$

i=16 {-1} M

2.5. ICA

X

roll, pitch, yaw

B **P** ICA

Fig.3 ICA **S**

[13]

ICA

$$\mathbf{B}\hat{\mathbf{Y}}\mathbf{B}+\mathbb{D}æ\mathbf{B} \quad (4)$$

$$æ\mathbf{B}=\left\{\left(\mathbf{I}+E\left[\tilde{u}(S)S^T\right]\right)\mathbf{B}^T\right\}^T \quad (5)$$

$$\tilde{u}(s)=-\tanh(s) \quad (6)$$

ϵ 0.1 I

$$\mathbf{S}=\mathbf{B}^T\mathbf{X} \quad (7)$$

$$\mathbf{X}=\sum_i^n \mathbf{X}_i=\sum_i^n \mathbf{B}_i S_i \quad (8)$$

3.

3.1.

SIFT-Localization

roll, pitch 10

roll, pitch 75 roll,

pitch 60

Fig.4 .

1pixel Fig.4

Scale:σk^2 2

SIFT

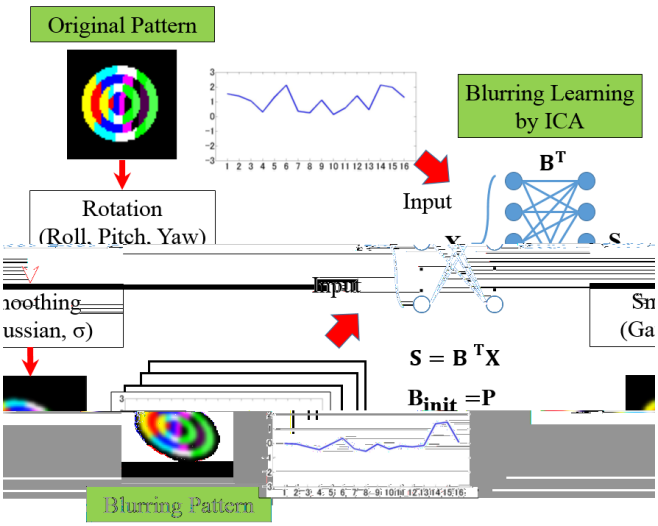


Fig. 3 Update Code Generator/Detector by ICA

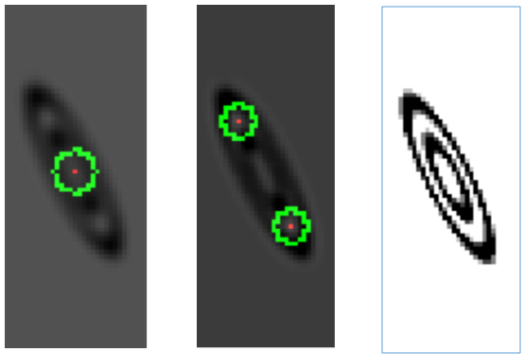


Fig. 4 Marker Detection by SIFT-Localization (roll: 60deg, pitch: 60deg)

3.2.

SIFT-Localization

EP802A

17 × 23mm

1m 2m 640×480

1m

2m 1m

2

SIFT-Localization **Fig.5**

1m 2m

σk^5 σk 1m

1.1% 2m 0.31%

[7] 640×480 0.6%

Fig.5, **Fig.6**

Fig.6

5003 1 3680

2 866 3 457

2m VGA 307200

1/6

3.3.

bit $\mathbf{X}_i$

Fig.7 $\mathbf{X}_i$ M

Fig.7

Fig.8 bit

bit 2,4,6,8,10,12,14bit 1

Fig.9(A) **X**

$\mathbf{S=W^TX}$

1bit

Fig.9(A)

Fig.9 (B) (C)

(B) RGB ±10.24 (C) ±25.6

(B)

(C)

RB

3.4. ICA

bit

X bit

900

16bit 14400

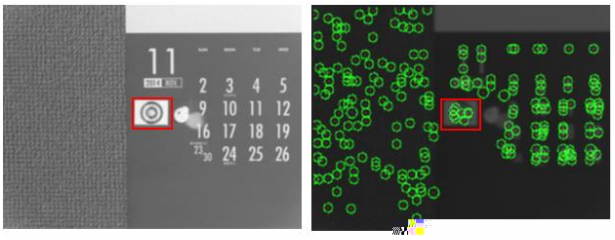
10000

Fig.10 B

bit

Fig.7 W M

Fig.8 bit



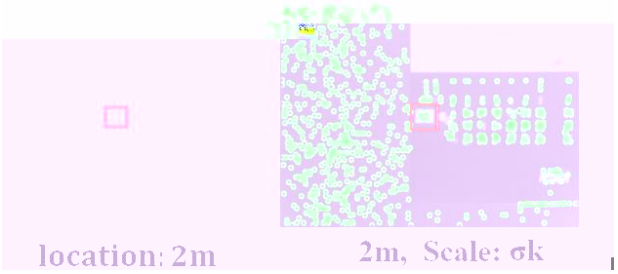


Fig. 5 Marker Detection by SIFT-Localization

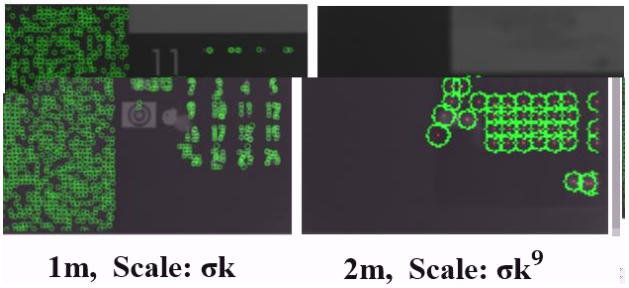


Fig. 6 Scale difference of SIFT-Localization