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$$F = 0 = x_j - x_p - x_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) \\ - (1 + p_3 r_j^2 + p_4 r_j^4)[p_1(r_j^2 + 2x_j^2) + 2p_2 x_j y_j] + f_x \frac{r}{q}$$

$$G = 0 = y_j - y_p - y_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) \\ - (1 + p_3 r_j^2 + p_4 r_j^4)[2p_1 x_j y_j + p_2(r_j^2 + 2y_j^2)] + f_y \frac{s}{q}$$

.

: $\boldsymbol{x}_j, \boldsymbol{y}_j$ (2 :)

: X_j, Y_j, Z_j (3 :)

: $\boldsymbol{w}_i, \phi_i, \kappa_i, X_i, Y_i, Z_i$ (6 :)

x, y : f_x, f_y (2 :)

: $\boldsymbol{x}_p, \boldsymbol{y}_p$ (2 :)

: k_1, k_2, k_3 (3 :)

: p_1, p_2, p_3, p_4 (4 :)

6

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RMSE .

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6 ,

RMSE

,

$$RMSE = \sqrt{\frac{\sum (\boldsymbol{x}_{\text{수중영상}} - \boldsymbol{x}_{\text{scanning영상}})^2}{n-1}}$$

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$\boldsymbol{x}_{\text{수중영상}}$:

$\boldsymbol{x}_{\text{scanning영상}}$:

$\boldsymbol{n}$:

[0002]

, 1

[0003]

[0004]

(offset),

[0005]

[0006]

[0007]

[0008]

5 × 5

(search window)

[0009]

[0010]

$$F = 0 = x_j - x_p - x_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) \\ - (1 + p_3 r_j^2 + p_4 r_j^4)[p_1(r_j^2 + 2x_j^2) + 2p_2 x_j y_j] + f_x \frac{r}{q}$$

[0011]

[0012]

[0013]

$$: \quad x_j, y_j \quad (2 :)$$

[0014] : X_j, Y_j, Z_j (3 :)

[0015] : $w_i, \phi_i, \kappa_i, X_i, Y_i, Z_i$ (6 :)

[0016] x, y : f_x, f_y (2 :)

[0017] : x_p, y_p (2 :)

[0018] : k_1, k_2, k_3 (3 :)

[0019] : p_1, p_2, p_3, p_4 (4 :)

[0020]

RMSE .

[0021] RMSE .

[0022]
$$RMSE = \sqrt{\frac{\sum (x_{\text{수증영상}} - x_{\text{scanning영상}})^2}{n-1}}$$

[0023] .

[0024] x 수증영상 :

[0025] $x_{\text{scanning영상}}$:

[0026] n :

[0027] , ,
(offset), ,
.

[0028] , . ,
.
.

[0029] 2 .

[0030] (S30), (S40), (S10), (S20),
(S50) (S60)

[0031] (S10) ,

[0032] 3

[0033] 3 , 3

[0034] 4

[0035] (S20)
3

[0036] 5

[0037] 5 (S20)

[0038] (S30) (S20)

[0039] (S30) 5 × 5

[0040] 6 (Search Window)

[0041] 6 (Search Window) 5 × 5 8

0) 6 (i, j) (0,

[0042] (S30) (Search Window)

[0043] (S40) 7

7 9

[0044] (S50)

[0045]

$$1) \quad (\quad)$$

$$1 \quad .$$

1

$$x_{ij} = -f \left[\frac{m_{11}(X_j - X_i) + m_{12}(Y_j - Y_i) + m_{13}(Z_j - Z_i)}{m_{31}(X_j - X_i) + m_{32}(Y_j - Y_i) + m_{33}(Z_j - Z_i)} \right]$$

$$y_{ij} = -f \left[\frac{m_{21}(X_j - X_i) + m_{22}(Y_j - Y_i) + m_{23}(Z_j - Z_i)}{m_{31}(X_j - X_i) + m_{32}(Y_j - Y_i) + m_{33}(Z_j - Z_i)} \right]$$

$$x \quad y$$

$$2$$

2

$$x_{ij} = -f_x \left[\frac{m_{11}(X_j - X_i) + m_{12}(Y_j - Y_i) + m_{13}(Z_j - Z_i)}{m_{31}(X_j - X_i) + m_{32}(Y_j - Y_i) + m_{33}(Z_j - Z_i)} \right]$$

$$y_{ij} = -f_y \left[\frac{m_{21}(X_j - X_i) + m_{22}(Y_j - Y_i) + m_{23}(Z_j - Z_i)}{m_{31}(X_j - X_i) + m_{32}(Y_j - Y_i) + m_{33}(Z_j - Z_i)} \right]$$

$$1 \quad 2 \quad .$$

$$x_{ij} : i \quad j \quad x \quad (\quad)$$

$$y_{ij} : i \quad j \quad y \quad (\quad)$$

$$f_x : \quad x$$

$$f_y : \quad y$$

$$X_i : \quad x \quad (\quad)$$

$$Y_i : \quad y \quad (\quad)$$

$$Z_i : \quad z \quad (\quad)$$

$$X_j : \quad j \quad x \quad (\quad)$$

$$Y_j: \quad j \quad y \quad (\quad)$$

$$Z_j: \quad j \quad z \quad (\quad)$$

$$m_{11} = \cos\phi \cos\kappa$$

$$m_{12} = \sin\omega \sin\phi \cos\kappa + \cos\omega \sin\kappa$$

$$m_{13} = -\cos\omega \sin\phi \cos\kappa + \sin\omega \sin\kappa$$

$$m_{21} = -\cos\phi \sin\kappa$$

$$m_{22} = -\sin\omega \sin\phi \sin\kappa + \cos\omega \cos\kappa$$

$$m_{23} = \cos\omega \sin\phi \sin\kappa + \sin\omega \cos\kappa$$

$$m_{31} = \sin\phi$$

$$m_{32} = -\sin\omega \cos\phi$$

$$m_{33} = \cos\omega \cos\phi$$

$$q, r, s = \begin{matrix} 2 \\ 3 \end{matrix}$$

3

$$q = m_{31}(X_j - X_i) + m_{32}(Y_j - Y_i) + m_{33}(Z_j - Z_i)$$

$$r = m_{11}(X_j - X_i) + m_{12}(Y_j - Y_i) + m_{13}(Z_j - Z_i)$$

$$s = m_{21}(X_j - X_i) + m_{22}(Y_j - Y_i) + m_{23}(Z_j - Z_i)$$

$$\begin{matrix} 2 & 3 & 4 \end{matrix}$$

4

$$x_{ij} = -f_x \frac{r}{q}$$

$$y_{ij} = -f_y \frac{s}{q}$$

2)

Principal Point) (PP: Indicated
Principal Point) (Fiducials)

[0070] 8 .

[0071] 8 , (IPP) (PP) , (IPP)

(PP) (Offset) (x_p, y_p) .

[0072] , (IPP) 4 5

5

$$x_j - x_p = -f_x \frac{r}{q}$$

$$y_j - y_p = -f_y \frac{s}{q}$$

[0073]

[0074] 3)

[0075] 5 6 .

6

$$x_j - x_p - x_{\text{방사왜곡량}} = -f_x \frac{r}{q}$$

[0076]

[0077] 6 .

$$x_{\text{방사왜곡량}} = x_j (1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6)$$

[0078]

[0079] r_j ; j

$$r_j = \sqrt{(x_j - x_p)^2 + (y_j - y_p)^2}$$

[0080]

[0081] 7 .

7

$$x_j - x_p - x_j (1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) = -f_x \frac{r}{q}$$

[0082]

[0083] y 8 .

8

$$y_j - y_p - y_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) = -f_y \frac{s}{q}$$

[0084]

[0085] 4)

[0086]

[0087]

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$$x_j - x_p - x \text{ 방사왜곡량} - x \text{ 비중심왜곡량} = -f_x \frac{r}{q}$$

$$x \text{ 비중심왜곡량} = (1 + p_3 r_j^2 + p_4 r_j^4) [p_1 (r_j^2 + 2x_j^2) + 2p_2 x_j y_j]$$

$$x_j - x_p - x_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) - (1 + p_3 r_j^2 + p_4 r_j^4) [p_1 (r_j^2 + 2x_j^2) + 2p_2 x_j y_j] = -f_x \frac{r}{q}$$

[0088]

10

$$y_j - y_p - y \text{ 방사왜곡량} - y \text{ 비중심왜곡량} = -f_y \frac{s}{q}$$

$$y \text{ 비중심왜곡량} = (1 + p_3 r_j^2 + p_4 r_j^4) [2p_1 x_j y_j + p_2 (r_j^2 + 2y_j^2)]$$

$$y_j - y_p - y_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) - (1 + p_3 r_j^2 + p_4 r_j^4) [2p_1 x_j y_j + p_2 (r_j^2 + 2y_j^2)] = -f_y \frac{s}{q}$$

[0089]

[0090] 5)

[0091]

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F = 0, G = 0

11

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11

$$F = 0 = x_j - x_p - x_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) \\ -(1 + p_3 r_j^2 + p_4 r_j^4)[p_1(r_j^2 + 2x_j^2) + 2p_2 x_j y_j] + f_x \frac{r}{q}$$

$$G = 0 = y_j - y_p - y_j(1 + k_1 r_j^2 + k_2 r_j^4 + k_3 r_j^6) \\ -(1 + p_3 r_j^2 + p_4 r_j^4)[2p_1 x_j y_j + p_2(r_j^2 + 2y_j^2)] + f_y \frac{s}{q}$$

11

$$x_j, y_j \quad (2 : \quad)$$

$$X_j, Y_j, Z_j \quad (3 : \quad)$$

$$w_i, \phi_i, \kappa_i, X_i, Y_i, Z_i \quad (6 : \quad)$$

$$f_x, f_y \quad (2 : \quad)$$

$$x_p, y_p \quad (2 : \quad)$$

$$k_1, k_2, k_3 \quad (3 : \quad)$$

$$p_1, p_2, p_3, p_4 \quad (4 : \quad)$$

$$\begin{array}{ccccccc} & & 11 & & 24 & & 5 \\ & & & & & & 17 \\ , & 17 & & & 17 & & 1 \\ & & & & 9 & & 9 \\ & & & & & & 9 \end{array}$$

$$\begin{array}{ccccccc} & & 9 & & 9 & & 2 \\ & & & & 11 & & 18 \\ & & & & & & \end{array} \quad (x, y)$$

$$\begin{array}{ccccccc} & & 17 & & 17 & & 17 \\ & & & & & & \end{array}$$

(; MPV: Most Probable Value)

$$\begin{array}{ccccccc} & & (& 11) & & \text{Tayler's series} & 6 \\ & & 2 & & & \text{offset } 2 & 3 \end{array}$$

4 17 , , x

7 8

$x_{보정} = x_{관측} - x_p - x_{방사왜곡} - x_{비중심왜곡}$

[0107] (S60) (scanning) (S50)

[0108] 9 9 RMSE 9 RMSE(Root Mean Square Error) - -

[0109] RMSE 12 , RMSE (S50)

12

[0110]
$$RMSE = \sqrt{\frac{\sum (x_{수증영상} - x_{scanning영상})^2}{n-1}}$$

[0111]

[0112] $x_{수증영상}$:

[0113] $x_{scanning영상}$:

[0114] n :

[0115]

[0116] 1

[0117] 2

[0118] 3

[0119] 4

[0120] 5

[0121] 6 (Search Window)

[0122] 7

[0123] 8

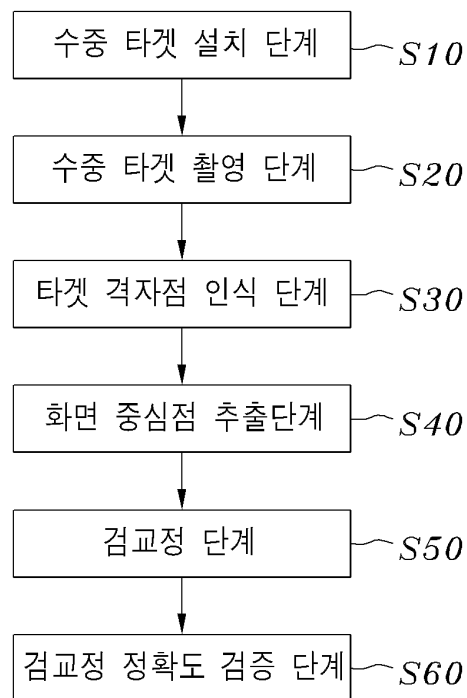
[0124]

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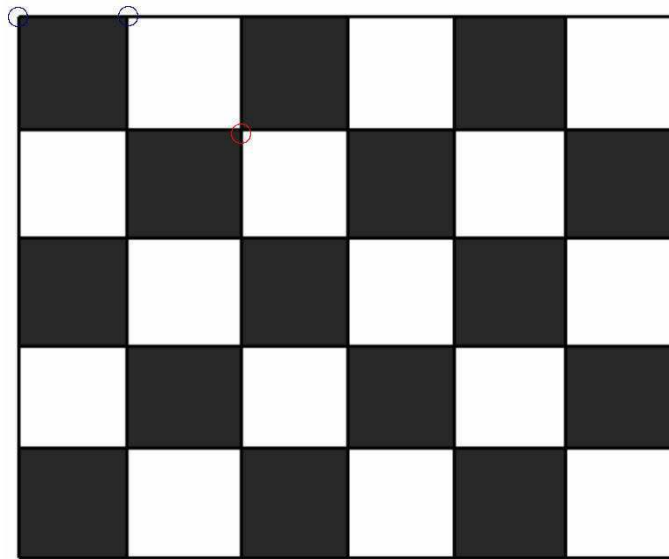
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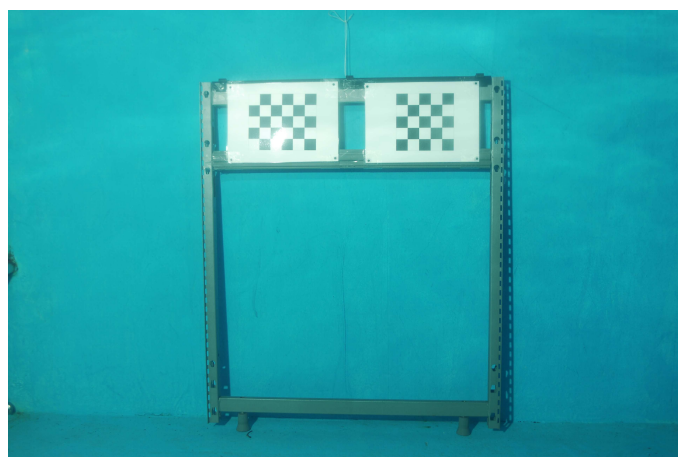
2



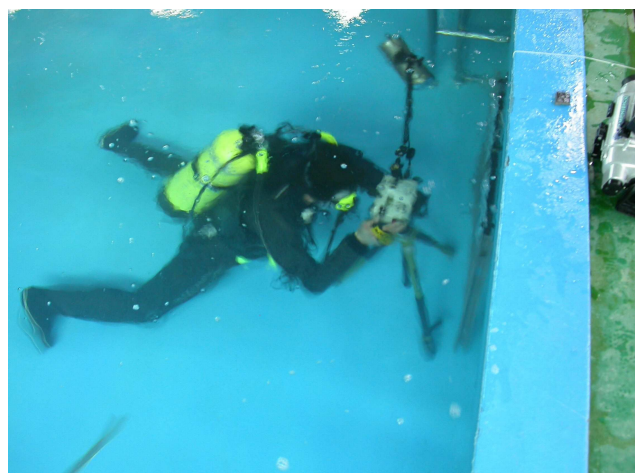
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4



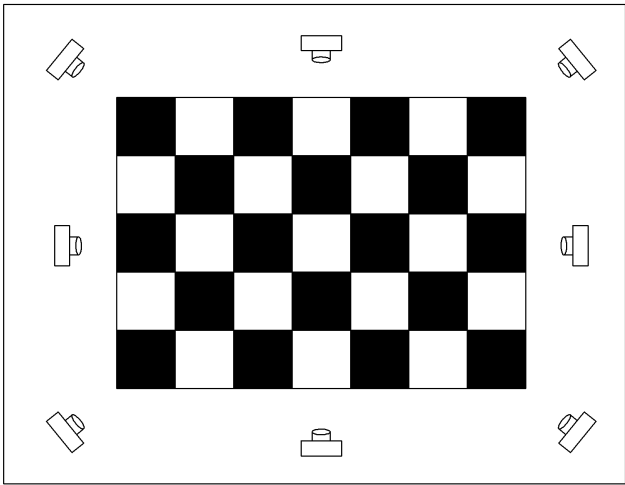
5



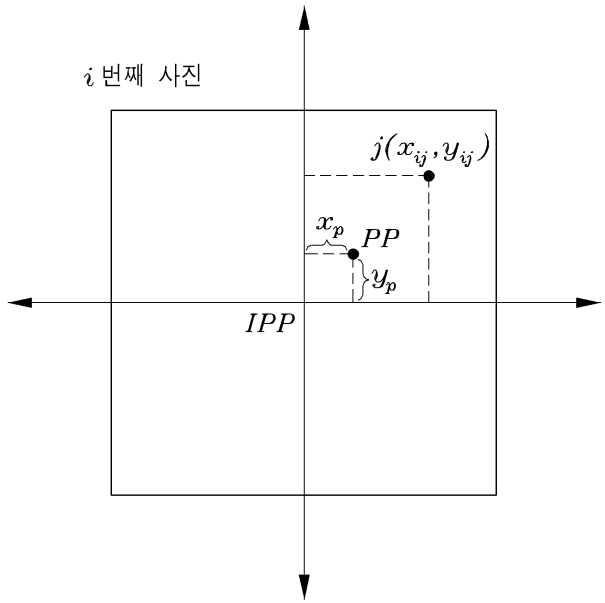
6

6				2
	4		0	
		(i,j)		
	1		5	
3				7

7



8



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