

视觉 SLAM 理论与实践 - 作业 4

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1. 代码可参见./code/undistort_image.cpp

去畸变的结果如 Fig.1所示



Figure 1: 图像去畸变

2. 代码可参见./code/disparity.cpp

点云结果如 Fig.2所示



Figure 2: 双目视差

3. 1)

$$\frac{d\mathbf{Ax}}{d\mathbf{x}} = \mathbf{A}^T \quad (1)$$

2)

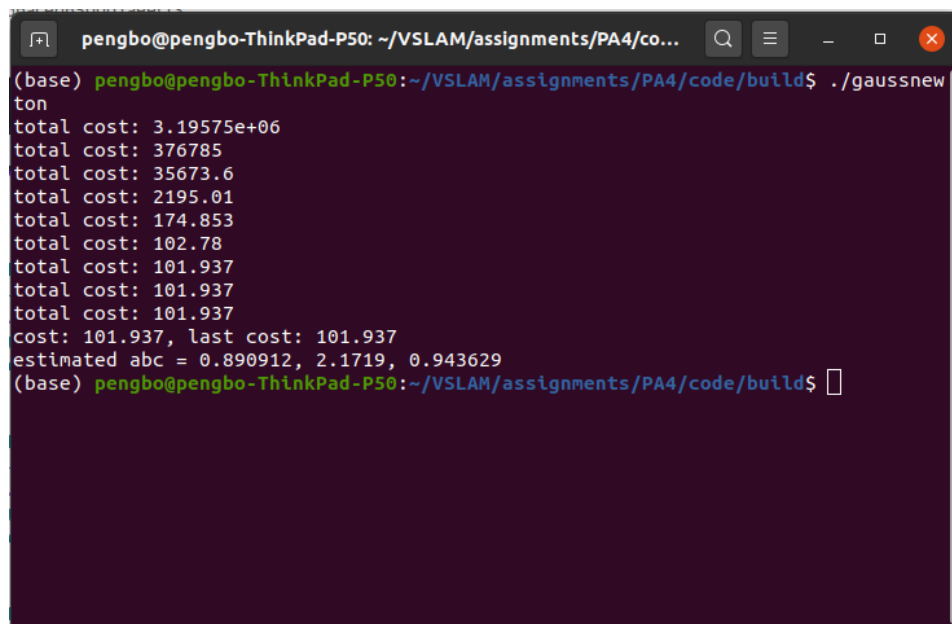
$$\frac{d\mathbf{x}^T \mathbf{Ax}}{d\mathbf{x}} = (\mathbf{A} + \mathbf{A}^T)\mathbf{x} \quad (2)$$

3)

$$\begin{aligned} \mathbf{x}^T \mathbf{Ax} &= \text{tr}(\mathbf{x}^T \mathbf{Ax}) \\ &= \text{tr}(\mathbf{Axx}^T) \end{aligned} \quad (3)$$

4. 代码可参见./code/gaussnewton.cpp

拟合结果如 Fig.3所示

A terminal window with a dark purple background and white text. The window title is 'pengbo@pengbo-ThinkPad-P50: ~/VSLAM/assignments/PA4/co...'. The prompt is '(base) pengbo@pengbo-ThinkPad-P50:~/VSLAM/assignments/PA4/code/build\$'. The user has entered './gaussnewton'. The output shows a series of 'total cost' values decreasing from 3.19575e+06 to 101.937, followed by 'cost: 101.937, last cost: 101.937' and 'estimated abc = 0.890912, 2.1719, 0.943629'. The prompt is now '(base) pengbo@pengbo-ThinkPad-P50:~/VSLAM/assignments/PA4/code/build\$' with a cursor.

```
(base) pengbo@pengbo-ThinkPad-P50:~/VSLAM/assignments/PA4/co...
(base) pengbo@pengbo-ThinkPad-P50:~/VSLAM/assignments/PA4/code/build$ ./gaussnew
ton
total cost: 3.19575e+06
total cost: 376785
total cost: 35673.6
total cost: 2195.01
total cost: 174.853
total cost: 102.78
total cost: 101.937
total cost: 101.937
total cost: 101.937
cost: 101.937, last cost: 101.937
estimated abc = 0.890912, 2.1719, 0.943629
(base) pengbo@pengbo-ThinkPad-P50:~/VSLAM/assignments/PA4/code/build$
```

Figure 3: 曲线拟合

5. 1)

$$v_k - (x_k - x_{k-1}) = -w_k \quad (4)$$

$$y_k - x_k = n_k \quad (5)$$

因此 $v_k - (x_k - x_{k-1}) \sim N(0, Q)$, $y_k - x_k \sim N(0, R)$, 对应的误差变量为:

$$\begin{aligned} \mathbf{e} &= \mathbf{z} - \mathbf{H}\mathbf{x} \\ &= \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ y_1 \\ y_2 \\ y_3 \end{bmatrix} - \begin{bmatrix} -1 & 1 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & -1 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix} \end{aligned} \quad (6)$$

2)

$$\mathbf{W} = \begin{bmatrix} Q & 0 & 0 & 0 & 0 & 0 \\ 0 & Q & 0 & 0 & 0 & 0 \\ 0 & 0 & Q & 0 & 0 & 0 \\ 0 & 0 & 0 & R & 0 & 0 \\ 0 & 0 & 0 & 0 & R & 0 \\ 0 & 0 & 0 & 0 & 0 & R \end{bmatrix} \quad (7)$$

3) 待优化目标为

$$J = \frac{1}{2}(\mathbf{z} - \mathbf{H}\mathbf{x})^T \mathbf{W}^{-1}(\mathbf{z} - \mathbf{H}\mathbf{x}) \quad (8)$$

最优解为

$$\mathbf{x}^* = (\mathbf{H}^T \mathbf{W}^{-1} \mathbf{H})^{-1} \mathbf{H}^T \mathbf{W}^{-1} \mathbf{z} \quad (9)$$

因此当矩阵 $\mathbf{H}^T \mathbf{W}^{-1} \mathbf{H}$ 可逆时存在唯一解。由于 \mathbf{W} 为对角阵, 因此当矩阵 \mathbf{H} 为列满秩时矩阵 $\mathbf{H}^T \mathbf{W}^{-1} \mathbf{H}$ 可逆。本例中 \mathbf{H} 为列满秩矩阵, 故存在唯一解。