Estimating Lighthouse Intrinsic Parameters Using LM Optimization

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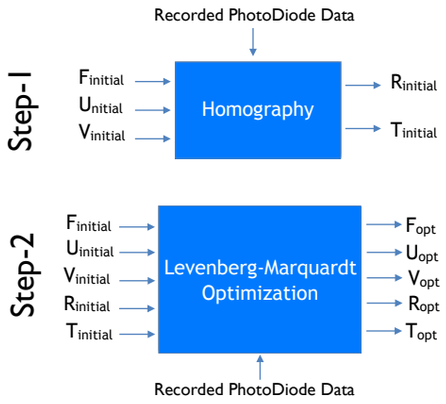
Intrinsic Parameters Matrix

$$K = \begin{pmatrix} \alpha_u & 0 & u_0 \\ 0 & \alpha_v & v_0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} x^d \\ y^d \\ 1 \end{pmatrix} = K \begin{pmatrix} x^n \\ y^n \\ 1 \end{pmatrix}$$

- **Default** : $\alpha_u = \alpha_v = 1$, $u_0 = v_0 = 0$
- **Our Formulation**: $\alpha_u = \alpha_v = F$, $u_0 = U$, $v_0 = V$

Parameters Estimation



Simulation Results

We simulate time stamps along with some user defined **U**, **V** and **F** and observe if the LM optimization yields the original intrinsic parameters.

Mean Relative Error in **U** (over 10000 samples) : **14%**

Mean Relative Error in **V** (over 10000 samples) : **10%**

Mean Relative Error in **F** (over 10000 samples) : **6%**

Average Residual (**Optimal U,V &F**) ≈ **2.5×10^{-6}**

Average Residual (**For U = V = 0 , F = 1**) ≈ **0.067**

Lighthouse Calibration Results

Optimal **U** (over 6000 samples) : **0.282**

Optimal **V** (over 6000 samples) : **-0.058**

Optimal **F** (over 6000 samples) : **0.954**

Average Residual (**Optimal U, V & F**) ≈ **5.6×10^{-5}**

Average Residual (**For U = V = 0 , F = 1**) ≈ **0.092**

- While viewing a visual scene on the HMD , less amount of jitter in the scene is observed when optimal intrinsic parameters are used as compared to the default values (**U = V = 0 , F = 1**)

Takeaways

- Importance of lighthouse calibration for improving pose estimation
- Usage and implementation of an optimization technique such as Levenberg-Marquardt for calibrating the lighthouse base station and pose estimation

Conclusions and Future Work

- In VR , such a parameter estimation improves pose estimation and reduces jitteriness in the visual scene
- Future work could include modifying the LM algorithm to calculate a more generic intrinsic parameter matrix

References

1. Zhang, Zhengyou. "A flexible new technique for camera calibration." *IEEE Transactions on pattern analysis and machine intelligence* 22.11 (2000): 1330-1334.
2. Shao-xiong, Tian, Lu Shan, and Liu Zong-ming. "Levenberg-Marquardt algorithm based nonlinear optimization of camera calibration for relative measurement." *Control Conference (CCC), 2015 34th Chinese*. IEEE, 2015.

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